

UNIVERSITY OF CAPE TOWN

Department of Civil Engineering



THE EFFECT OF HIGH SOLID RETENTION TIMES IN ACTIVATED SLUDGE REACTORS ON OPERATIONAL COSTS AT MITCHELLS PLAIN WWTP

**CIV: 5017Z Minor Dissertation presented in partial fulfilment of the
requirements for the degree of Master of Engineering in Civil
Engineering**

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Abstract

Many wastewater treatment plants (WWTPs) in South Africa, which use activated sludge (AS) processes, experience difficulty managing solid retention times (SRT), also referred to as sludge age. To avoid dealing with large quantities of sludge waste, some of these WWTPs operate the AS reactors at extended SRTs, far beyond what is required for sufficient nutrient removal or to produce a stable waste activated sludge. Hence, the strategy to operate at high SRTs could be due to a variety of factors, such as insufficient or faulty sludge handling facilities, insufficient means of sludge disposal, high cost of flocculant agents, lack of operational skills, etc.

At higher SRTs, waste flow rates are lower, which leads to a lower demand on a WWTPs sludge handling facilities and lower pumping rates. In return, a higher SRT will lead to a higher oxygen utilization rate (OUR) in the AS reactor. This will lead to higher electricity consumption by the aeration equipment or possible poor effluent quality, where (i) the aeration equipment is limited in potential to supply oxygen required to meet the increased demands for organic removal and nitrification and (ii) the thickened sludge production resulting in poor oxygen transfer within the reactor and sludge overflow from secondary settling tanks that have reached their limits in the surface area required for the given solids thickness.

Rising cost in electricity and fuel are a daily reality for all in South Africa (SA), resulting in acute energy awareness in all sectors of business, both public and private. This awareness and the need for energy efficiency will continue to escalate, especially with the SA energy supplier (ESKOM) continuing to request and apply escalation rates far above the inflation rate.

With this in mind, the aim of this study is to determine the effect of high solid retention times in activated sludge reactors on operational costs at wastewater treatment plants by developing a plant wide steady state model, based on previous work carried out by Marais and Ekama, (1976), Ekama and Wentzel, (2008a), Ekama and Wentzel, (2008b), Wentzel *et al.*, (2008) and Ekama 2009. The model simulated various scenarios with different SRT's at different influent flow rates to find the correlation between electrical energy consumption cost and the operational cost of sludge handling at various SRT's. The various scenarios were evaluated using the EQI and OCI performance indices developed by the IWA benchmark simulation task group (Copp, 2002, Nopens *et al.*, 2010), and modified by (De Ketele, Davister & Ikumi, 2018). These performance indices were then further modified, as described in Chapter 3.7.2, to be improve the relevance to this study.

The study found that the average electrical energy (kWh) required for aeration in the Modified Ludzack-Ettinger (MLE) reactor increased by 13.8% from a SRT of 10 days to a SRT of 30 days. The average electrical energy (kWh) for aeration in the University of Cape Town (UCT) reactor increase by 14.7% over the same SRT periods (refer to Section 4.2.3). It was further found the average electrical energy required for pumping, decreased between a range of 2.1% and 1% from a SRT of 10 days to a SRT of 30 days over the range of flows considered. Electrical energy required for dewatering was also found to decrease with an increase in SRT (22% from 10 days to 30 days), while mixing energy remains constant. Since the majority of the electrical consumption can be attributed to aeration, the increase of electrical energy consumption with SRT of aeration is not offset by the decrease with SRT of the other OCI drivers. The study found that the electrical energy consumption cost increases by 11.6% from an SRT of 10 days to an SRT of 30 days. The rate of increase, however, decreases at higher SRT's.

The study further confirmed that the operational costs of sludge handling, which includes dewatering energy consumption, chemical usage, and sludge disposal, decreases with an increase in SRT.

The study found that the operational costs of sludge handling decreased by 23% from an SRT of 10 days to an SRT of 30 days. As with electrical energy, the rate of decrease in operational costs, decreases at higher SRT's.

In conclusion, study found that although most of the OCI drivers became more cost effective at higher SRT's the increased cost of electricity consumption of aeration at higher SRT's leads to higher overall operating costs at higher SRT's. This confirms the hypothesis that the increase in electrical energy consumption cost will outweigh the savings in operational costs of sludge handling, and therefore it is more economical to operate AS reactors at lower SRTs.

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List of Symbols

Symbol	Description
a_{opt}	Optimum a-recycle ratio
a_{prac}	Practical a-recycle ratio
$^{\circ}C$	Temperature (degrees celcius)
S_{bsfi}	Biodegradable soluble organics
S_{ti}	COD concentration in inflow
X_t	MLSS concentration in the mixed liquor
$f_{s,up}$	Fraction of total COD which is unbiodegradable particulate
$f_{s,us}$	Fraction of total COD which is unbiodegradable soluble
f_{x1}	Anoxic mass fraction
f_{xm}	Unaerated sludge mass fraction
Y_H	Biomass Yield of OHO's
R_s	Sludge age
b_{HT}	Endogenous respiration rate OHO's
f_H	Fraction of endogenous residue in OHO's
f_n	Fraction of nitrogen in VSS
f_p	Fraction of phosphorus in VSS
f_{iOHO}	VSS/TSS ratio of activated sludge
$f_{s,up}$	Fraction of unbiodegradable particulate COD within the total COD
$f_{s,us}$	Fraction of unbiodegradable soluble COD within the total COD
FO_c	Carbonaceous oxygen flux
FO_d	Nitrification Oxygen flux
FO_n	Denitrification oxygen
FO_t	Total oxygen flux
FX_t	Mass flux of sludge
FX_v	Mass flux of volatile solids in sludge
f_{cv}	COD/VSS ratio of sludge
X_{Ioi}	Concentration of unbiodegradable particulate organics in inflow
β	Pollutant weighing factors
μ_{AM20}	Specific growth rate
pH	Measure of how acidic/basic water is

Symbol	Description
$T_{\min}$	Minimum temperature
e^-	Electrons
a	Average volume $\text{Fe}(\text{NH}_4)_2(\text{SO}_4)_2$ used to titrate blank (ml)
b	Average volume $\text{Fe}(\text{NH}_4)_2(\text{SO}_4)_2$ used to titrate sample (ml)
N	Normality of $\text{Fe}(\text{NH}_4)_2(\text{SO}_4)_2$

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1 Introduction

1.1 Background

The constitution states that all people living in South Africa have the right of access to at least basic water and sanitation services. As of 2018, around 80% of households in South Africa have access to sanitation services. However, delivery of these services is unevenly spread, where in some municipalities only 50% of residents have access to adequate sanitation facilities (Department Water and Sanitation, 2018).

The 2021 Green Drop Audit found that 39% of Wastewater Treatment Plants (WWTP) were identified to be in a critical score level. This compared to the 29% from the 2013 Green Drop Audit indicates that there has been a regress in the state of wastewater systems in South Africa. In many cases, poor performance of these plants could be attributed to a lack of skilled and experienced technical staff to operate the treatment facilities to its full potential. (Department of Water and Sanitation, 2022)

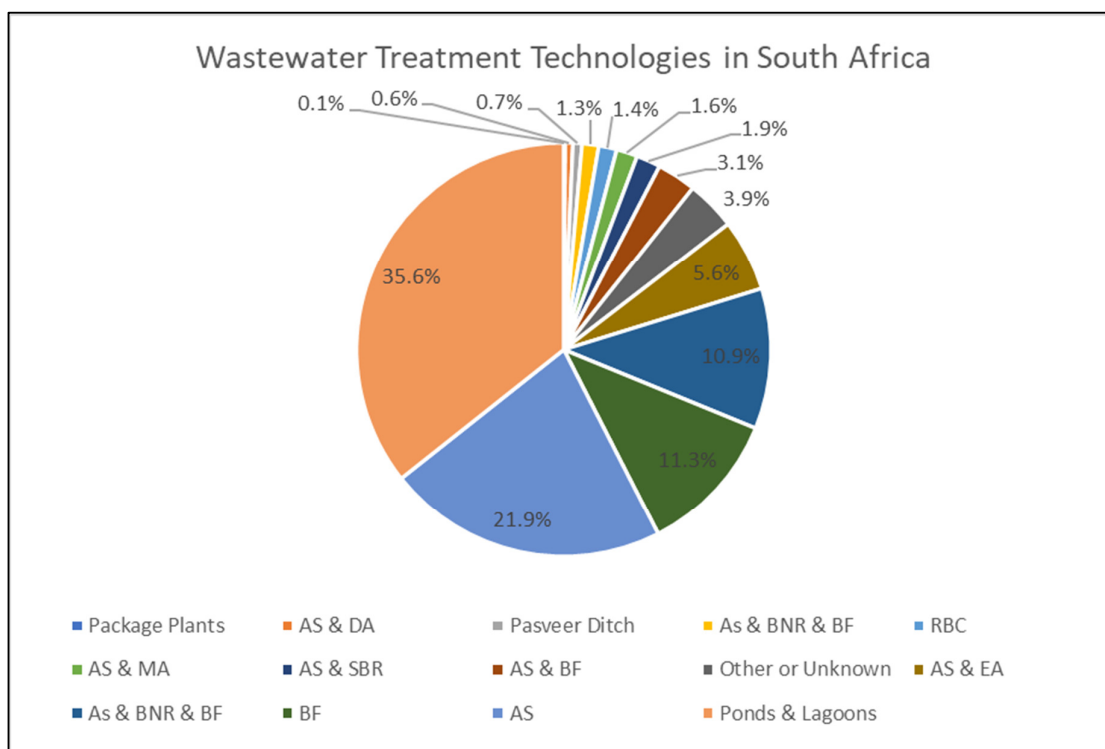


Figure 1-1: Distribution of Wastewater Treatment Technologies used in South Africa (Department of Water and Sanitation, 2022)

South Africa currently has 850 municipal WWTPs. Of these 850 plants, 46.9% make use of Activated sludge technologies, or variations thereof, to treat wastewater (Department of Water and Sanitation, 2022). Activated sludge technologies are energy intensive because of the need to

introduce oxygen (aeration) into the system. Global studies have found that aeration accounts for the highest consumption of energy in wastewater treatment, with upwards of 60% of the energy used on treatment plants attributed to aeration (Musvoto & Ikumi, 2016). Furthermore, indicators are that, on average, water and wastewater accounts for roughly 17% of energy consumption within a typical South African metro. When the use of liquid fuel is excluded and electricity consumption alone is considered, the portion is much higher. The water and wastewater sectors can often represent as much as 25% of an entire municipality's electricity consumption (SEA, 2017). This is illustrated in Figure 1-2.

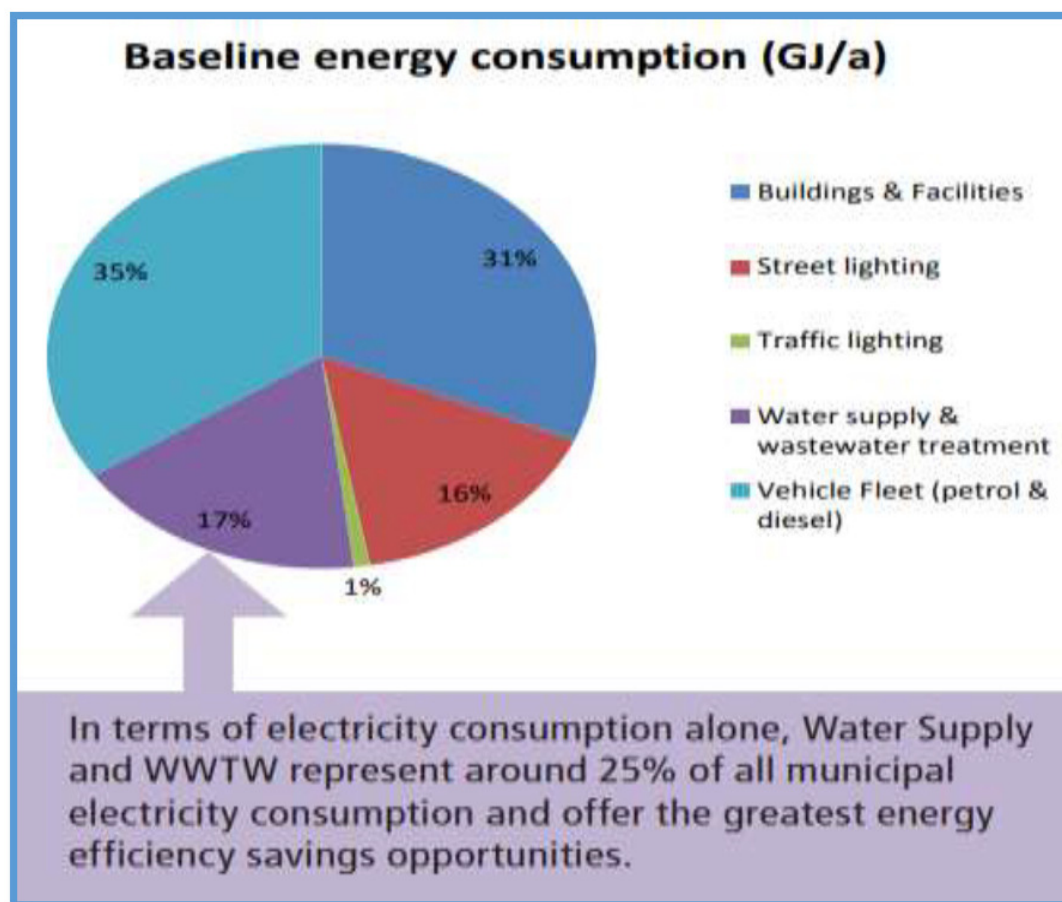


Figure 1-2: Baseline energy consumption per sector of an average South African Metro (SACN, 2014)

Sludge handling and sludge treatment is another critical component of a WWTP. Any limitations in sludge treatment capacity or operations will impact negatively on the overall wastewater treatment capability, as sludge and liquid treatment are interdependent. The 2021 Green Drop Audit found that 36.7% of WWTPs in South Africa had no sludge handling facilities or had insufficient information regarding sludge handling facilities. It was also noted that 8.9% of the treatment plants made use of mechanical dewatering of sludge. With population growth

and increased flow demand, the relatively small footprint required by mechanical dewatering has led to an increased use of the technology over the past few years, with this increase expected to continue. However, mechanical dewatering comes at a much higher operational cost, when compared to other sludge handling technologies (Department of Water and Sanitation, 2022).

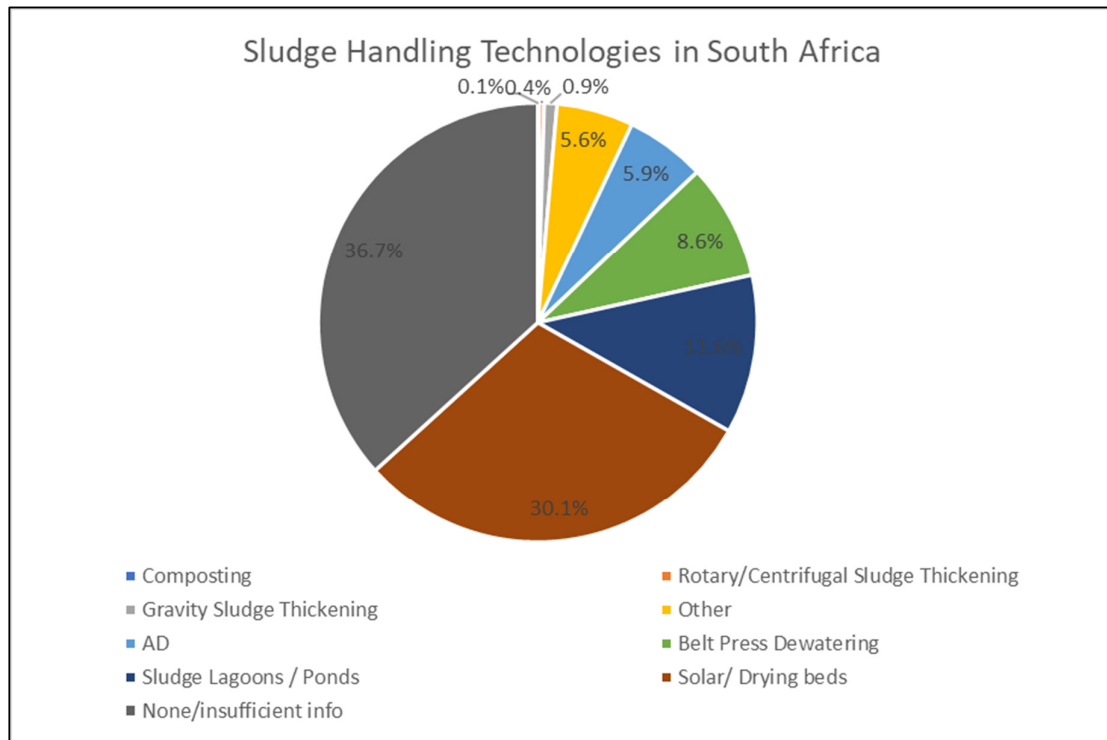


Figure 1-3: Distribution of sludge Handling Technologies used in South Africa (Department of Water and Sanitation, 2022)

With the findings from the 2021 Green Drop Audit, as well as the current economic and energy climate, it is becoming more apparent that the demands for efficient and cost-effective water and sanitation services is increasing. The demand for municipalities to investigate and develop ways of ensuring continuous effective management of water and sanitation facilities are ever increasing.

The aim of this study is to utilise mass balanced steady state models to virtually replicate a full scale WWTP and to determine the correlation between electrical energy consumption cost and the operational cost of sludge handling. Towards this effort, the Mitchells plan WWTP was selected as the case study.

1.2 Problem Statement

Many wastewater treatment plants (WWTPs) in South Africa, which use activated sludge (AS) processes, experience difficulty managing solid retention times (SRT). The poor capacity to manage sludge volumes generated from the AS treatment process could be due to a variety of factors, such as insufficient or faulty sludge handling facilities, insufficient means of sludge disposal, high cost of flocculant agents, lack of operational skills, etc. To avoid dealing with large quantities of sludge, many WWTP operate the AS reactors at extended SRTs, far beyond what is required for sufficient nutrient removal or to produce a stable waste activated sludge.

At higher SRTs, waste flow rates are lower, which leads to a lower demand on a WWTPs sludge handling facilities and lower pumping rates. In return, a higher SRT will lead to a higher oxygen utilization rate (OUR) in the AS reactor. This will lead to higher electricity consumption by the aeration equipment or possible poor effluent quality, where (i) the aeration equipment is limited in potential to supply oxygen required to meet the increased demands for organic removal and nitrification and (ii) the thickened sludge production resulting in poor oxygen transfer within the reactor and sludge overflow from secondary settling tanks that have reached their limits in the surface area required for the given solids thickness (Henze *et al.*, 2008).

1.3 Research Questions and Hypotheses

With Mitchells Plain WWTP selected as the case study for this research investigation, the following is the list of research questions:

1. What is the correlation between electrical energy consumption cost and the SRT in AS reactors.
2. What is the correlation between the operational cost of sludge handling and SRT in AS reactors.
3. What is the correlation between electrical energy consumption cost and the operational cost of sludge handling based on the SRT in AS reactors.

It is hypothesized that a higher SRT in AS reactors will lead to higher electrical energy consumption costs, but to lower operational costs of sludge handling. However, the increase in electrical energy consumption cost will outweigh the savings in operational costs of sludge handling, and therefore it is more economical to operate AS reactors at lower SRTs.

1.4 Study Aims

The overarching aim of this study is to find the correlation between electrical energy consumption cost and the operational cost of sludge handling. This will be done by developing a mass balanced steady state model to replicate the individual process units at Mitchells Plain WWTP, including the AS reactors and sludge handling facilities.

The aims mentioned above will be attained by achieving the following research objectives:

1. Carrying out a literature review of previous work carried out on electrical energy consumption and sludge handling at WWTP's.
2. Reviewing the current infrastructure at Mitchells Plain WWTP and the models that could be used to virtually replicate the treatment processes of the plant.
3. Developing the mass balanced steady state model by integrating various unit process steady state model equations in a way that is tailored to suit the configuration of MPWWTP.
4. Using the model from (3) towards performance of a scenario analysis, to determine the correlation between solids retention times, electrical energy consumption and waste sludge production.

1.5 Scope and Limitations

The steady state model will only be applicable to the City of Cape Town's Mitchells Plain WWTP and will not be applicable for any other wastewater treatment facilities. Furthermore, the assumption was made that all underground infrastructure (pipeline, sumps, etc) is capable of conveying the hydraulic load as determined by the model. The data used to simulate the model will be based on (Wentzel, Ekama & Loewenthal, 2003, Ikumi *et al.*, 2015, Ubisi *et al.*, 1997) data on MPWWTP, which provides a comprehensive characteristic of the influent, including the waste component compositions, required as input to the model. The model will be based on Steady state process equations of (Ekama & Wentzel, 2008a; Ekama *et al.*, 2019, Ekama 2021) and will be MS Excel coded. Due to the explicit nature of the steady state model equations, the significant parameters that influence important system performance variables are identifiable intuitively.

2 Literature Review

The model for Mitchells Plain WWTP is based on previous models and will be a combination of these models to set up a plant wide model. This chapter will provide a review of the biological, physical and chemical processes used in the wastewater treatment system unit operations and the previous work done to create the steady-state models that could replicate these processes towards the prediction of system performance.

2.1 Wastewater Treatment Unit Operations and associated Processes

2.1.1 Preliminary Treatment

Preliminary treatment is a critical process in the wastewater treatment system, and it generally comprises of screening and grit removal. In addition to organic solids, a variety of other materials such as rags, plastics, sand, metal particles etc. are transported through sewer systems with wastewater. Although these materials constitute a small portion of the total wastewater flow, they can significantly interfere with the treatment process and damage process equipment (Van Niekerk, 2022).

2.1.2 Primary Treatment

Conventional wastewater treatment systems usually have two types of settling or sedimentation tanks. The first is primary settling tanks (PST) which is part of the primary treatment step, while the second is secondary settling tanks (SST) which form part of the secondary treatment step.

Primary treatment is typically the first step in the wastewater treatment process after the removal of coarse solids and grit by the preliminary treatment process. The main objective of primary treatment is to remove easily settleable solids and floating material found in wastewater, by means of sedimentation, and thus reduce the suspended solids content in the wastewater (Metcalf & Eddy and Aecom, 2014).

Almost all treatment plants that have primary treatment make use of mechanically scraped circular or rectangular PSTs. The selection of type and size will be dependent on design requirements and site specifications. Well designed and efficiently operated PSTs can remove from 50 – 70% of the suspended solids from the influent wastewater. Sludge settles to the bottom of the tank from where it is extracted. Primary treated wastewater is discharged from the PST usually by means of an overflow weir and is conveyed to the next process step. Figure 2-1 illustrates a schematic of a typical circular PST.

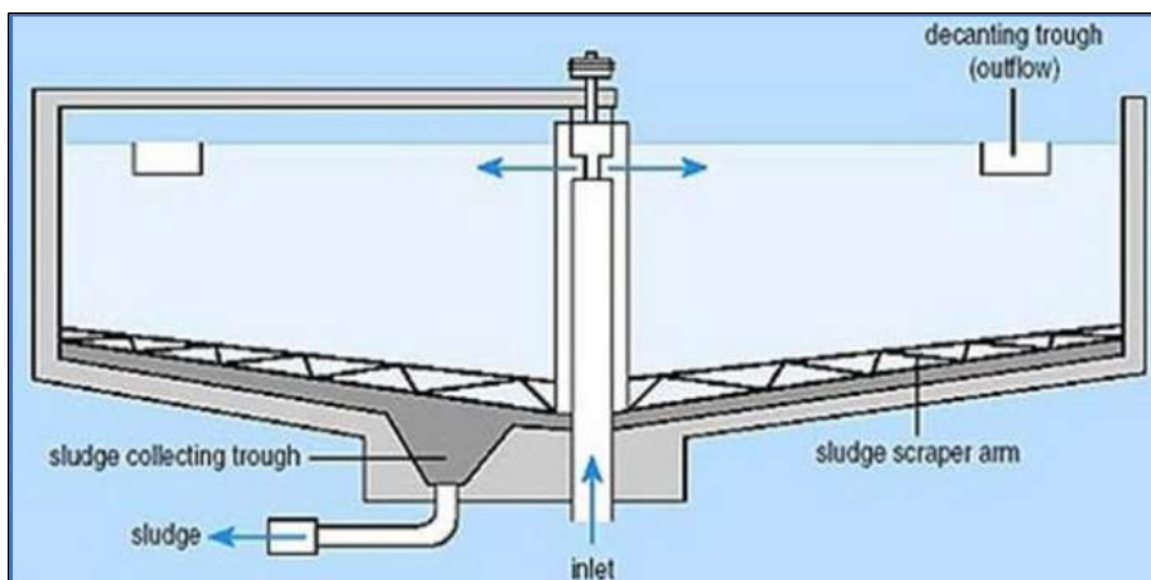


Figure 2-1: Schematic of a Typical Circular PST (extract from Van Niekerk, 2022)

2.1.3 Activated Sludge Reactor

2.1.3.1 Biological Nutrient Removal: Modified Ludzack-Ettinger (MLE)

The MLE system is a nitrification-denitrification system that utilizes a primary anoxic reactor as well as a secondary aerobic reactor in order to achieve organic material and nitrogen removal. The original configuration, designed by Ludzack and Ettinger, utilized partially separated anoxic and aerobic zones. The aerobic zone is where oxygen is introduced to be the electron acceptor in order to facilitate activated sludge growth. The anoxic zone is a zone where an absence of oxygen is experienced and where nitrate acts as the electron acceptor to facilitate activated sludge growth. This sludge growth requires substrate from the influent wastewater and by using these constituents it effectively removes them from the effluent leaving the reactor. The raw influent would be discharged into the primary reactor in an anoxic state. The water would pass through the anoxic reactor to the secondary aerobic reactor where nitrification of ammonia takes place. Flow would then pass from the aerobic reactor to the secondary settling tanks (SST), and the SST underflow would be returned to the aerobic reactor. The mixing between the reactors would lead to an exchange between the nitrified and anoxic liquors. The nitrate which then entered the anoxic tank was denitrified to nitrogen gas (Henze, et al., 2008).

The system reported variable results in terms of denitrification (the conversion of nitrate to nitrogen gas). A modification was introduced by completely separating the primary anoxic and secondary aerobic tanks, recycling the flow from the SST's to the primary anoxic tank (s-recycle), and introducing a recycle flow of mixed liquor from the secondary anoxic tank to the primary anoxic tank (a-recycle) (Henze *et al.*, 2008). The system modification led to a significant

improvement in nitrogen removal. This modified configuration is implemented at Mitchells Plain WWTP phase 2. Figure 2-2 shows the configuration of the Modified Ludzack-Ettinger process.

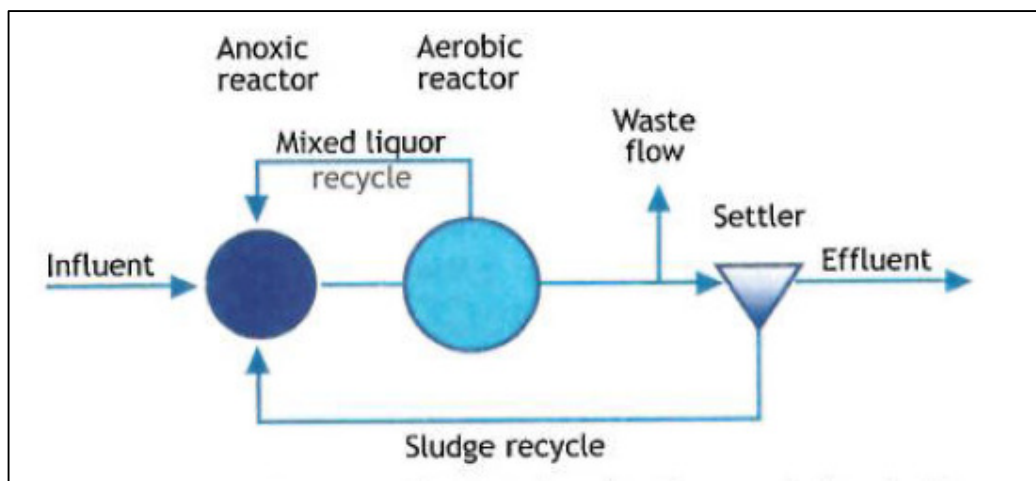


Figure 2-2: MLE system configuration (Henze, et al., 2008)

2.1.3.2 Biological Nutrient Removal: University of Cape Town (UCT)

The Modified UCT system is a nitrification-denitrification excess biological phosphorus removal system (NDEBPR). It makes use of three different zones within the reactor namely an anaerobic zone, anoxic zone and an aerobic zone. Figure 2-3 shows the configuration of the Modified UCT system.

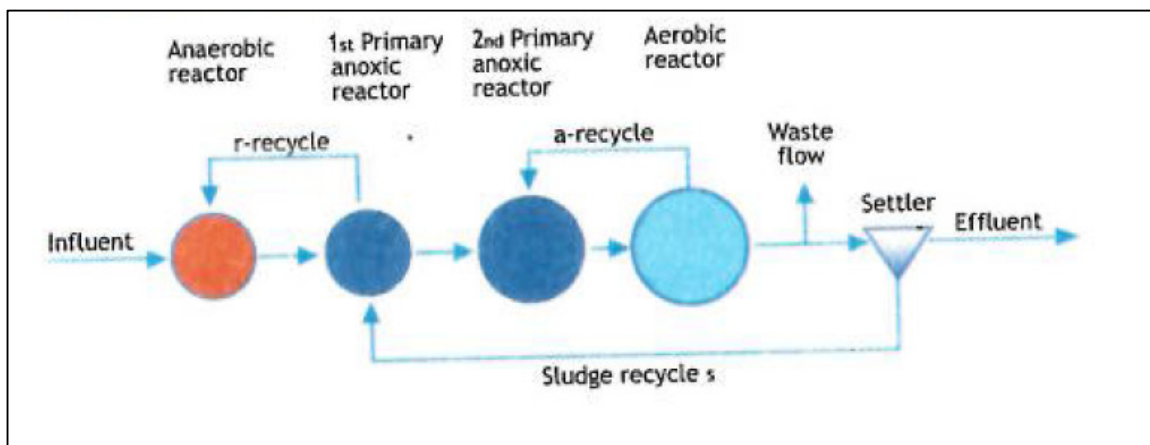


Figure 2-3: Modified UCT System configuration (Henze, et al., 2008)

The typical phosphorus requirement for biomass growth is somewhere in the region of 0.025 mgP/mgVSS ordinary heterotrophic organisms (OHO's) present in 'normal' aerobic activated sludge systems. This means that roughly between 15-25% of the influent phosphorus in

municipal wastewater would be removed by means of sludge wasting from the biological reactor, with the rest of the influent phosphorus passing through with the effluent (Ekama, et al., 1984). As time has passed, effluent quality requirements of WWTP's was increased and the need for excess (more than normal) phosphorus removal was required. The 15-25% P-removal (without any chemical addition) of normal aerobic activated sludge plants was no longer sufficient and Excess Biological Phosphorus Removal (EBPR) systems were developed. The Modified UCT system is such a system that allows for organic matter removal by means of aeration, nitrogen removal by means of nitrification and denitrification as well as phosphorus removal by means of the addition of an anaerobic zone. Organic matter and nitrogen removal is achieved by following the same principles as for the MLE system.

EBPR systems creates an environment that stimulates the growth of organisms with the ability to take up large amounts of phosphorus called phosphorus accumulating organisms (PAO's) in addition to the growth of OHS's. Therefore, these EBPR systems creates an environment where PAO's and OHO's coexists. The PAO's can accommodate a P uptake of up to 0.38 mgP/mgVSS. The higher the percentage PAO's in the system the greater the amount of P-removal (Ekama, *et al.*, 1984; Henze, *et al.*, 2008).

In the anaerobic reactor, PAO's take up volatile fatty acids (VFA's) from the influent as well as the VFA's created from the fermentation of the readily biodegradable substrate. Under anaerobic conditions the OHO's are unable to utilize the VFA's because there are no external electron acceptors (oxygen or nitrate). The PAO's take up VFA's by linking them to form long chain carbon chains called poly- β -hydroxyalkanoates (PHA's). The storage of these PHA's requires the consumption of polyphosphates (polyP) and thus leads to the release of P (Henze, et al., 2008 ; Wentzel *et al.* 1990).

In the presence of an electron acceptor (nitrate in the anoxic zone and oxygen in the aerobic zone) the PAO's use the stored PHA's for energy generation and growth. The PHA's are used as an energy source to take up P from the mixed liquor and regenerate the polyP used in the storage of the PHA's as well as the synthesis of polyP in the new cells that are generated. The P uptake in the new cells that are generated means that more P is taken up in the aerobic and anoxic zones than the amount of P that is released in the anaerobic zone. Optimization of the various recycle flows shown in Figure 2-3 will lead to high percentages of P removal and

2.1.4 Secondary Settling Tanks (SST) – Flux Theory

The flux theory is a widely accepted SST design procedure in South Africa and will be used in this model. The flux theory principle states solids transport through a unit area per unit time (flux) entering an SST is equal to that exiting an SST. The theory and design of SST's are based on three main factors namely, the zone settling velocity of the sludge in the SST, the concentration of sludge the sludge in the SST and the accumulation of sludge in the SST.

Zone settling refers to the observation that particles, irrespective of their size, settle at the same velocity throughout a certain depth (called a zone depth). Depending on the depth there

will be various zones where particles will settle at different velocities, but in each zone all particles settle at the same velocity. The rate of settlement is inversely related to the sludge concentration.

The relationship between zone settling velocity and sludge concentration was determined as the exponential equation given below, and has been validated by various researchers including (Rachwal, et al., 1982 and White, 1976).

$$V_{zs} = V_0 \exp(-nX)$$

Where;

V_{zs} is the zone settling velocity

V_0 is a flux theory settling constant determined from multiple batch stirred settling tests over a range of concentrations

n is a flux theory settling constant determined from multiple batch stirred settling tests over a range of concentrations

X is the sludge concentration

The constants V_0 and n , that represent the settling characteristics of the sludge, are determined by linear least squares regression of natural logarithm $\ln V_{zs}$ versus X over a range of concentrations from 1 to 12 g/l.

2.1.5 Anaerobic Digestion (AD)

The model for the capacity evaluation of the anaerobic digesters at Mitchells Plain WWTP will be based on the work done by (Sötemann, et al., 2005) created a steady-state model for anaerobic digestion that is comprised of three sequential parts, namely a kinetic part, a stoichiometry part and a carbonate system weak acid/base chemistry part.

At equilibrium anaerobic digestion is mediated by a consortium of four organism groups (Batstone, *et al.*, 2002; Massé & Droste, 2000):

1. Acidogens
2. Acetogens
3. Acetoclastic methanogens
4. Hydrogenotrophic methanogens

Acidogens convert complex organics to short chain fatty acids (SCFA) - acetic and propionic (HAc, HPr), carbon dioxide (CO₂) and hydrogen (H₂). Acetogens convert HPr to HAc and H₂. Acetoclastic methanogens convert HAc to CO₂ and methane (CH₄) and hydrogenotrophic methanogens convert H₂ and CO₂ to CH₄ and water (Sötemann, et al., 2005).

The pH level in the digester is very important. The methanogens are neutrophiles which means they are very sensitive to pH and need a pH between 7 and 8 to produce methane. In order

to keep the pH at this level, the acetogens and acetolastic methanogens need to utilize or convert the SCFAs (HAc & HPr) as soon as they are produced.

The process where acidogens convert complex organics to SCFAs is called hydrolysis, and this is the slowest process which occurs in anaerobic digestion. The kinetics of this process is therefore the only one that requires consideration when modeling for a steady-state (Vavilin, et al., 2001). The processes that follow hydrolysis occur at a higher rate and can therefore be assumed to reach completion. This assumption implies that the products of the processes that follow hydrolysis do not build up in an AD system and the concentrations of these products will be low enough to be negligible. Therefore, it can be assumed that the products of hydrolysis are the digester end products once they have been dealt with stoichiometrically (Söttemann, et al., 2005). Thus the steady-state anaerobic model developed by (Söttemann, et al., 2005) considers three aspects:

1. The kinetics of the hydrolysis process
2. The stoichiometric conversion of the hydrolysis products to digester end products
3. The effect of the end products on the digester pH

2.1.5.1 Kinetics of Hydrolysis

In order to determine a kinetic expression to express the hydrolysis rate (Söttemann, et al., 2005) considered four different equations that have all been used to model various biological processes for a number of years:

1. 1st order
2. Specific 1st order
3. Monod kinetics
4. Saturation

All four equations delivered sufficiently accurate results, but (Söttemann, et al., 2005) decided to use the Monod kinetics (3) equation to express the rate of hydrolysis.

The four system variables are:

1. Residual biodegradable organics concentration (S_{bp})
2. Acidogen biomass concentration (Z_{AD})
3. Unbiodegradable organics concentration (S_{up})
4. Methane concentration (S_m)

By applying a mass balance over the system for the above-mentioned parameters, a steady state model can be derived based on the hydrolysis rate equation that was chosen. The equations that were derived by (Söttemann, et al., 2005) are given in Table 2-1.

Table 2-1: Steady State Anaerobic digester kinetic equations

Variable	Equation
Hydrolysis rate (r_h)	$r_h = \frac{K_m S_{bp}}{(K_s + S_{bp})} Z_{AD}$
Residual biodegradable organics concentration (S_{bp})	$S_{bp} = \frac{K_s (1/R + b_{AD})}{Y_{AD} K_m - (1/R + b_{AD})}$
Acidogen biomass concentration (Z_{AD})	$Z_{AD} = \frac{Y_{AD} (S_{bpi} - S_{bp})}{[1 + b_{AD} R (1 - Y_{AD})]}$
Unbiodegradable organics concentration (S_{up})	$S_{up} = S_{upi}$
Methane concentration (S_m)	$S_m = (1 - Y_{AD}) R r_h$

Where:

K_m = max specific hydrolysis rate (constant calculated by means of empirical methods)

K_s = Half saturation concentration (constant calculated by means of empirical methods)

R = Hydraulic retention time

Y_{AD} = Acidogen yield coefficient

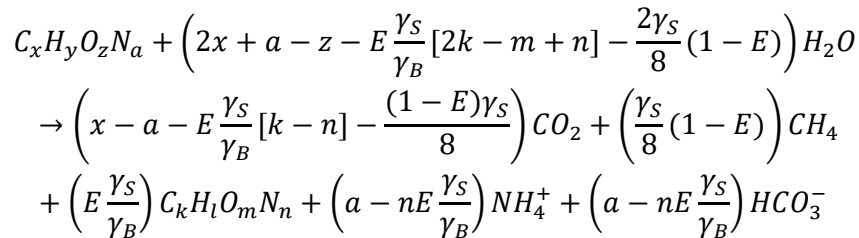
b_{AD} = Acidogen respiration rate

As for all models, a mass balance is important as it gives an indication of whether your calculations were done in accordance with the model. A COD mass balance over the system yields the equation:

$$S_{ti} = S_{te} + S_m = S_{bp} + Z_{AD} + S_{up} + S_m$$

2.1.5.2 Stoichiometry

The hydrolysis kinetics part of the (Sötemann, et al., 2005) model gives the concentration of biodegradable COD utilized and converted to AD products. The stoichiometric part of the model is used to determine the concentrations of these products generated. The stoichiometric equations are derived by considering the electron donors and electron acceptors of the anaerobic digestion processes. A general reaction for the AD process is given as follows:



Where;

$C_xH_yO_zN_a$ denotes the composition of the biodegradable particulate organics (BPO) where x, y, z and a are calculated from the characterization of the sludge entering the AD.

$C_kH_lO_mN_n$ denotes the general composition of biomass and $k = 5$, $l = 7$, $m = 2$ and $n = 1$.

E denotes the fraction of BPO COD removed that is converted to sludge mass

$(1-E)$ denotes the fraction of BPO COD removed and converted to methane gas

$$\gamma_s = 4x + y - 2z - 3a$$

$$\gamma_b = 4k + l - 2m - 3n$$

With the equation for the AD processes the mol/l of each product can be determined and with molar mass known the concentration can be calculated.

2.1.5.3 Weak acid/base chemistry

As previously mentioned, the pH of the AD is important as it will only operate efficiently within a certain range of pH level. The pH is governed by the inorganic carbon system. In other words, the pH of the digester is defined by the partial pressure of CO_2 (p_{CO_2}) and the bicarbonate (HCO_3^-) concentration generated. The total bicarbonate generated is equal to the total alkalinity generated and can be calculated from the stoichiometric equations. The partial pressure of CO_2 by the gaseous CO_2 and CH_4 produced (both of which can be determined from the stoichiometric equations). The values calculated for p_{CO_2} and the alkalinity is plotted on an acidity-alkalinity graph which then gives a value for the pH of the AD.

2.1.6 Sludge Thickening

2.1.6.1 Dissolved-Air Flotation (DAF)

Dissolved-air flotation (DAF) units can be used for clarification (solid-liquid separation) of activated sludge as well as sludge thickening. (Bratby & Marais, 1976) presents design criteria for DAF units for both applications. Figure 2-4 shows a schematic representation of a DAF unit.

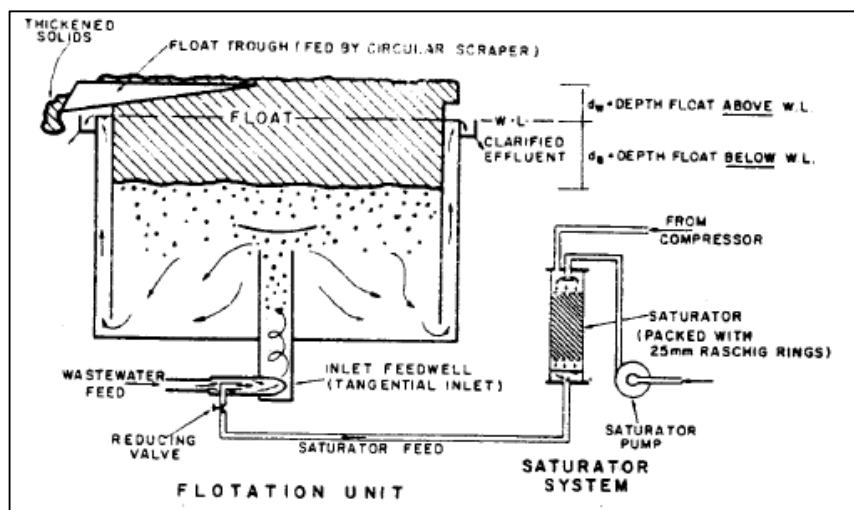


Figure 2-4: Typical DAF unit (Bratby & Marais, 1976)

Simply stated, a DAF unit consists of a basin, called a flotation unit, and a saturator system. The saturator system introduces dissolved air into the flotation unit, where solid-liquid separation occurs. What the schematic in Figure 2-4 describes is pressure saturated water sent to the flotation unit via the saturator through a pressure reducing valve (PRV). Pressure on the downstream side of the PRV is very close to atmospheric. This leads to the water becoming supersaturated with air at this point and forms very small bubbles. This is where the wastewater stream is also introduced into the flotation unit. The small bubbles attach to the wastewater particles which leads to the particle's density becoming lower than that of water. Because of this density difference the wastewater sludge 'floats' to the top of the unit where it is continuously removed (Bratby & Marais, 1976).

In the design of a DAF unit for clarification, the most important factor is the down flow rate. The down flow rate is taken as equivalent to the bubble-particle agglomerate rising rate. The design is based on bubble-particle agglomerate that rises at the slowest rate and is called the limiting down flow rate. The down flow rate is dependent on the mass of air that is absorbed onto solids particles which is expressed as an air/mass ratio. The ratio is equal to mass of air introduced by the saturator feed over the mass of solids introduced by the wastewater stream. The area requirement for clarification is given by the total flow (wastewater and saturator feed) over the limiting down flow rate.

The design of a DAF unit for thickening is based on two main factors namely, solids loading rate and depth of float above the water level. Float refers to the bubble-particle agglomerates that will form a sludge blanket at the top of the flotation unit. The solids loading rate is equal to the mass of solids introduced per unit area of the DAF per time ($\text{kg m}^{-2} \text{d}^{-1}$). For the design a required thickened sludge concentration is known a particular combination of solids loading rate and float depth will be selected based on cost effectivity. Once a solids-loading rate and float depth has been selected, the required area for the DAF can be calculated by taking the mass of solids introduced into the DAF per day over selected solids loading rate.

2.1.6.2 Gravity Sludge Thickener

Gravity thickeners are usually tanks that are equipped with a slowly rotating rake mechanism. The rake moves the sludge to a central hopper. The central hopper improves settling and compaction by disrupting inter-particle bridging. Due to the thickened nature of the sludge, the rake mechanism has to be stronger and have a higher torque than those required for primary- or secondary settling tanks.

Thickened sludge is withdrawn from the underflow of a gravity thickener as opposed to by drawn from the top of the tank as is the case with a DAF. A specified thickened underflow concentration is selected. This selection is based on the capacity of the downstream unit, usually aerobic or anaerobic digesters. The required area for a gravity thickener is calculated by taking the mass of solids per day received by the upstream process unit (usually a primary settling tanks of waste flow from the activated sludge reactor) and dividing that by a selected solids loading rate. The solids loading rate will be based on the desired thickened sludge concentration and by the concentration of the feed sludge. Recommended solids loading rates ranges will be higher for primary sludge and lower for waste activated sludge.

2.1.7 Mechanical Sludge Dewatering

2.1.7.1 Filter Belt Press

A typical filter belt press comprises of two endless sieve belts woven from artificial fibres of stainless steel. The belts pass around a system of rollers at a constant speed. The belts perform the conveying, dewatering and pressing functions. Two belts travel together through the high pressures and sheer roller section of the machine, and then separate to return to their respective feed points at the top of the machine (see Figure 2-5).

Thickened sludge is mixed with flocculant and fed onto the surface of the filter belt. A large portion of the free water drains from the sludge by means of gravity in this first “gravity dewatering zone”. The sludge is then conveyed between the two belts and passes between or around a set of shear rollers where the sludge is subjected to high pressures and shear forces. More water is squeezed out during this process. The final dewatered sludge cake is then typically scraped of the belts and transported elsewhere to allow the belts to undergo a cleaning procedure before the cycle is repeated (WISA; WRC; ERWAT, 2007).

Typical results indicate that filter belt presses can dewater sludge to achieve a dry cake of 18% dry solids concentration, depending on the concentration of feed sludge and the application of the correct flocculant make-up. Solids capture rates for filter belt presses are typically around 96% (WISA; WRC; ERWAT, 2007).

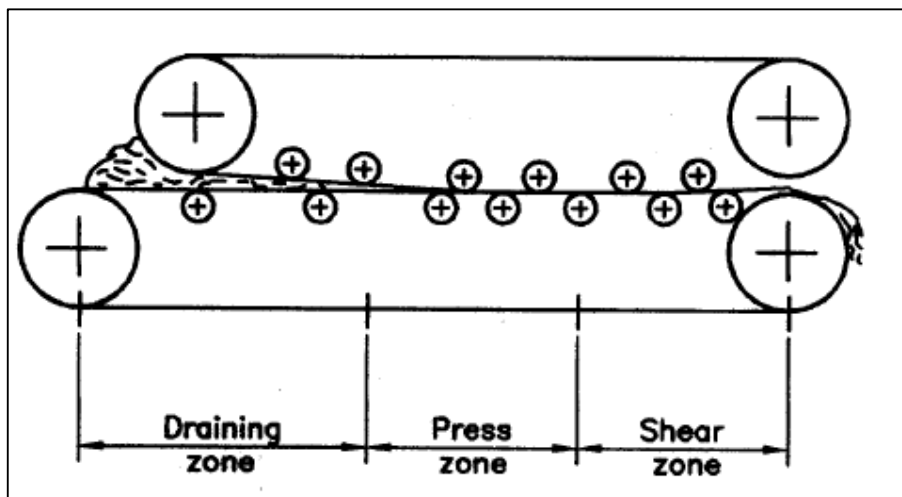


Figure 2-5: Schematic of a typical filter belt press (WISA; WRC; ERWAT, 2007)

2.2 Process Modelling

2.2.1 Dynamic and Steady State Modelling

Process modelling of wastewater treatment system can be divided into two groups, namely dynamic and steady state (SS) modelling. Dynamic models have been used for many years in the wastewater treatment industry and various activated sludge models have been developed to simulate carbon and nutrient removal (Gernaey, et al., 2004). Dynamic models are beneficial to evaluate complex transient conditions experienced at wastewater works but generally run on sophisticated software packages involving complex mathematical solvers which can make them impractical as a simplified design tool for decision making.

The steady state and dynamic activated sludge and anaerobic digestion models are based on the same basic principles, mass balanced stoichiometry, just in simplified form for the steady state model, without significant loss of accuracy. Hence, based on the same biological processes used by dynamic models, various explicit steady state equations have been developed (Ekama, 2011b) which allow for the creation of steady state models. The developed steady-state models are simpler than the more sophisticated dynamic models and are mainly based on the stoichiometry and rate-limiting kinetics of the system processes. They have been implemented for various activated sludge configurations and also sludge treatment processes of anaerobic and aerobic digestion, using spreadsheet platforms (Wu, 2015). These steady state models have been found useful for (i) simple and easy estimation of system design and operational parameters such as reactor volume, sludge age, recycle ratios, and oxygen utilisation for a specific design standard, (ii) investigating how sensitive the performance of the system is to the operational and design parameters, (iii) estimating the upstream products which are used as inputs for

downstream processes, and (iv) providing a reference for cross-checking validated dynamic simulation models (Ikumi, 2022).

2.2.2 Models to replicate the Activated Sludge Processes

Table 2-2: AS and AD stoichiometry (Fotso Simo, 2020)

Equation	Equation Number	Reference
Organic Removal Stoichiometry		
$FS_{ti} = Q_i S_{ti}$	(1)	(Ekama & Wentzel, 2008a)
$FS_{bi} = FS_{ti}(1 - f_{srus} - f_{srup})$	(2)	
$FX_{li} = \frac{FS_{ti}f_{srup}}{f_{cv}}$	(3)	
$FX_{loi} = Q_i X_{loi}$	(4)	
$MX_{BH} = FS_{bi} \frac{Y_H R_s}{(1 + b_H R_s)}$	(5)	
$MX_{EH} = f_H b_H MX_{BH} R_s$	(6)	
$MX_I = R_s \frac{FX_{li}}{f_{cv}}$	(7)	
$MX_V = MX_{BH} + MX_{EH} + MX_I$	(8)	
$MX_{IO} = FX_{loi} R_s + f_{iOHO} MX_{BH}$	(9)	
$MX_t = MX_V + MX_{IO}$	(10)	
$FO_c = FS_{bi}[(1 - f_{cv} Y_H) + (1 - f_H) b_H \frac{Y_H f_{cv} R_s}{(1 + b_H R_s)}]$	(11)	
$FX_t = \frac{MX_t}{R_s}$	(12)	
$S_{te} = S_{use} + f_{cv} X_v$	(13)	
Nitrogen Removal Stoichiometry		
$N_a = N_{ae} = \frac{K_{nT}(b_{AT} + \frac{1}{R_s})}{\mu_{AmT} - (b_{AT} + \frac{1}{R_s})}$	(14)	(Ekama & Wentzel, 2008b)
$N_{ae} = \frac{K_{nT}(b_{AT} + \frac{1}{R_s})}{\mu_{AmT}(1 - f_{xt}) - (b_{AT} + \frac{1}{R_s})}$	(15)	
$N_{ae} = \frac{K_{nT}}{(S_f - 1)}$	(16)	
$N_{ae} = N_{ai} + N_{obsi} + N_{obpi} - (N_s - N_{oupi})$	(17)	

$N_{te} = N_{ouse} + N_{ae}$	(18)	
$N_s = f_n \frac{MX_v}{Q_i R_s}$	(19)	
$N_{te} = N_{ti} - N_s$	(20)	
$N_{ne} = N_c = N_{ti} - N_{te} - N_s$	(21)	
$D_{p1RBCOD} = \frac{f_{sb's} S_{bi} (1 - f_{cv} Y_H)}{2.86}$	(22)	
$D_{p1SBCOD} = \frac{K_2 f_{x1} S_{bi} Y_H R_s}{(1 + b_h R_s)}$	(23)	
$D_{p1} = D_{p1RBCOD} + D_{p1SBCOD}$	(24)	
$D_{p3SBCOD} = \frac{K_3 f_{x3} S_{bi} Y_H R_s}{(1 + b_h R_s)}$	(25)	
$D_{p3} = 0 + D_{p3SBCOD}$	(26)	
$FO_n = 4.57 N_c Q_i$	(27)	
$FO_d = 2.86 (N_c - N_{ne}) Q_i$	(28)	
$FO_t = FO_c + FO_n - FO_d$	(29)	
Phosphorus Removal Stoichiometry		
$MX_{PAO} = \frac{Y_{PAO}}{(1 + b_{PAO,T} R_s)} FS_{bs,PAO} R_s$	(30)	(Henze, et al., 2008)
$MX_{E,PAO} = f_{XE,PAO} * b_{PAO,T} * MX_{PAO} * R_s$	(31)	
$MX_{OHO} = \frac{Y_{OHO}}{(1 + b_{OHO,T} R_s)} FS_{b,OHO} R_s$	(32)	
$MX_{E,OHO} = f_{XE,OHO} * b_{OHO,T} * MX_{OHO} * R_s$	(33)	
$MX_I = \frac{f_{XI,COD,i} FS_{ti} R_s}{f_{cv}}$	(34)	
$S_{bsf,i,conv} = S_{bsf,i} - 8.6(sS_{NO3,s} + S_{NO3,i}) - 3.0(sS_{O2,s} + S_{O2,i})$	(35)	
$S_{bsf,Ann} = \frac{\frac{S_{bsf,i,conv}}{(1 + s)}}{[1 + k_{F,T} \frac{MX_{OHO}}{Q_i(1 + s)} \frac{f_{AN}}{N}]^n}$	(36)	
$FS_{bs,PAO} = Q_i[S_{bsf,i,conv} - (1 + s)S_{bsf,Ann}] + Q_i S_{bsai}$	(37)	
$\Delta P_{PAO} = f_{P,PAO} \frac{MX_{PAO}}{R_s} \frac{1}{Q_i}$	(38)	
$\Delta P_{OHO} = f_{P,OHO} \frac{MX_{OHO}}{R_s} \frac{1}{Q_i}$	(39)	
$\Delta P_{XE} = f_{P,XE} \frac{(MX_{E,PAO} + MX_{E,OHO})}{R_s} \frac{1}{Q_i}$	(40)	
$\Delta P_{XI} = f_{P,XI} \frac{MX_{I,i}}{R_s} \frac{1}{Q_i}$	(41)	

$\Delta P_{SYS,POT} = \Delta P_{PAO} + \Delta P_{OHO} + \Delta P_{XE} + \Delta P_{XI}$	(42)	
$\Delta P_{SYS,ACT} = \min(\Delta P_{SYS,POT}; T_{P,i})$	(43)	
$MX_{VSS} = MX_{PAO} + MX_{OHO} + MX_{E,PAO} + MX_{E,OHO} + MX_I$	(44)	
$MX_{FSS} = f_{FSS,OHO}MX_{OHO} + f_{FSS,PAO}MX_{PAO} + FX_{ISS,i}R_s$	(45)	
$MX_{TSS} = MX_{VSS} + MX_{ISS}$	(46)	
$f_{p,TSS} = \frac{\frac{f_{p,OHO}MX_{OHO}}{f_{VT}}}{MX_{TSS}} + \frac{\frac{f_{p,XE}(MX_{E,OHO} + MX_{E,PAO})}{f_{VT}}}{MX_{TSS}} + \frac{\frac{f_{p,XI}MX_{I,i}}{f_{VT}}}{MX_{TSS}} + \frac{\frac{f_{p,PAO}MX_{PAO}}{f_{VT,PAO}}}{MX_{TSS}} + \frac{\frac{f_{p,FSS,i}MX_{FSS}}{f_{VT}}}{MX_{TSS}}$	(47)	
$X_{P,e} = f_{p,TSS}TSS_e$	(48)	
$T_{P,e} = T_{P,i} - \Delta P_{SYS,ACT} + X_{P,e}$	(49)	
$FO_{2,PAO} = (1 - f_{CV}Y_{PAO})FS_{bs,PAO} + f_{CV}(1 - f_{E,PAO})b_{PAO,T}MX_{PAO}$	(50)	
$FO_{2,OHO} = (1 - f_{CV}Y_{OHO})FS_{b,OHO} + f_{CV}(1 - f_{E,OHO})b_{OHO,T}MX_{OHO}$	(51)	
$FO_C = FO_{2,OHO} + FO_{2,PAO}$	(52)	
Anaerobic Digestion Stoichiometry		(Sötemann, et al., 2005)
$R = \frac{V}{Q}$	(53)	
$S_{bpi} = (1 - f_{PS'up})S_{ti} - S_{bsai}$	(54)	
$S_{upi} = f_{PS'up}S_{ti}$	(55)	
$S_{bp} = \frac{K_s(\frac{1}{R} + b_{AD})}{Y_{AD}K_m - (\frac{1}{R} + b_{AD})}$	(56)	
$S_{bp \text{ hydrolysed}} = S_{bpi} - S_{bp}$	(57)	
$Z_{AD} = \frac{Y_{AD}(S_{bpi} - S_{bp})}{[1 + b_{AD}R(1 - Y_{AD}\{1 - f_{AD}\})]}$	(58)	
$Z_E = f_{AD} * b_{AD} * Z_{AD} * R_s$	(59)	
$r_h = \frac{K_m S_{bp}}{[Z_{AD}(K_s + S_{bp})]}$	(60)	
$S_m = (1 - Y_{AD})Rr_h + S_{bsai}$	(61)	
$Q_m = [(1 - Y_{AD})Rr_h + S_{bsai}] \frac{24}{64}$	(62)	
$S_{te} = S_{up} + Z_{AD} + S_{bp} + Z_E + S_m$	(63)	

$C_xH_yO_zN_a + \left(2x + a - z - \frac{ED_S}{D_B}(n + 2k - m) - \frac{(1-E)D_S}{4} \right) H_2O$ $\rightarrow \left(x - a - \frac{ED_S}{D_B}(n - k) - \frac{(1-E)D_S}{8} \right) CO_2 + \left(\frac{(1-E)D_S}{8} \right) CH_4$ $+ \left(\frac{ED_S}{D_B} \right) C_kH_lO_mN_n + \left(a - \frac{nED_S}{D_B} \right) NH_4^+$ $+ \left(a - n \frac{ED_S}{D_B} \right) HCO_3^-$	(64)	
$CH_3COOH \rightarrow CH_4 + CO_2$ and	(65)	
$CH_3COO^- + H_2O \rightarrow CH_4 + HCO_3^-$	(66)	
$S_{bsHAcI} = \frac{S_{bsai}}{(1 + 10^{pH_i - pK'_a})}$	(67)	
$S_{bsAci} = \frac{S_{bsai}}{(1 + 10^{pK'_a - pH_i})}$	(68)	
$p_{CO_2} = \frac{[HCO_3^-](1 + 10^{pK'_{c1} - pH} + 10^{pH - pK'_{c2}})}{10^{-pK'_{HCO_2}}(1 + 10^{pH - pK'_{c1}} + 10^{2pH - pK'_{c1} - pK'_{c2}})}$	(69)	

Equations 1-13 in Table 2-2 above represent the stoichiometric equations for organic removal in the case where P is not removed. The mathematical equations to obtain various parameters like biomass mass, oxygen utilized, chemical oxygen demand (COD) in the effluent etc. are obtained as shown in those equations.

Equations 14-29 in Table 2-2 above are the stoichiometric equations in case there is nitrogen removal. Parameters like N in the effluent, denitrification potential, oxygen used for nitrification etc. can be determined using such mathematical equations.

Equations 30-52 in Table 2-2 above are the stoichiometric equations if P-removal is present in the AS. The mathematical equations to obtain various parameters like P removed via biomass, P in the effluent, mass of biomass in the AS reactor etc. are obtained using the aforementioned equations.

Equations 53-69 in Table 2-2 above are the stoichiometric equations representing the processes taking place in the AD. Parameters like COD hydrolysed, biomass concentration in the AD reactor, methane production etc. can be obtained using these equations.

2.3 South African Contextualisation

2.3.1 Current State of Wastewater Treatment in South Africa

The water sector in South Africa is governed by the Department of Water and Sanitation (DWS) in terms of the National Water Act (NWA). Since 2008, the Green Drop certification process has

been used as incentive-based regulation as a response to challenges in the South African wastewater sector. The aim of the programme is to promote changes in behaviour of individuals and institutions to facilitate continuous improvement and implementation of best practices in the management of wastewater networks and systems.

The Green Drop audit provides a score for each wastewater system which is aggregated into an overall score for the relevant Water Services Institution (WSI). The audit scorecard evaluates evidence against 5 Key Performance Areas (KPA's):

1. Capacity Management
2. Environmental Management
3. Financial Management
4. Technical Management
5. Effluent Management

A wastewater system that achieves $\geq 90\%$ Green Drop score, is regarded as excellent and is then allocated the prestigious Green Drop status. A system that achieves $< 31\%$ is regarded as a dysfunctional system which would require appropriate interventions and is placed under regulatory focus.

The latest Green Drop Audit was carried out in 2021 and the review period was 1 July 2020 – 30 June 2021. Apart from the audit score, other outputs from the Green Drop audit were:

- A Cumulative Risk Rating (CRR) for each WWTP, expressed as a percentage.
- Technical Site Assessment scores for selected collector and treatment systems inspected, expressed as a percentage.
- A collective “Very Rough Order of Estimates” (VROOM) cost for all treatment systems within each WSI, expressed in Rand.

Compliance with the Green Drop requirements was generally poor. Only 2.6% (22) of municipal wastewater systems scored the minimum of 90% to achieve Green Drop certification. This is down from the 60 systems which achieved certification in 2013. 39% (334) of municipal wastewater systems scored below 31% and were determined to be in critical score level. This compared to the 29% found in 2013 indicates a regress in the state of wastewater systems. When one looks at the provincial level, the Western Cape achieved a provincial average score of 84% which is vastly higher than the national average. Similar provincial scores for Gauteng (68%) and KwaZulu Natal (68%) were achieved. These three provinces represent the biggest metropolitan areas which indicates that poor wastewater treatment performance is skewed towards the more rural areas within South Africa

Table 2-3 below summarizes the Green Drop scores achieved by the different provinces in South Africa and compares it to the score achieved in 2013.

Table 2-3: Summary of 2021 Green Drop Performance (Department of Water and Sanitation, 2022)

Provinces	2013 GD Score	2021 GD Score
Eastern Cape	65%	51%
Free State	51%	26%
Gauteng	83%	68%
KwaZulu Natal	82%	68%
Limpopo	45%	29%
Mpumalanga	44%	49%
North West	47%	30%
Northern Cape	44%	41%
Western Cape	85%	84%

The Green Drop risk analysis (CRR) focuses specifically wastewater treatment. It considers 4 core risk indicators, namely design capacity, operational flow, technical capacity and effluent quality. Table 2-4 below summarizes the %CRR/CRR_{max} scores achieved during the latest audit for the different provinces in South Africa. A high percentage indicates that a wastewater system is at high risk and in critical condition, while a low percentage indicates low risk.

Table 2-4: %CRR/CRR_{max} scores

Provinces	# of WWTPs	2021 Ave CRR/CRR _{max} % deviation
Eastern Cape	123	72.3%
Free State	96	81.2%
Gauteng	60	58.8%
KwaZulu Natal	147	60.3%
Limpopo	64	84.7%
Mpumalanga	76	74.1%
North West	78	89.7%
Northern Cape	48	85%
Western Cape	158	53.1%
National Total	850	70.1%

(Edokpayia, et al., 2020) reviewed the current trends of water and wastewater treatment systems in South Africa and also highlighted the laws and policies that govern such treatment. They reported the following challenges at wastewater treatment facilities:

- Improper funding for the maintenance and expansion of existing infrastructure.
- A lack of skilled laborers to effectively operate the facilities. It is estimated that there is only 31.5% of the operators required at WWTP's available in South Africa. This presents a shortfall of an estimated 2 661 operators.
- The monitoring of effluent compliance is inadequate at most South African WWTP's.

2.3.2 Electrical Energy Consumption Benchmarks

(Van Niekerk, 2022) carried out a study to benchmark electrical energy consumption in WWTP's in Cape Town. The study used data from 18 activated sludge plants (ASP) in Cape Town (of which Mitchells Plain WWTP was one) to calculate the benchmarks.

The study benchmarked main energy key performance indicators and categorized them for 3 different classes of activated sludge plants namely (i) Macro Plants (WWTPs with hydraulic capacity of >25 ML/day), (ii) Large Plants (WWTPs with hydraulic capacity of 10-25 ML/day) and (iii) Medium Plants (WWTPs with a hydraulic capacity of 2- <10 ML/day).

The study found that the overwhelming majority of electrical energy consumed on ASPs is attributed to the process equipment, with an average of 95% contribution. Other categories such as HVAC, site lighting and office equipment only made up 5%. The study further found that the main contributor to overall electrical energy consumption is aeration. About 60% of electrical energy consumed at ASP plants in Cape Town is consumed by aeration. Table 2-5 shows the % aeration contribution for the different categories of ASPs.

Table 2-5: % aeration consumption in terms of total consumption in WWTPs (Van Niekerk, 2022)

% Aeration Contribution	ASP Plant Category
52%	Large (10-25 ML/d) ASP WWTPs in CT
59%	Macro (>25ML/d) ASP WWTPs in CT
60%	Overall average for ASP WWTPs in CT
69%	Medium (2- <10 ML/d) ASP WWTPs in the CCT

Further in the study, Van Niekerk (2022) calculated overall electricity cost (in Rand) for each of the various processes of the ASPs, assessing their % contribution of energy costs relative to the operational costs (OPEX) at the ASPs. The findings show that between 2014 and 2020, the median of electrical costs for medium plants attribute 30% of the total OPEX, while at Large and Macro plants it was 19% and 20% respectively. The overall median was 21%.

Moreover, it was calculated that the average total electricity consumption cost per m³ of water treated for the ASP treatment plant in Cape Town is R1.27/m³, while the average electricity consumption cost of aeration per m³ of water treated is R0.75/m³. The correlation of average cost

per m^3 treated (R/m^3) and average daily sewage treated (m^3/d) between 2014 and 2020 for both total and aeration cost is illustrated in Figure 2-6 (Van Niekerk, 2022).

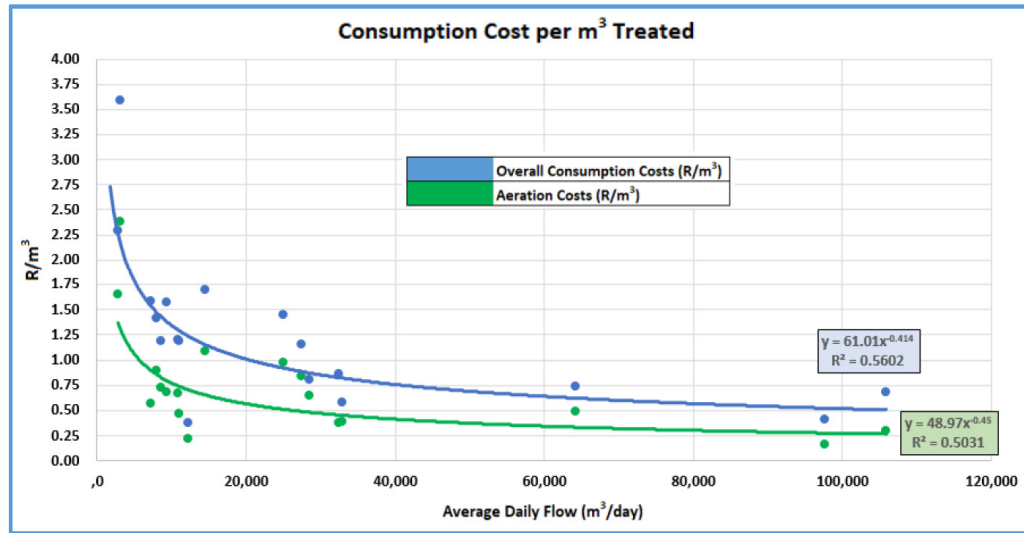


Figure 2-6: Electricity consumption cost per m^3 treated (extract from Van Niekerk, 2022)

While the electrical consumption cost of aeration was calculated as $\text{R}0.75/\text{m}^3$, the average electrical consumption costs for secondary sludge (WAS) treatment was calculated as only $\text{R}0.023/\text{m}^3$. This is comprised of $\text{R}0.007/\text{m}^3$ for sludge thickening, $\text{R}0.012/\text{m}^3$ for the operation of Belt Filter Presses and $\text{R}0.004/\text{m}^3$ for the Polymer make up and dosing system. An additional $\text{R}0.019/\text{m}^3$ was calculated for secondary sludge pumping, which is not included in the overall electricity consumption cost for secondary sludge handling. Figure illustrates the correlation between electrical consumption costs for sludge handling and sludge flows.

It is seen that the electrical consumption cost of sludge handling is roughly 32.6 times lower than the electrical consumption cost of aeration. However, while the electrical consumption cost of aeration constitutes the overwhelming majority of secondary treatment OPEX, the electrical consumption cost of sludge handling only makes up a small portion of the overall OPEX for sludge handling.

3 Methods

3.1 Introduction

This chapter describes the methods used and steps followed to achieve the research objectives. Figure below broadly outlines the methodology followed for this study.

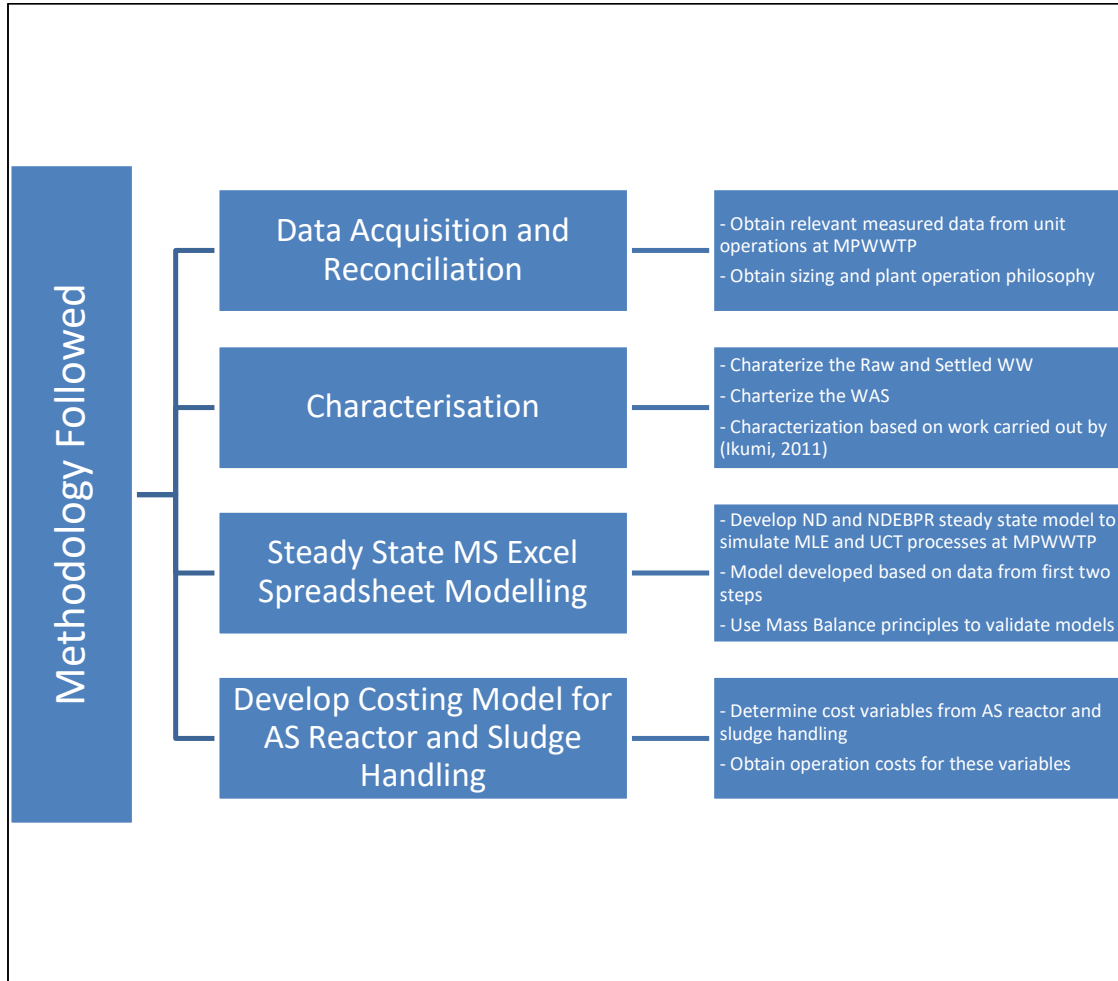


Figure 3-1: Outline of Research Methodology followed for this study

3.2 Background to Mitchells Plain Wastewater Treatment Plant (MPWWTP)

During the 1970's, as part of the Mitchells Plain development, the MPWWTP was planned to provide a treatment facility for the area. The first phase of the MPWWTP entailed a 4 ML/d capacity WWTP and was constructed during the mid-1970's. In 1980, with the addition of 4

biological reactors, the treatment capacity of the works was increased to 24 ML/d. By the addition of further biological reactors as well as primary and secondary sedimentation tanks the works is currently designed to have a treatment capacity of 45 ML/d (Cape Wastewater Consultants, 1999).

Other additions to the plant included balancing tanks added in the 1980's to provide flow equalization as well as additional maturation ponds. The ponds were added to improve the bacteriological quality of the effluent. Later that decade, a fat removing facility was included in the treatment train. In the early 1990's the capacity of the maturation ponds were double and sludge dewatering centrifuges were installed to counter the increasing problem of sludge disposal (Cape Wastewater Consultants, 1999).

Today Mitchells Plain WWTP is split into four separate treatment areas named phase 1 through to phase 4. Figure 3-2 shows a site layout of Mitchells Plain WWTP. The four separate sections consist of the following:

- Phase 1: Activated Sludge Plant (4 ML/d) – currently inactive
- Phase 2: Activated Sludge Plant (20 ML/d)
- Phase 3: Sludge Treatment
- Phase 4: Activated Sludge Plant (25 ML/d)

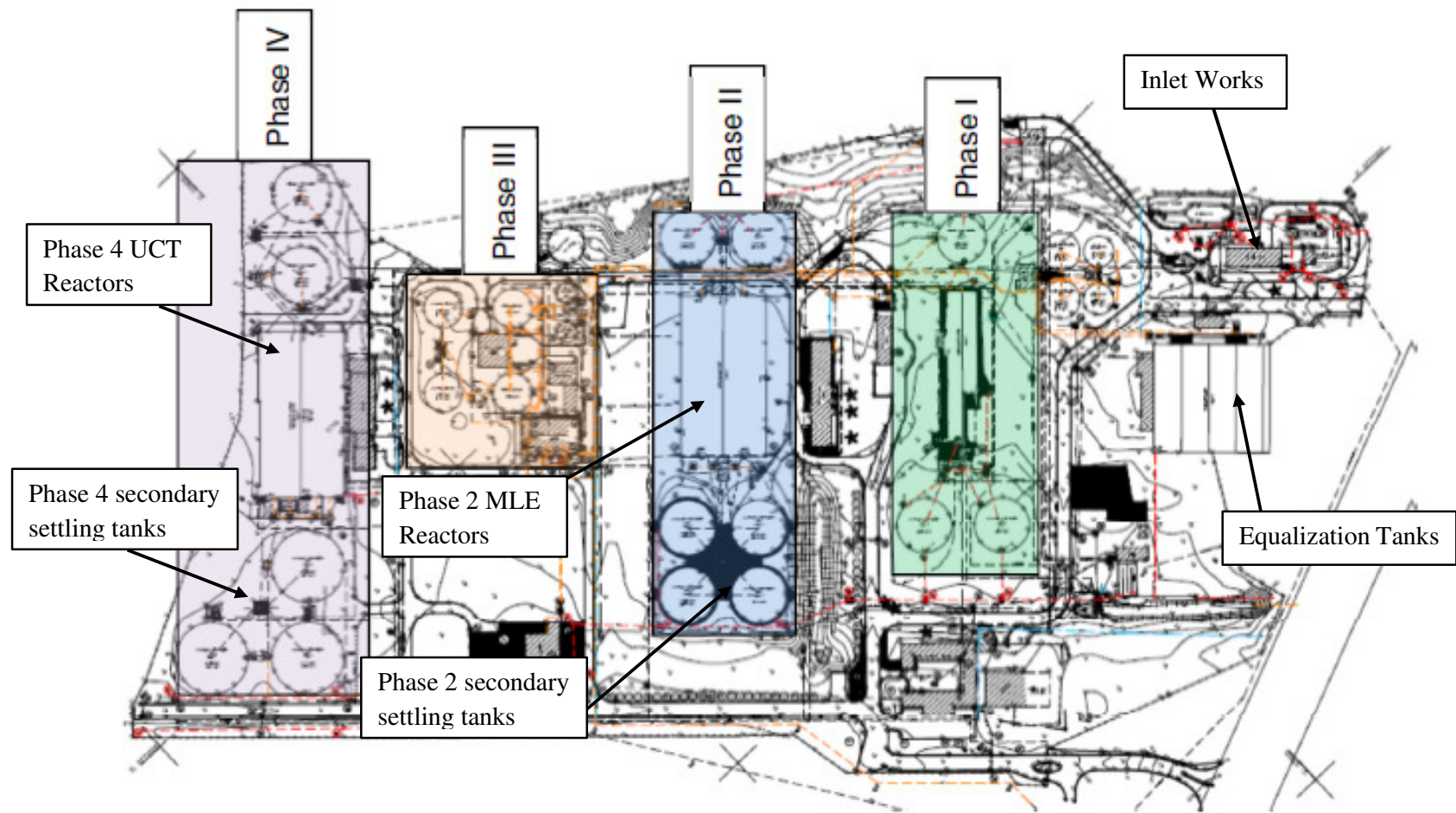


Figure 3-2: Existing Site Layout (Kritzinger, 2015)

The catchment area of Mitchells Plain WWTP includes a population of roughly 480 000 people. The plant is classified as an “A” Works with the design capacity of 45 MI/d at 883 mg/l Chemical Oxygen Demand (COD). The plant’s operations are governed by Permit No. 934 B issued on 09 March 1981 in terms of Chapter 4 of the National Water Act, 1998 (Act No.36 of 1998) by the Department of water affairs (DWA), within which operating terms and conditions are embedded, stipulating clearly the expected quantity and quality of treated effluent to be discharged into water body (City of Cape Town: Wastewater Branch, 2014). Figure 3-3 shows the catchment area of Mitchells Plain WWTP.

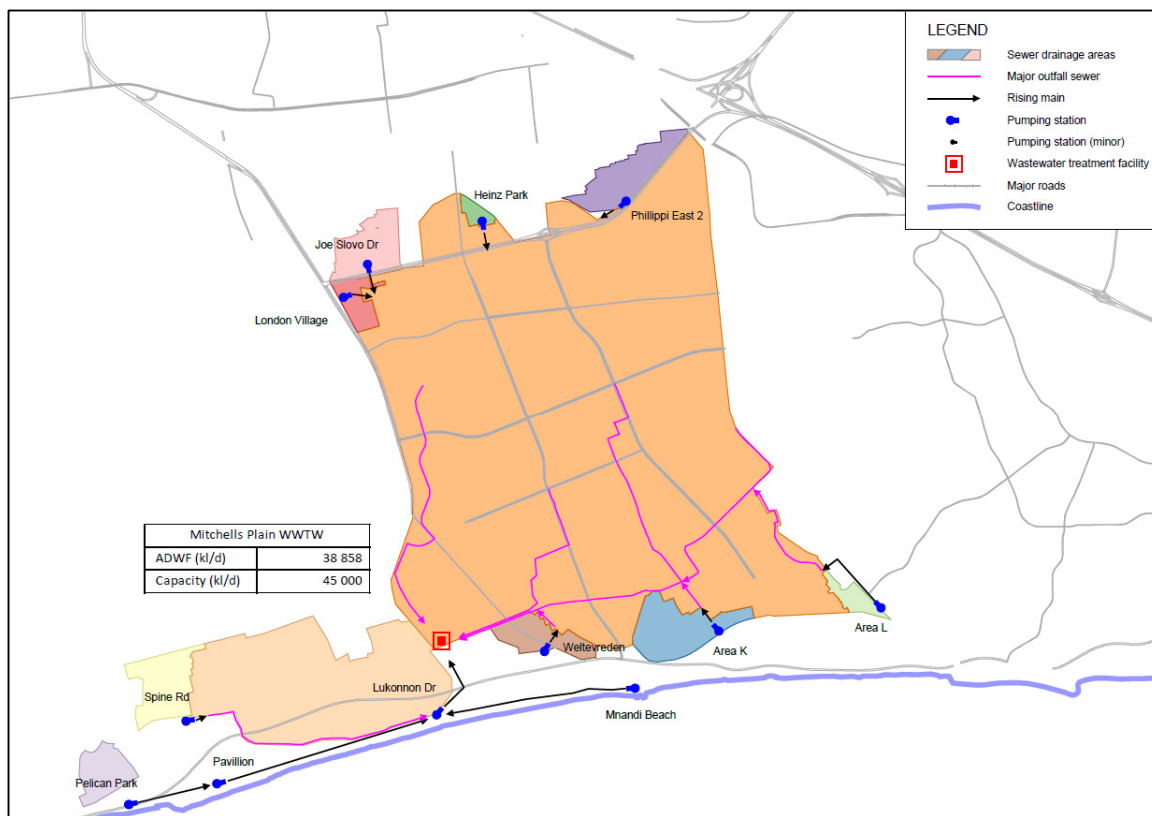


Figure 3-3: Mitchells Plain catchment area (City of Cape Town: Wastewater Branch, 2014)

This chapter looks at the existing infrastructure at Mitchells Plain WWTP and provides detailed specifications of each treatment step in order to determine the optimum existing capacity of the plant. As mentioned in Section 3.1, phase 1 of the works is inactive and will need extensive refurbishment in order to effectively contribute to the treatment capacity of the plant. It will therefore not be included in the capacity model and will not be discussed in this chapter.

3.3 Process Description for MPWWTP

3.3.1 Preliminary Treatment

The head of the works, or preliminary treatment step comprises of two coarse bar screens which are situated in two deep channels. The screens are raked manually and are placed just upstream of two separate sets of Archimedean screw pumps that lift the raw wastewater into two separate channels. Each channel is equipped with a mechanical coarse and fine screen. There is also an emergency by-pass channel in case of mechanical failure of these screens. The emergency channel is equipped with a manually raked coarse- as well as fine screen. The purpose of the screening step is to remove large solids such as plastics, rags or other such debris so that these solids are not transported into the bio-reactors, where they will accumulate and with time, decrease the volume and treatment capacity of the reactors.

After the screening step, two grit traps, also known as degritters, are used to remove smaller solids such as sand and silts. In the “vortex” type grit traps, paddle drives installed in the centre of a circular basin is used created a vortex type flow pattern. Grit is removed my means of settlement. The flow velocity in the grit trap is slowed down causing the denser grit to settle, while the water flows out of the grit trap at the top. The solids that settle at the bottom of the grit trap is removed by an air lift pump that discharges the grit in a grit classifier for dewatering before disposal.

Mitchells Plain WWTP has 4 equalization basins. During periods of peak flows, water is diverted to these basins while during periods of low flow water is pumped from these basins back into the system. The plant therefore uses the equalization basins more like overflow tanks than actual equalization tanks. Flow equalization reduces the peak oxygen demand of the biological reactors, thus meaning that smaller aeration equipment will be required. It also reduces the hydraulic load on the SST’s by reducing the difference between peak wet weather flow (PWWF) and the average dry weather flow (ADWF). These effects are however only achieved if the equalization tanks are constantly in use to ensure a constant flow to the plant. At MPWWTP there is still a fluctuation in influent flow as the equalization basins are only used as storage basins.

The preliminary treatment of wastewater is largely about removing solids in order to protect treatment steps downstream in the process train. Removal is achieved through screening, both manual and mechanical, and by settlement in grit traps. The final part of the preliminary treatment step, flow equalization, does not actually improve the quality of the wastewater but does improve and reduce the load on downstream treatment steps. Technical details of the process units and equipment used in the preliminary treatment step is given below.

Table 3-1: Technical Specification for Preliminary Treatment equipment (Cape Wastewater Consultants, 1999)

Primary Coarse Bar Screens	
Number of Screens	2
Bar Spacing	100mm
Screening Removal	Hoisted rake
Primary High lift Pumps	
Number of pumps	3
Type	Archimedean screw
Pumping rate	290 l/s each
Secondary High lift Pumps	
Number of pumps	3
Type	Archimedean screw
Pumping rate	290 l/s each
Mechanical Coarse Screens	
Number of Screens	2
Bar spacing	25mm
Screenings Removal	Mechanical, front raked
Mechanical Fine Screens	
Number of Screens	2
Bar spacing	12.5mm
Screenings Removal	Mechanical, front raked
Emergency Coarse Screen	
Number of Screens	1
Bar spacing	30mm
Screenings Removal	Manual, hand raked
Emergency Fine Screen	
Number of Screens	1
Bar spacing	Unknown
Screenings Removal	Manual, hand raked
Grit Traps	
Number of grit traps	2
Type	Vortex
Grit Removal	Mechanical, air lift pumps

Grit Classifier	
Number of grit classifiers	2
Type	Screw classifiers
Quantity of grit removed	4 m ³ /d
Tertiary High Lift Pumps	
Number of pumps	3
Type	Archimedean screw
Pumping rate	463 l/s each
Flow Equalization	
Number of Equalization Tanks	4
Volume of Tanks	2736 m ³
Total Volume	10 944 m ³
Number of Pumps	4
Pumping rate	160 l/s

3.3.2 Primary Treatment

Mitchells Plain WWTP's process train includes primary treatment in the form of primary sedimentation. Both the phase 2 and phase 4 segments of the works have two primary settlement tanks (PST's). The PST's are usually designed to have a maximum up flow rate of about 1.2 m/h at ADWF and a maximum up flowrate of 2.4 m/h at PWWF. Primary settlement tanks are typically designed to reduce the organic load by 30 – 50% and the solids load by 40-60% (Wentzel *et al.* (2004); Polorigni *et al.* (2021).

The specifications of the primary sedimentation for the two different plants are given in Table 3-2 below.

Table 3-2: Primary Sedimentation Specifications (Cape Wastewater Consultants, 1999)

Phase 2 Primary Sedimentation	
Number of Tanks	2
Diameter	25 m
Side Water Depth	3 m
Phase 4 Primary Sedimentation	
Number of Tanks	2
Diameter	26 m
Side Water Depth	3 m

From data gathered by the City of Cape Town's Scientific Services department the performance of the PST's at Mitchells Plain is shown in the Table 3-3 below. Excluded from the data set is the removal percentages of the last three years as there was only limited data for this period. As is seen in the table, the PST's in the Phase 2 process train have experienced many reliability issues during the period data was taken, but because the same raw wastewater flows through these two separate sets of PST's their historical performance can be combined in order to anticipate an expected removal percentage, to create a capacity model for this WWTP.

Table 3-3: Mitchells Plain WWTP PST performance

	P2 Ave TSS Removal %	P2 Ave COD Removal%	P4 Ave TSS Removal %	P4 Ave COD Removal %
2008-2009	68%	46%	52%	30%
2009-2010	64%	46%	57%	38%
2010-2011	No Data	No Data	64%	42%
2011-2012	42%	31%	64%	36%
2012-2013	No Data	No Data	54%	32%
2013-2014	No Data	No Data	44%	23%
2014-2015	No Data	No Data	63%	37%
2015-2016	No Data	No Data	46%	35%

During this period the PST's removed on average 51% of the influent Total Suspended Solids (TSS) load and 36% of the influent Chemical Oxygen Demand (COD) load.

3.3.3 Secondary Treatment

As previously mentioned, the Mitchells Plain WWTP is split into 2 operational segments namely phase 2 and phase 4. Flow is split after it passes through preliminary treatment and flows through two separate sets of PST's and biological reactors. This section describes the configuration of each phase's secondary treatment as well as the treatment process of each phase.

3.3.3.1 Phase 2

After receiving flow from the two phase 2 PST's, flow is split equally between 4 biological wastewater treatment trains. Each treatment train has a modified Ludzack-Ettinger (MLE) process configuration, but without internal mixed liquor suspended solids (MLSS) recycle. This configuration is designed for the removal of organics and nitrogen (via aerobic nitrification and anoxic denitrification), but not designed for the removal of phosphorus. Flow passes from the four MLE systems to four secondary settling tanks (SST's) for the physical separation of solids and liquids. An underflow of sludge is sent back from the SST's to the biological reactors. Table 3-4 provides the specifications of the phase 2 biological reactors.

Table 3-4: Phase 2 Secondary Treatment Specifications (Cape Wastewater Consultants, 1999)

Biological Reactors	
Number of Reactors:	4
Length:	77 m
Width:	10 m
Depth:	4 m
Anoxic Volume:	457 m ³ / reactor
Aerobic Volume:	2 623 m ³ / reactor
Total Volume:	3 080 m ³ / reactor
Aeration:	452 kg O ₂ / h
Secondary Settling Tanks	
Number of Tanks:	4
Diameter:	25 m
Side Wall Depth:	3 m
No of Sludge Return Pumps:	3
Pumping Rate:	101 l/s

At MPWWTP the phase 2 biological reactors do not have internal recycle from the aerobic to the anoxic zone (a-recycle). This means that the nitrates formed by nitrification is only returned to the anoxic zone by means of the sludge underflow recycle from the SST (i.e., the s-recycle).

The omission of the a-recycle means that very careful operational control over the s-recycle is required in order to avoid denitrification in the SST's which will cause sludge flotation. Not having an a-recycle could also reduce the nitrogen removal capacity of the biological reactor.

3.3.3.2 Phase 4

As mentioned in Section 3.3.2, the phase 4 plant also has two PST's to reduce the sludge- and organic load on the biological reactors. After flow has passed through the PST's it is diverted to two identical parallel biological reactors. The reactors' make use of a modified UCT process configuration. Flow passes from the two biological reactors to three secondary settling tanks (SST's) for the physical separation of solids and liquids. An underflow of sludge is sent back from the SST's to the biological reactors. Table 3-5 provides the specifications of the phase 4 biological reactors.

Table 3-5: Phase 4 Secondary Treatment Specifications (Cape Wastewater Consultants, 1999)

Biological Reactors	
Number of Reactors:	2
Length:	77.25 m
Width:	20 m
Depth:	4 m
Anaerobic Volume:	915 m ³ / reactor
1 st Primary Anoxic Volume:	610 m ³ / reactor
2 nd Primary Anoxic Volume:	915 m ³ / reactor
Aerobic Volume:	3 660 m ³ / reactor
Total Volume:	6 100 m ³ / reactor
Aeration:	904 kg O ₂ / h
No of Internal Recycle Pumps:	1 / reactor
Pumping Rate:	55 l/s
Secondary Settling Tanks	
Number of Tanks:	3
Diameter:	32.7 m
Side Wall Depth:	4 m
No of Sludge Return Pumps:	3
Pumping Rate:	165 l/s

3.3.4 Tertiary Treatment

A tertiary treatment step is used at Mitchells Plain to further treat the effluent before final discharge. The first step of the tertiary treatment phase is disinfection. Chlorine dosing is used to kill or deactivate any disease-producing organisms, such as *E-coli* and to control any undesirable growth. Chlorine chips are dissolved and discharged into a chlorine contact tank where the effluent flows through. The effluent is disinfected during the time spent in the chlorine contact tank (contact time).

After the effluent has passed through the chlorine contact tanks, it flows into maturation ponds. The maturation ponds provide time for final settlement of any solids which might have overflowed from the SST's and improves the bacteriological quality of the effluent by means of Ultraviolet (UV) treatment from sunlight. The maturation ponds also act as a buffer in the event of a breakdown (City of Cape Town: Wastewater Branch, 2014).

3.3.5 Sludge Treatment (Phase 3)

As seen in Figure 3-2 the sludge treatment section at MPWWTP was constructed as separate treatment facility and is labelled phase 3. The sludge treatment at MPWWTP contains the following processes:

- **Primary Sludge Handling**
 - Gravity Sludge Thickeners
 - Anaerobic Digesters
 - Gas Holding Tank
 - Belt Presses
- **Waste Activated Sludge Handling**
 - Dissolved Air Flotation (DAF) Sludge Thickeners
 - Belt Presses

Under current operation of the plant, the only process units that are in operation are the gravity sludge thickeners and the belt presses. All other process units have been out of operation for a number of years. For the purpose of this study, it will be assumed that these units can be brought back into operation without having to undergo major refurbishment and at minimal costs. Table 3-6 below provides the specifications of the existing infrastructure at MPWWTP that can be used for sludge treatment.

Table 3-6: Sludge Treatment Infrastructure Specifications (Cape Wastewater Consultants, 1999)

Primary Sludge Handling	
Sludge Thickeners	
Number of Thickeners:	2
Diameter:	8.5 m
Side Water Depth:	3.5 m
Type:	Gravity, sloping bottom with central sludge hopper (25° slope). Rotating bridge with sludge scrapers.
Primary Anaerobic Digesters	
Number of Digesters:	2
Diameter:	17.5 m
Volume:	2 800 m ³ /digester
Secondary Anaerobic Digesters	
Number of Digesters:	2
Diameter:	17.5 m
Volume:	2 800 m ³ /digester
Gas Holding Tank	
Number of Tanks:	1
Diameter:	17 m
Height:	2.2 m
Volume:	500 m ³
Waste Activated Sludge Handling	
Dissolved Air Flotation Sludge Thickener	
Number of DAF thickeners:	1
Configuration:	Rectangular
Length:	15 m
Width:	5 m
Depth:	2 m
Volume:	150 m ³
Thickened Sludge Removal:	Mechanical surface scraping

3.4 Wastewater Characterization

Ikumi (2011) replicated, at laboratory scale, three full scale wastewater treatment plant schemes in order to develop a three-phase plant-wide mathematical model for sewage treatment. The schemes comprised of (1) a modified Ludzack – Ettinger (MLE) AS system treating settled wastewater, (2) an MLE AS system treating raw wastewater and a (3) University of Cape Town (UCT) AS system treating settled wastewater.

The three experimental systems were all fed with wastewater collected from MPWWTP. Measured masses of macerated primary sludge (PS), collected from Athlone WWTP, were added to settled wastewater samples collected from MPWWTP to simulate raw wastewater. Therefore, the settled wastewater used by Ikumi (2011) in schemes (1) and (3), as described above, represent wastewater from MPWWTP only, while the raw wastewater used in scheme (2) represents a composite of primary sludge collected from Athlone WWTP and settled wastewater collected at MPWWTP. Furthermore, in order to increase the biological excess P removal (BEPR) in scheme (3), 200mg/l of acetate was dosed to the settled wastewater feed to the UCT AS system (Ikumi, 2011).

As both process trains at the Mitchells Plain WWTP makes use of primary sedimentation, the characterization of the settled wastewater samples from Mitchells Plain WWTP, carried out by Ikumi (2011) was used in this study. The settled wastewater fed to scheme (3) was chemically altered, therefore the characteristics of the settled wastewater fed to scheme (1) was deemed to best represent the settled wastewater of MPWWTP. The characteristics of the settled wastewater fed to scheme (1) was used in the steady state MLE and UCT models developed to simulate the Phase 2 and Phase 4 (refer to Section 3.3.3) process trains at MPWWTP respectively.

3.4.1 Influent Chemical Oxygen Demand (COD) Characterization

The COD characteristics of the wastewater used in this study is shown in Figure 3-4 below:

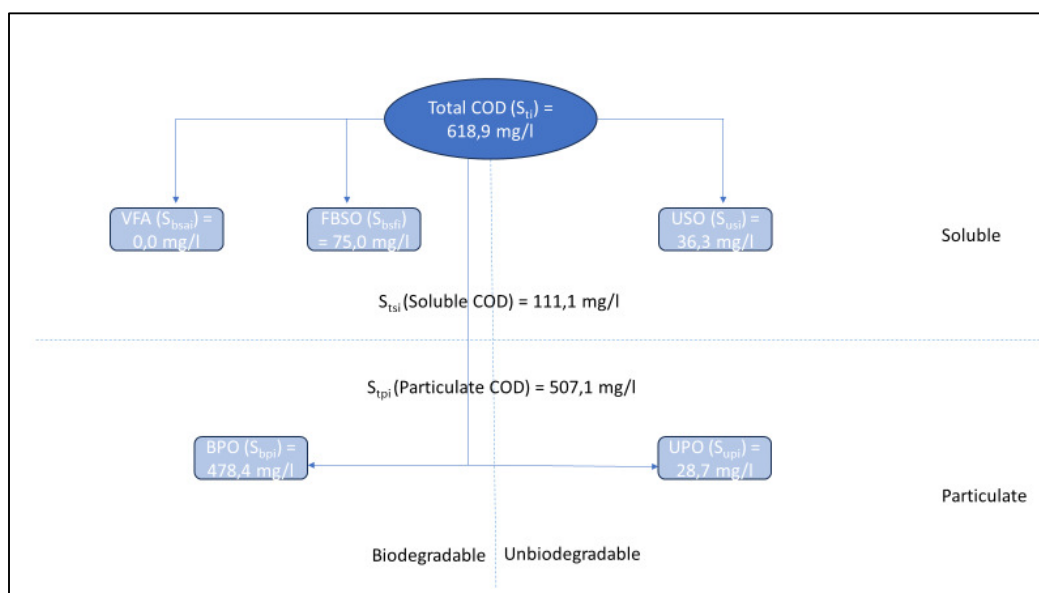


Figure 3-4: The COD Characteristics for settled wastewater at Mitchells Plain WWTP, measured in mgCOD/l (Ikumi, 2011)

3.4.2 Influent Total Kjeldahl Nitrogen (TKN) Characterization

The TKN characteristics of the wastewater used in this study is shown in Figure 3-5 below:

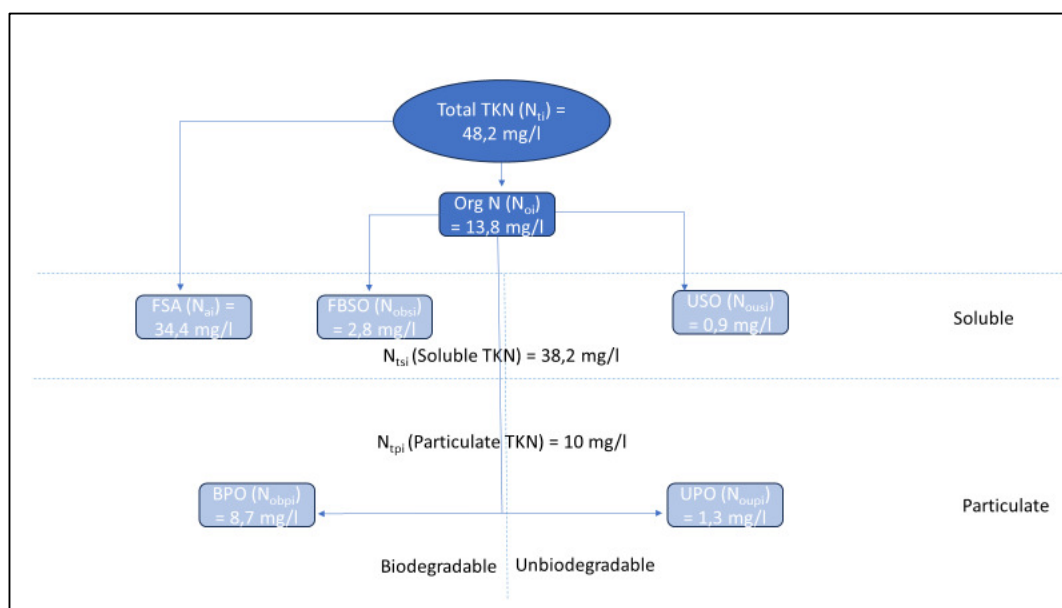


Figure 3-5: The TKN Characteristics for settled wastewater at Mitchells Plain WWTP, measured in mgN/l (Ikumi, 2011)

3.4.3 Influent Total Phosphorus (TP) Characterisation

The TP characteristics of the wastewater used in this study is shown in Figure 3-6 below:

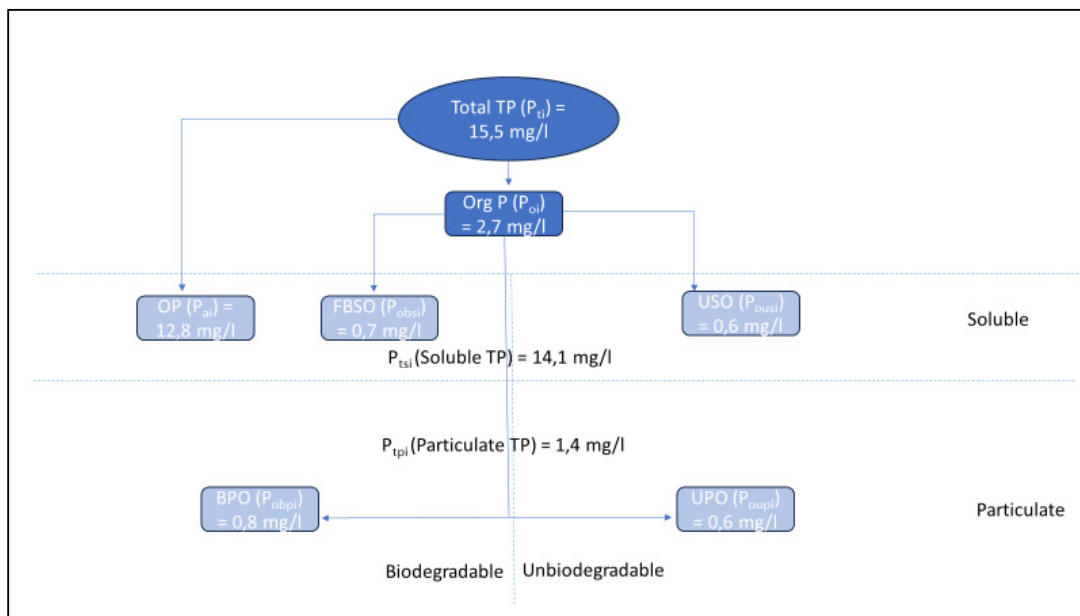


Figure 3-6: The TP Characteristics for settled wastewater at Mitchells Plain WWTP, measured in mgP/l (Ikumi, 2011)

3.4.4 Influent Total Organic Carbon (TOC) Characterisation

The TOC characteristics of the wastewater used in this study is shown in Figure 3-6 below:

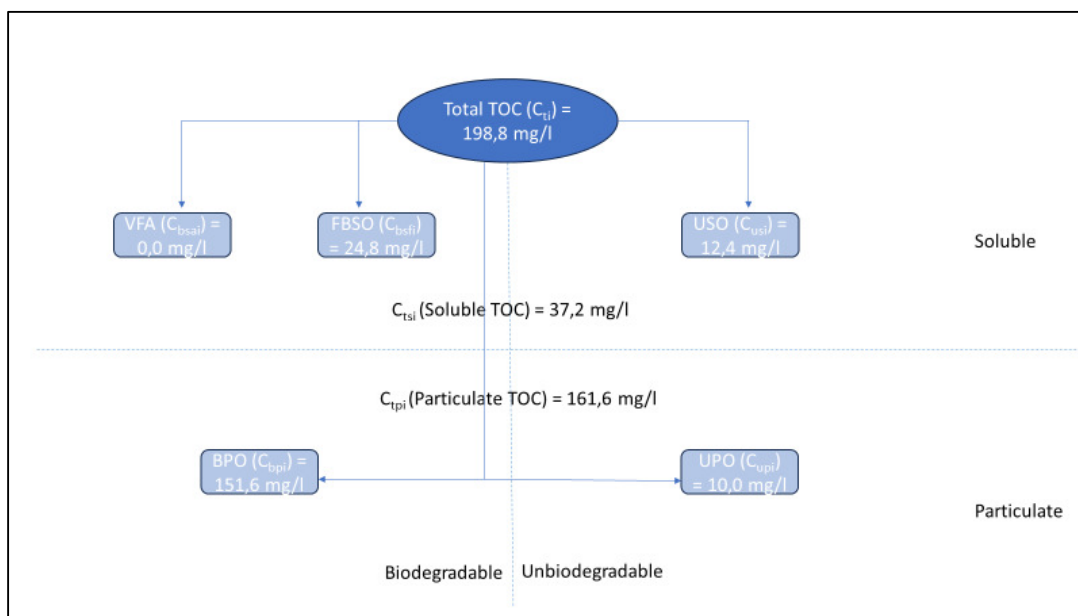


Figure 3-7: The TOC Characteristics for settled wastewater at Mitchells Plain WWTP, measured in mgC/l (Ikumi, 2011)

3.4.5 Influent Suspended Solids (SS)

Samples of settled wastewater from MPWWTP were taken over 5 test periods for the study carried out by (Ikumi, 2011). The average values of the results were used as the influent settled wastewater SS concentrations. The influent wastewater SS concentration are provided in Table 3-7 below:

Table 3-7: Influent Suspended Solids Concentrations

Parameter	Influent Settled WW concentration
TSS	240.7 mgTSS/l
VSS	189.3 mgVSS/l
ISS	51.4 mgISS/l

3.5 Process Modelling

There have been several developments of complex single unit process steady-state models. Table 3-8 summarizes different components of the model that were incorporated in the tool. These models aim to replicate biological processes taking place in WWTPs. The various previously

developed single unit process models relevant to this project, namely, influent wastewater characterization, activated sludge reactor (i.e., organism growth and decline, nitrification-denitrification models and biological excess phosphorus removal models), secondary settling (1-d flux theory) and physical units such as thickening (DAF) and dewatering were linked together to form a plant-wide model such that the outputs from upstream unit process become inputs for the downstream unit process (Henze *et al.*, 2008; Ekama, 2009). Anaerobic digestion (AD) was not considered as the case study for MPWWTP did not include AD unit operations.

The plant-wide Steady-State (PWSS; Ekama, 2009) model was formed based on the principles of material (carbon (C), hydrogen (H), oxygen (O), nitrogen (N) and phosphorus (P)) mass and charge balanced bioprocess. The PWSS model was developed in Microsoft Excel (refer to Section 2.2).

Table 3-8: Summary of WRRF models incorporated in the developed tool

Process model	Reference
Activated sludge steady-state behaviour	Marais and Ekama, 1976
Organic material removal	Ekama and Wentzel, 2008a
Biological nitrogen removal (BNR)	Ekama and Wentzel, 2008b
Nitrification denitrification enhanced biological phosphorus removal	Wentzel et.al, 2008
Secondary Settling - idealized one-dimensional flux theory	Ekama and Marais, 1986; Ekama <i>et al.</i> , 1997
Dissolved-Air Floatation (DAF)	Bratby & Marais, 1976
Plant-wide mass balance steady state WWTP model	Ekama, 2009

The BNR AS models were created to simulate the MPWWTP Phase 2 - Modified Ludzack-Ettinger (MLE), and Phase 4 - University of Cape Town (UCT) AS reactors which are used at the wastewater treatment works. These models are based on the literature described in Section 2.1.3. The models were setup to fully replicate the size and volumes of the reactors in use at MPWWTP. Refer to Table 3-4 and Table 3-5 in Section 3.3.3, which describes and summarises the unit sizes of the MLE and UCT reactor configurations.

The four separate biological treatment trains of Phase 2 were combined to act as a single BNR AS system in the steady state model developed to replicate the MLE process. It was assumed that flow is split equally between the four separate units, and therefore they can be combined to work as a single unit. The same methodology was applied to develop the SST model, where the combined surface area was used to simulate the performance of the SSTs using idealized one-dimensional flux theory.

As previously mentioned, the Phase 2 MLE reactors at MPWWTP have no internal recycles (a-recycle). The s-recycle ratio is based on the critical recycle ratios as determined by the SST model.

Similar to the model that was developed to simulate the MLE process, the parameters given in Table 3-5 were used to develop the steady state model to replicate the Phase 4 UCT process at MPWWTP. The two separate biological treatment trains were combined to act as a single BNR AS system in the model.

The Phase 2 (MLE) and Phase 4 (UCT) biological treatment systems and linked SST models act as individual unit process within the plant wide steady state model. The waste activated sludge produced from each of the models are combined and used as an input for the physical sludge thickening and dewatering units. The physical characteristics of the DAF unit is provided in Table 3-6. A schematic of the PWSS model is shown in Figure 3-8.

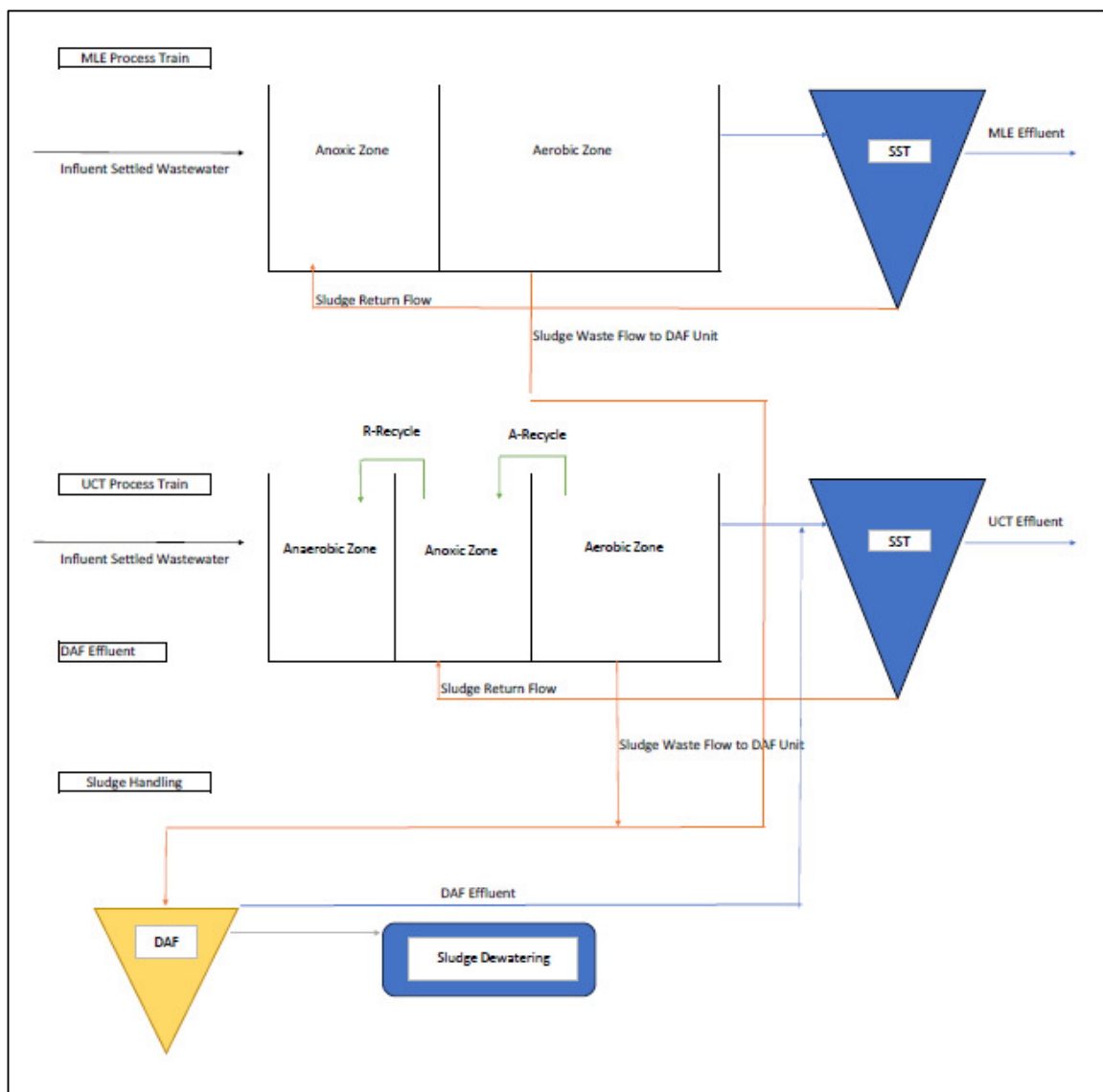


Figure 3-8: PWSS Model Schematic

As mentioned in Section 3.2, the MPWWTP is noted to have a design capacity of 45 ML/d, with a flow split of 20 ML/d and 25 ML/d to the Phase 2 (MLE) and Phase 4 (UCT) process train respectively. This relates to a flow split of 44.4%:55.6% between the MLE and UCT Process trains. This flow split was applied to a range of influent flows to simulate the PWSS model at different SRT's to determine the effect of SRT's on operational costs. The different scenarios applied to the model is described in Section 3.7.1.

The main objective of the model is to generate a set of results which can be used to determine the operational costs. The operational costs considered in this study include energy consumption (kWh) from aeration, pumping and sludge thickening and dewatering. Chemical consumption, especially polymer used for flocculation in sludge dewatering, was also included

to determine operational costs. Other operational costs that are incurred on MPWWTP was not considered, as they were deemed to **not** be impacted by the SRT of the BNRAS reactor, and would therefore be similar, with negligible differences, for the same influent flow at different SRTs.

Energy consumption from aeration is determined by an aeration model which calculates the actual oxygen transfer rate (OTR in kgO/kWh). The oxygen demand is determined by the BNRAS model. The air flow mass is calculated based on the oxygen demand, the mass of O₂ in air (23.2%), the Standard Oxygen Transfer Efficiency (SOTE) for diffusers (6.25% per m of water depth), which is corrected for site conditions (temperature and altitude) and an applied fouling factor F (0.7) (Metcalf & Eddy & Aecom, 2014). Only the average aeration energy requirement was considered, as peak aeration power is for sizing the aeration equipment, not for energy consumption by it.

Pumping energy was calculated from flows as well as static head required. The following static heads were used for the various flows:

- A- and R-recycle: 0.5m
- WAS: 1m
- RAS: 1m
- Sludge flow from thickening to dewatering: 3m

The energy consumption for dissolved-air flotation (DAF) unit is determined by the air flow mass required for thickening of the sludge. Once the air flow is determined the energy consumed was calculated in the same manner as that of the aeration energy consumption.

For dewatering, a local supplier for Huber Technologies was contacted to provide information on the mechanical specifications of Belt Filter presses (BFP) that is common use on WWTPs such as MPWWTP (Stammer, 2023). The equipment has a standard kW-rating, with total running time determined by the solids- and hydraulic loading rate. The energy consumption for dewatering was calculated based on the kW-rating and required running time required for BFP's to dewater the WAS determined by the BNRAS model.

The detailed model input variables and outputs, as developed in Microsoft Excel is illustrated in Annexure A.

3.6 Model Evaluation

The SS model was evaluated by performing mass balances on COD, TKN and TOD to ensure the model is internally consistent with conservation of mass and flow principles. Furthermore, the steady state model is based on scientifically sound principles from previous investigations (refer to Table 3-8).

The steady state model, coded in MS Excel, is explicit in nature, showcasing all the links between model components, parameters, and variables. This allows for intuitive identification of significant parameters and can be used in explaining the reasons behind the findings of the investigation. With this in mind, it was decided that the application of the steady state model, and not the more sophisticated dynamic simulation model, would be better suited to this study. Future work could involve the investigations using dynamic simulations to observe the impacts with dynamic conditions.

The thesis from Ikumi (2011) utilised steady state models to calculate variables of significance and the predictions from that model matched well to the experimentally measured data for both a lab scale MLE and UCT system fed MPWWTP sewage. This further validates the use of the steady state scenario for this study.

The equations below were used to check the mass balance across the model. The mass balance for the various scenarios, described in Section 3.7.1, is shown in Annexure A.

COD Mass Balance

$$COD_{in} = COD_{out}$$

$$FS_{ti} = Q_e S_{te} + Q_w S_{te} + Q_w X_v f_{cv} + FO_c$$

Where;

- FS_{ti} is the flux of COD entering the reactor (kgCOD/d)
- Q_e is the effluent flow rate (ML/d)
- S_{te} is the effluent COD concentration (mgCOD/l)
- Q_w is the waste flow rate (ML/d)
- X_v is the concentration of volatile suspended solids in the reactor (mgVSS/l)
- f_{cv} is the COD/VSS ratio
- FO_c electrons passed to oxygen (kgCOD/d)

TKN Mass Balance (if complete nitrification occurs)

$$TKN_{in} = TKN_{out}$$

$$FN_{ti} = Q_e N_{te} + Q_w N_{te} + Q_i N_s + Q_i N_{ne}$$

Where;

- FN_{ti} is the flux of TKN entering the reactor (kgN/d)
- N_{te} is the effluent TKN concentration (mgN/l)
- Q_i is the influent flow rate (ML/d)

- N_s is the equivalent concentration of N contained in the reactor VSS in the influent (mgN/l)
- N_{ne} is the nitrate concentration in the effluent (mgN/l)

TOD Mass Balance

$$TOD_{in} = TOD_{out}$$

$$FS_{ti} + 4.57FN_{ti} = TOD_{effluent} + TOD_{waste} + TOD_{n_2-gas} + FO_t$$

$$FS_{ti} + 4.57FN_{ti} = Q_e * (S_{usi} + 4.57N_{te}) + (Q_w * (S_{usi} + 4.57N_{te}) + Q_w X_{v,cv} + 4.57Q_w N_s) + 2.86Q_i * (N_c - N_{ne}) + FO_t$$

Where;

- N_c is the nitrification capacity (mgN/l influent)

3.7 Scenarios Modelled and Performance Evaluation

With the reactor volumes set, a constant influent flow was selected for each reactor over a range of solids retention periods (SRTs). At a constant inflow, an AS reactor will have varied operational parameters which are all influenced by the SRT. The operational parameters which are influenced by the selected SRT include the (i) mass of TSS in the reactor (MXt, mgTSS/l), (ii) the waste flow rate (Q_w , m³/d), (iii) the aeration requirements (kgO/d) as well as the (iv) recycle flows required for optimal performance. These operational parameters all affect the operational costs.

3.7.1 Scenarios

As mentioned in Section 3.5, the MPWWTP has a design capacity of 45 ML/d, with a flow split of 44.4%:55.6% between the MLE and UCT Process trains. With a constant influent flow, the effect of the reactor SRT on operational costs can be determined by simulating the reactors at various SRTs. In order to gain an understanding of the relationship between the operational cost, SRT and influent flow, the PWSS model was simulated over a range of influent flows with the 44.4%:55.6% flow split applied. The various scenarios are summarised in Table 3-9 below.

Table 3-9: Scenarios Simulated

Scenario 1						
Q _i = 20 ML/d	Q _i -MLE = 8.89 ML/d	SRT = 10 days	SRT = 15 days	SRT = 20 days	SRT = 25 days	SRT = 30 days
	Q _i -UCT = 11.11 ML/d					
Scenario 2						
Q _i = 25 ML/d	Q _i -MLE = 11.11 ML/d	SRT = 10 days	SRT = 15 days	SRT = 20 days	SRT = 25 days	SRT = 30 days
	Q _i -UCT = 13.89 ML/d					

Scenario 3						
Q _i = 30 ML/d	Q _i -MLE = 13.33 ML/d	SRT = 10 days	SRT = 15 days	SRT = 20 days	SRT = 25 days	SRT = 30 days
	Q _i -UCT = 16.67 ML/d					
Scenario 4						
Q _i = 35 ML/d	Q _i -MLE = 15.56 ML/d	SRT = 10 days	SRT = 15 days	SRT = 20 days	SRT = 25 days	SRT = 30 days
	Q _i -UCT = 19.44 ML/d					
Scenario 5						
Q _i = 40 ML/d	Q _i -MLE = 17.78 ML/d	SRT = 10 days	SRT = 15 days	SRT = 20 days	SRT = 25 days	SRT = 30 days
	Q _i -UCT = 22.22 ML/d					
Scenario 6						
Q _i = 45 ML/d	Q _i -MLE = 20 ML/d	SRT = 10 days	SRT = 15 days	SRT = 20 days	SRT = 25 days	SRT = 30 days
	Q _i -UCT = 25 ML/d					

The minimum SRT was selected to ensure that complete nitrification takes place in each of the BNR AS reactors. The minimum SRT to achieve nitrification was calculated as 6.09 days and 8.45 days for the MLE- and UCT reactors respectively. Therefore, 10 days was the lowest selected SRT value for the scenario analysis.

3.7.2 Performance Evaluation

Operational Cost Index (OCI) and Effluent Quality Index (EQI) are performance indices (PIs) that were derived from a previous study carried out by the International Water Association (IWA) benchmark simulation modelling task group (Copp, 2002, Nopens *et al.*, 2010). These PIs were further developed by (De Ketele, Davister & Ikumi, 2018) to produce WWTP model output evaluations that are compatible with South African WWTPs. These PIs were used to evaluate the simulated performance of the scenarios described in Section 3.7.1, as indicated below.

3.7.2.1 Effluent Quality Index Application

The EQI equations, as modified by (De Ketele, Davister & Ikumi, 2018), is provided below.

$$EQI = EQI_{water} + EQI_{gas} + EQI_{sludge}$$

$$EQI_{water} = \frac{1}{T \cdot 1000} \int_{t_0}^{t_{end}} (\beta_{TSS} \cdot TSS(t) + \beta_{COD} \cdot COD(t) + \beta_{FSA} \cdot FSA(t) + \beta_{NO} \cdot NO(t) + \beta_{OP} \cdot OP(t) + \beta_x \cdot X(t)) \cdot Q_e(t) \cdot dt$$

$$EQI_{gas} = \frac{1}{T \cdot 1000} \int_{t_0}^{t_{end}} (\beta_{CO_2} \cdot FCO_2(t) + \beta_{CH_4} \cdot FCH_4(t) + \beta_{N_2O} \cdot FN_2O(t)) \cdot dt$$

$$EQI_{sludge} = \frac{1}{T \cdot 1000} \int_{t_0}^{t_{end}} \frac{38}{x(t)} \cdot (\beta_{As} \cdot As(t) + \beta_{Cd} \cdot Cd(t) + \beta_{Cr} \cdot Cr(t) + \beta_{Cu} \cdot Cu(t) + \beta_{Pb} \cdot Pb(t) + \beta_{Hg} \cdot Hg + \beta_{Ni} \cdot Ni + \beta_{Zn} \cdot Zn + \beta_{CFU} \cdot CFU + \beta_{ova} \cdot ova) \cdot F_{Sludge}(t) \cdot dt$$

As this study does not consider anaerobic digestion, only the effluent quality of water was considered and quantified. The model assumes that there are no solids carry over into the final effluent. Therefore, the TSS parameter was removed. Furthermore, as the simulations were carried out in steady state, the results of the various scenarios will have a linear correlation. The time period is therefore of insignificant importance. A time period of one (1) day was selected. With this in mind, the equations above could be simplified to those provided below:

$$EQI = EQI_{water}$$

$$EQI_{water} = \frac{1}{T \cdot 1000} (\beta_{COD} \cdot COD + \beta_{FSA} \cdot FSA + \beta_{NO} \cdot NO + \beta_{OP} \cdot OP) \cdot Q_e$$

$$PU_x = \beta_x \cdot (X_{limit} - X)$$

The β -factors are based on site-specific regulations. The factors were calculated based MPWWTP effluent quality permit and are illustrated in Table 3-10 below.

Table 3-10: Beta factors: Weighting factors to determine the weight of each pollutant relative to COD

Variable in EQI	Unit	Limit	Beta (β)
COD	mgCOD/l	75	1
Free and Saline Ammonia	mgN/l	10	7.5
Nitrate + Nitrite	mgN/l	15	5
Ortho-Phosphorus	mgP/l	10	7.5

If the PU_x term is negative, this reflects an effluent pollutant concentration (X) which exceeds the regulated limit (X_{limit}). A positive PU_x term indicates that the effluent pollutant concentration is lower than the regulated limit, while a zero (0) result equates to an effluent pollutant concentration which matches the limit.

3.7.2.2 Operational Cost Index Application

(De Ketele, Davister & Ikumi, 2018) modified the OCI equation to including the weighting of economic factors which are country dependant, such as energy tariffs. The equation derived by (De Ketele, Davister & Ikumi, 2018) is shown below.

$$OCI = ((AE + PE - MP + ME + HE) * Energy Cost + SP * Disposal Cost + EC * Carbon Cost$$

Where;

- AE is aeration energy required

- *PE* pumping energy required
- *MP* is methane produced
- *ME* is mixing energy required
- *HE* is heating energy required
- *SP* is sludge production
- *EC* is external C addition

As anaerobic digestion is not considered in this study, *MP*, *HE* and *EC* was not considered as part of the *OCI* used to evaluate the scenarios described in Section 3.7.1. Additional terms for the addition of chemicals (polymer) used in the dewatering process, and energy consumption for sludge thickening and dewatering were added to the *OCI* equation used in this study. The *OCI* equation used in this study is provided below.

$$OCI = ((AE + PE + ME + DE) * Energy\ Cost + SP * Disposal\ Cost + CA * Chemical\ Cost$$

Where;

- *DE* is energy required for sludge dewatering
- *CA* is chemical (polymer) required for sludge dewatering

Aeration (*AE*) and pumping energy (*PE*) was determined from the BNR AS models as described in Section 3.5. A static lift 2m, 5m and 5m was used for the RAS flow, WAS flow and influent flow respectively to calculate the pumping energy. These assumptions were based on visual inspections on site. A static lift of 1m was used for internal recycle flows.

The volume of sludge produced for disposal was based on the assumption that the dewatering equipment can produce a dewatered sludge with a solids content of 18%. The amount of polymer required (*CA*) was calculated based on technical specifications from manufacturers (kg Polymer/dry ton of sludge). The dewatering energy (*DE*) consumption was based on the belt presses and sludge feed pump installed at MPWWTP, with the daily operating hours calculated based on the equipment's hydraulic and solids loading capacity. Mixing energy is determined based on the volume of the unaerated zones of the reactor. The required energy for mixing usually amounts to 0.005 kW/m³ of reactor volume (De Ketele, Davister & Ikumi, 2018). This value was used to determine mixing energy in this study.

The cost of energy is based on City of Cape Town (COCT) tariffs at MPWWTP. The COCT applies a time-of-use tariff on MPWWTP, however because the average energy consumption used from the SS model, an average tariff of 208.62c/kWh was calculated for the various time-of-use periods and used.

The sludge disposal and chemical costs are based on actual costs incurred at MPWWTP for disposal of sludge and polymer (obtained from monthly operational reports). The average cost for disposal of sludge was calculated as R195/m³ while the cost of polymer is R60/kg. Based

on manufacturer specifications, on average, 7.5 kg of polymer is required per dry ton of sludge for sufficient flocculation.

Table 3-11 below summarised the operational costs used in the OCI equation. Table 3-12 summarises the components of the PWSS model which formed part of the OCI.

Table 3-11: Summary of Operational Costs

Variable	Cost
Energy Cost	208.62c/kWh
Disposal Cost	R 195/m ³
Chemical Cost	R 60/kg

Table 3-12: Components of the OCI

Unit Operation	OCI Component					
	Aeration (AE)	Pumping (PE)	Mixing (ME)	Dewatering (DE)	Chemicals (CA)	Sludge Disposal
Anoxic – MLE Reactor			✓			
Aerobic – MLE Reactor	✓					
Waste Flow MLE		✓				
RAS MLE		✓				
Anaerobic – UCT Reactor			✓			
Anoxic – UCT Reactor			✓			
Aerobic – UCT Reactor	✓					
R-Recycle – UCT Reactor		✓				
A-Recycle – UCT Reactor		✓				
Waste Flow UCT		✓				
RAS UCT		✓				
Sludge Thickening (DAF)		✓				
Sludge Dewatering				✓	✓	✓

3.8 Conclusive Summary

The methodology followed in order to obtain a conclusive and accurate results to test the hypothesis of this thesis are detailed in this Chapter. Steady state models that simulate individual process units were developed based on previous literature. The relevant models are summarized in Table 3-8. The physical characteristics of each model is based on the actual process units found at MPWWTP, which are described in Section 3.2. The individual models were linked together to form a plant-wide model such that the outputs from upstream unit process become inputs for the downstream unit process. The plant-wide steady state model is based on the work carried out by (Ekama, 2009) to develop a PWSSM.

Accurate wastewater characterisation is a critical step in the development of steady state models. (Ikumi, 2011) carried out a comprehensive characterisation of settled wastewater at MPWWTP. This characterisation was used in the development of the BNRAS models to simulate the MLE- and UCT reactors at MPWWTP.

The relevant models used to simulate individual process, as well as how they are linked together is described in this chapter. Figure 3-8 provides a schematic of the PWSSM developed and how the individual process units are linked together. The principle of conservation of mass and flow was used to evaluate the model and ensure consistent results. Mass balance calculations were carried out and used check during the various scenarios simulated.

Various scenarios were modelled and evaluated based on effluent quality (EQI) and operational cost indices (OCI) as described by (De Ketele, Davister & Ikumi, 2018). The main aim of the study is to review the impact SRTs on operational costs. Therefore, both the EQI and OCI were tailored to best suit the simulation carried out and to only indicate relevant information that is affected by the SRT of the BNRAS reactor. Parameters which aren't affected by the SRT of the BNRAS reactor, or deemed negligible were omitted from the indices calculations. The OCI, described in Section 3.7.2.2, was used to address the mains aims of this thesis. However, the main objective of any WWTP remains to produce a good quality effluent that will have the least amount of impact on the receiving environment, and therefore the EQI was also used in an evaluation of the various scenarios.

The results of the various scenarios which were simulated, using the methodology described in this chapter, is described in Chapter 4.

4 Results and Discussions

In this chapter, the outcomes produced by the model of the scenarios, described in Chapter 3.7.1, are presented and discussed. The results of the performance evaluation tool, described in Chapter 3.7.2, are presented and used to determine the correlation between the SRT of the BNRAS reactor and operational costs at MPWWTP and also the effect the SRT has on the effluent quality.

4.1 Mass Balance Verification

Before the model results were analysed to determine the correlation between SRT in the BNRAS reactors and operational costs, the mass balances were carried out on the model for the various scenarios to ensure that the model was internally consistent in tracking material of mass and flow. As mentioned in Chapter 3.6, mass balances were carried out over the model for the various scenarios. The Tables 4-1 to 4-3, below illustrate the mass balances for Scenarios 1 and 6. It was seen that the mass balance over the model for COD, N and TOD are 100%. The mass balances for all scenarios are provided with the detailed model outputs in Annexure A.

Table 4-1: COD Mass Balance

Scenario	MLE			UCT			Total			
	Q_i	8.89	ML/d	Q_i	11.11	ML/d	Q_i	20	ML/d	
1	COD _{in}	5501	kgCOD/d	COD _{in}	6877	kgCOD/d	COD _{in}	12378	kgCOD/d	100%
	COD _{out}	5501	kgCOD/d	COD _{out}	6877	kgCOD/d	COD _{out}	12378	kgCOD/d	
	$Q_e S_{te} + Q_w S_{te}$	323	kgCOD/d	$Q_e S_{te} + Q_w S_{te}$	403	kgCOD/d	$Q_e S_{te} + Q_w S_{te}$	726	kgCOD/d	
	$Q_w X_{vf_{cv}}$	1424	kgCOD/d	$Q_w X_{vf_{cv}}$	2258	kgCOD/d	$Q_w X_{vf_{cv}}$	3682	kgCOD/d	
	$V_p O_c$	3754	kgCOD/d	$V_p O_c$	4215	kgCOD/d	$V_p O_c$	7969	kgCOD/d	
6	Q_i	20	ML/d	Q_i	25	ML/d	Q_i	45	ML/d	100%
	COD _{in}	12378	kgCOD/d	COD _{in}	15473	kgCOD/d	COD _{in}	27851	kgCOD/d	
	COD _{out}	12378	kgCOD/d	COD _{out}	15473	kgCOD/d	COD _{out}	27851	kgCOD/d	
	$Q_e S_{te} + Q_w S_{te}$	726	kgCOD/d	$Q_e S_{te} + Q_w S_{te}$	908	kgCOD/d	$Q_e S_{te} + Q_w S_{te}$	1634	kgCOD/d	
	$Q_w X_{vf_{cv}}$	2882	kgCOD/d	$Q_w X_{vf_{cv}}$	5082	kgCOD/d	$Q_w X_{vf_{cv}}$	7964	kgCOD/d	
	$V_p O_c$	8770	kgCOD/d	$V_p O_c$	9483	kgCOD/d	$V_p O_c$	18253	kgCOD/d	

Table 4-2: TKN Mass Balance

Scenario	MLE			UCT			Total			
1	Q_i	8.89	ML/d	Q_i	11.11	ML/d	Q_i	20	ML/d	100%
	TKN _{in}	428	kgN/d	TKN _{in}	536	kgN/d	TKN _{in}	964	kgN/d	
	TKN _{out}	428	kgN/d	TKN _{out}	536	kgN/d	TKN _{out}	964	kgN/d	
	$Q_e N_{te} + Q_w N_{te}$	11	kgN/d	$Q_e N_{te} + Q_w N_{te}$	66	kgN/d	$Q_e N_{te} + Q_w N_{te}$	78	kgN/d	
	$Q_i N_s$	96	kgN/d	$Q_i N_s$	160	kgN/d	$Q_i N_s$	256	kgN/d	
	$Q_i N_{ne}$	321	kgN/d	$Q_i N_{ne}$	309	kgN/d	$Q_i N_{ne}$	630	kgN/d	
6	Q_i	20	ML/d	Q_i	25	ML/d	Q_i	45	ML/d	100%
	TKN _{in}	964	kgN/d	TKN _{in}	1205	kgN/d	TKN _{in}	2169	kgN/d	
	TKN _{out}	964	kgN/d	TKN _{out}	1205	kgN/d	TKN _{out}	2169	kgN/d	
	$Q_e N_{te} + Q_w N_{te}$	23	kgN/d	$Q_e N_{te} + Q_w N_{te}$	159	kgN/d	$Q_e N_{te} + Q_w N_{te}$	182	kgN/d	
	$Q_i N_s$	195	kgN/d	$Q_i N_s$	351	kgN/d	$Q_i N_s$	545	kgN/d	
	$Q_i N_{ne}$	746	kgN/d	$Q_i N_{ne}$	695	kgN/d	$Q_i N_{ne}$	1442	kgN/d	

Table 4-3: TOD Mass Balance

Scenario	MLE			UCT			Total			
1	Q_i	8.89	ML/d	Q_i	11.11	ML/d	Q_i	20	ML/d	100%
	TOD in	7460	kgO/d	TOD in	9324	kgO/d	TOD in	16784	kgO/d	
	TOD out	7460	kgO/d	TOD out	9324	kgO/d	TOD out	16784	kgO/d	
	TOD _{effluent}	347	kgO/d	TOD _{effluent}	485	kgO/d	TOD _{effluent}	832	kgO/d	
	TOD _{waste}	1889	kgO/d	TOD _{waste}	3010	kgO/d	TOD _{waste}	4899	kgO/d	
	TOD _{N2-gas}	459	kgO/d	TOD _{N2-gas}	884	kgO/d	TOD _{N2-gas}	1343	kgO/d	
	FO _t	4764	kgO/d	FO _t	4945	kgO/d	FO _t	9709	kgO/d	
6	Q_i	20	ML/d	Q_i	25	ML/d	Q_i	45	ML/d	100%
	TOD in	16784	kgO/d	TOD in	20979	kgO/d	TOD in	37763	kgO/d	
	TOD out	16784	kgO/d	TOD out	20979	kgO/d	TOD out	37763	kgO/d	
	TOD _{effluent}	814	kgO/d	TOD _{effluent}	1159	kgO/d	TOD _{effluent}	1973	kgO/d	
	TOD _{waste}	3789	kgO/d	TOD _{waste}	6704	kgO/d	TOD _{waste}	10493	kgO/d	
	TOD _{N2-gas}	1083	kgO/d	TOD _{N2-gas}	1989	kgO/d	TOD _{N2-gas}	3072	kgO/d	
	FO _t	11097	kgO/d	FO _t	11127	kgO/d	FO _t	22224	kgO/d	

4.2 Modelled Reactor Conditions

The developed PWSS model was used to simulated various scenarios, as described in Chapter 3.7.1. The results produced from the various scenarios influence the parameters used to evaluate the performance of WWTP in terms of the OCI and EQI described in Chapter 3.7.2. In this

chapter, various reactor conditions are assessed to determine the effect of reactor SRT and influent flow rate on these conditions.

4.2.1 Reactor Sludge Masses and Concentrations

The predicted reactor concentrations at a temperature of 16°C are presented in Table 4-4 below. The explicit equations used to predict the activated sludge masses are all directly linked to the flux of influent organic and inorganic materials, as well as the SRT of the reactor. It is therefore expected that mass of suspended solids in the reactors will increase with an increase in SRT and influent flow rate. This is illustrated in Figure 4-1 and Figure 4-2 respectively.

Table 4-4: Predicted Reactor Concentrations (@ 16°C)

Total Flow (ML/d)	Flow MLE (ML/d)	Flow UCT (ML/d)	SRT (days)	MLE		UCT		
				TSS (kg)	Xt (mgTSS/l)	TSS (kg)	Xtaer (mgTSS/l)	Xtanaer (mgTSS/l)
20	8.89	11.11	10	17516	1422	23617	2093	1046
			15	23729	1926	31933	2830	1415
			20	29621	2404	39744	3522	1761
			25	35355	2870	47258	4188	2094
			30	40998	3328	54548	4834	2417
25	11.11	13.89	10	21895	1777	29521	2616	1308
			15	29662	2408	39916	3537	1769
			20	37027	3005	49679	4402	2201
			25	44193	3587	59072	5235	2617
			30	51247	4160	68185	6042	3021
30	13.33	16.67	10	26274	2133	35425	3139	1570
			15	35594	2889	47900	4245	2122
			20	44432	3607	59615	5283	2641
			25	53032	4305	70887	6282	3141
			30	61497	4992	81821	7250	3625
35	15.56	19.44	10	30653	2488	41330	3662	1831
			15	41526	3371	55883	4952	2476
			20	51838	4208	69551	6163	3082
			25	61871	5022	82701	7328	3664
			30	71746	5824	95458	8459	4229
40	17.78	22.22	10	35032	2844	47234	4186	2093
			15	47459	3852	63866	5659	2830
			20	59243	4809	79757	7068	3534
			25	70709	5739	95618	8473	4237

				MLE		UCT		
Total Flow (ML/d)	Flow MLE (ML/d)	Flow UCT (ML/d)	SRT (days)	TSS (kg)	Xt (mgTSS/l)	TSS (kg)	Xtaer (mgTSS/l)	Xtanaer (mgTSS/l)
			30	81996	6655	112122	9936	4968
45	20.00	25.00	10	39411	3199	53138	4709	2354
			15	53391	4334	71849	6367	3183
			20	66648	5410	89423	7924	3962
			25	79548	6457	106330	9422	4711
			30	92245	7487	122732	10876	5438

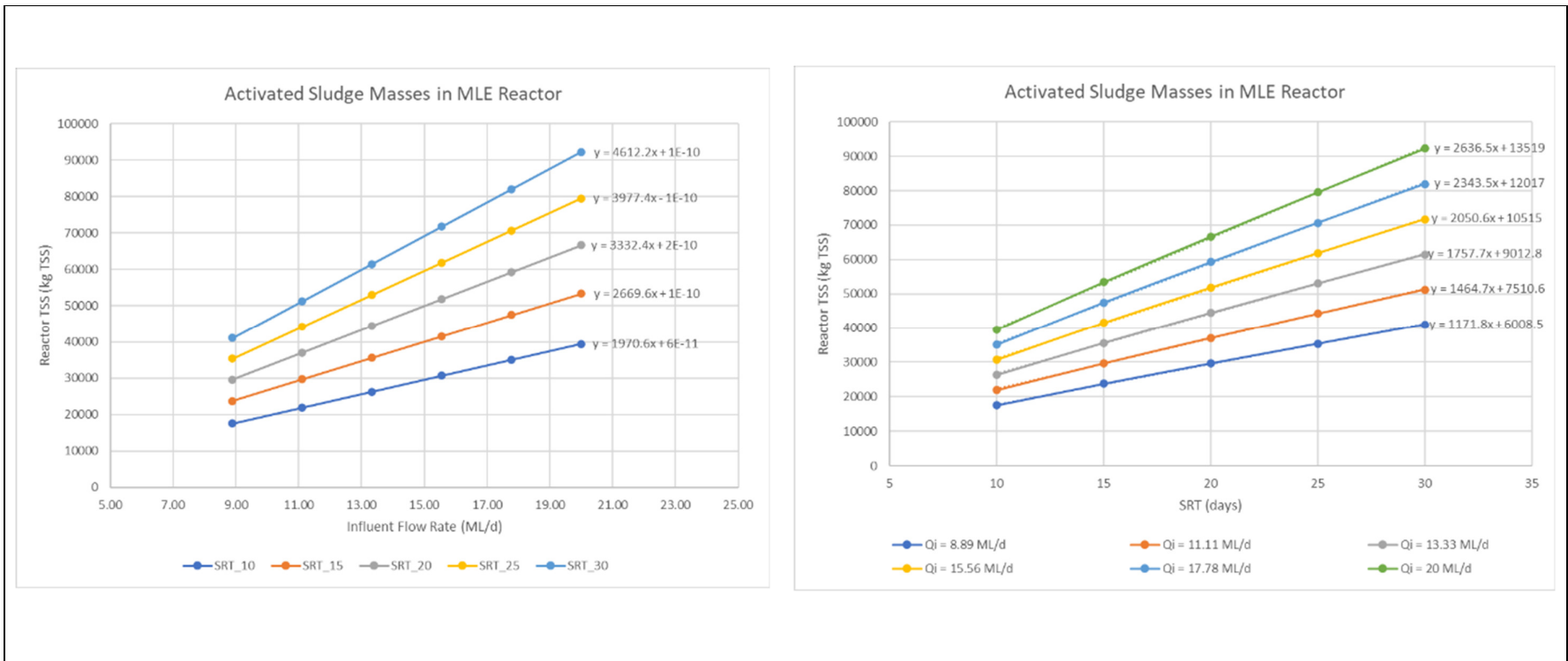


Figure 4-1: Predicted Activated Sludge Masses in MLE Reactor @ 16°C

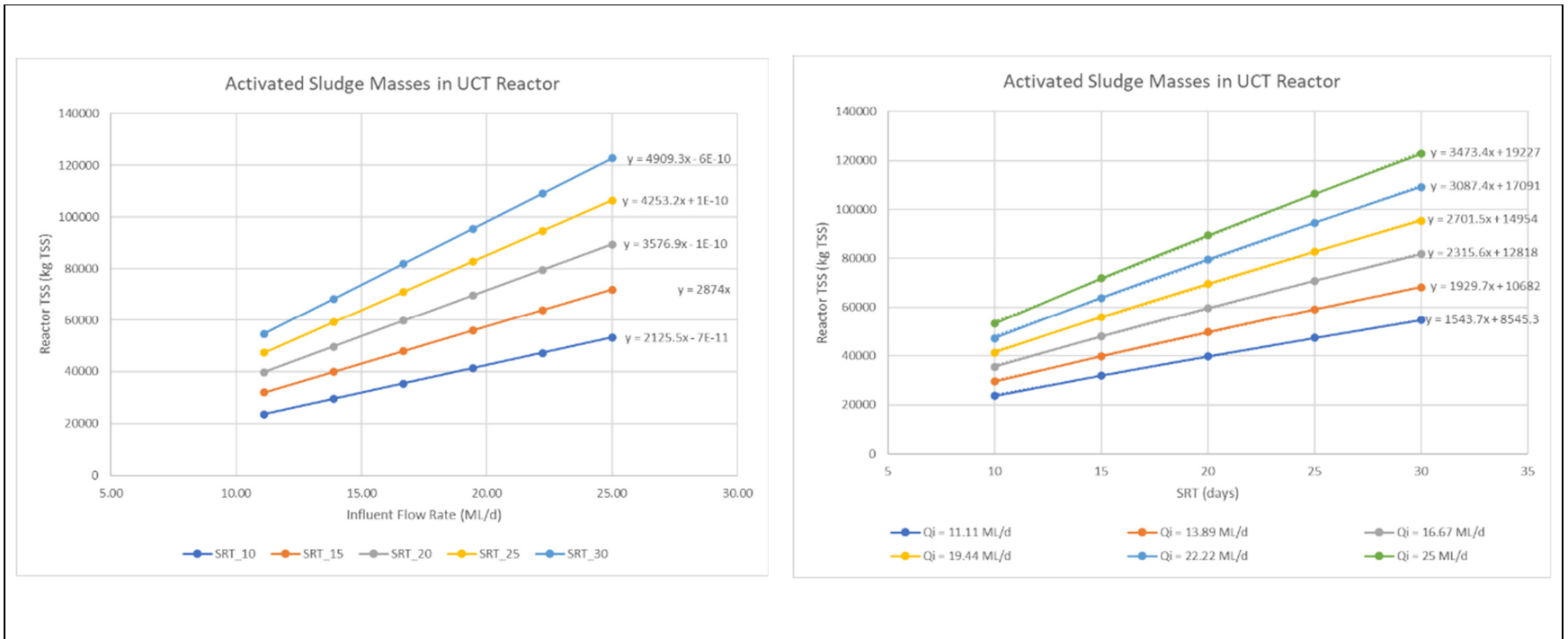


Figure 4-2: Predicted Activated Sludge Masses in UCT Reactor @ 16°C

The expected linear correlation between the sludge mass present in the reactor and the influent flow rate and SRT respectively, is seen in the figures above. It is further seen that the UCT reactor sludge mass is predicted to be between 6.4% and 7.9% higher than that of the MLE reactor for similar influent flow rates. At similar SRT's the activated sludge mass in the UCT reactor is predicted to be between 33.3% and 35.3% higher than that found in the MLE reactor. This is because the PAOs, found in the UCT system, accumulate a higher active biomass, as explained further in Section 4.2.2 below.

4.2.2 Reactor Active Fractions

The predicted active sludge masses in the MLE and UCT at a temperature of 16°C are presented in Figure 4-3 and Figure 4-4 respectively. The model results indicate a linear correlation between active sludge mass in the reactor and influent flow, while a 3rd order polynomial correlation was found between active sludge mass and the SRT. These correlations are illustrated in Figure 4-5 and Figure 4-6 respectively.

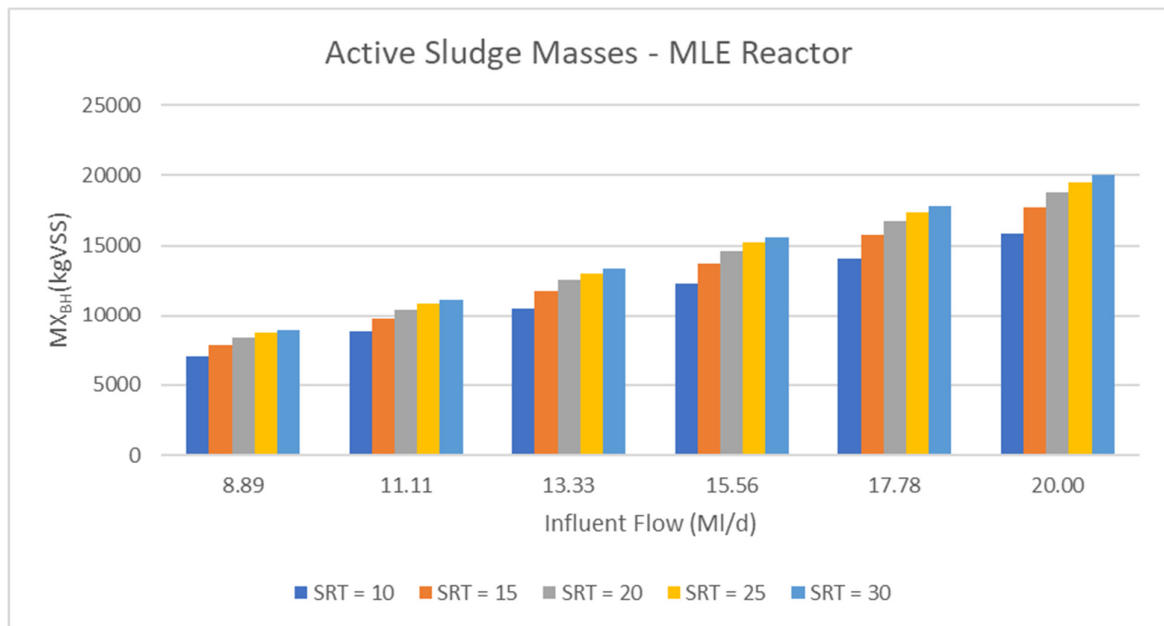


Figure 4-3: Activated Sludge Masses in MLE Reactor

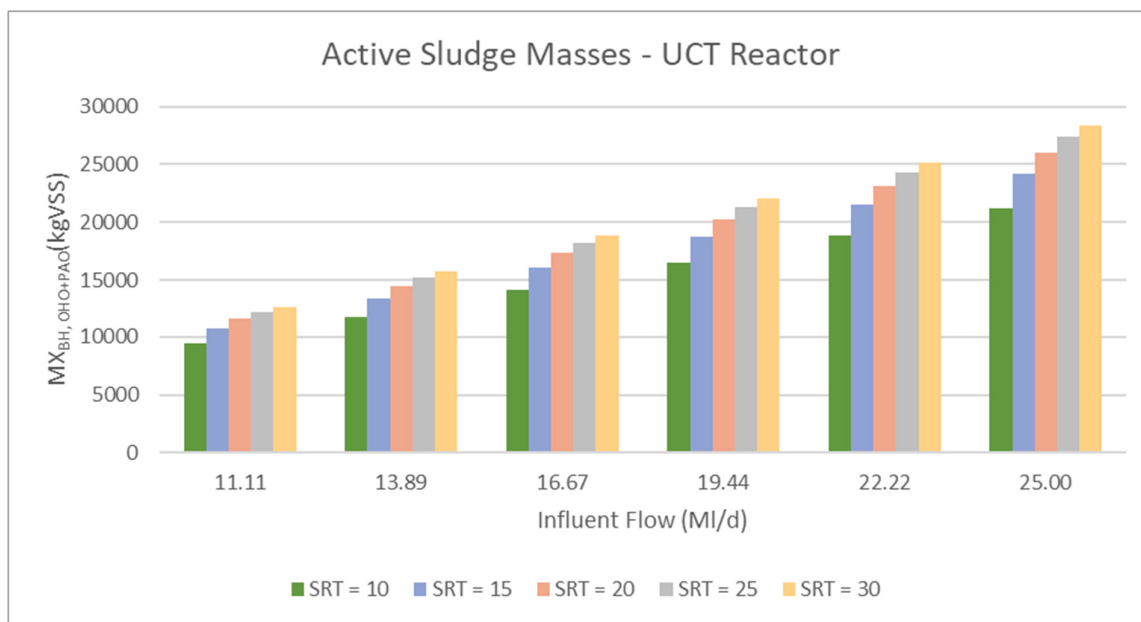


Figure 4-4: Activated Sludge Masses in UCT Reactor

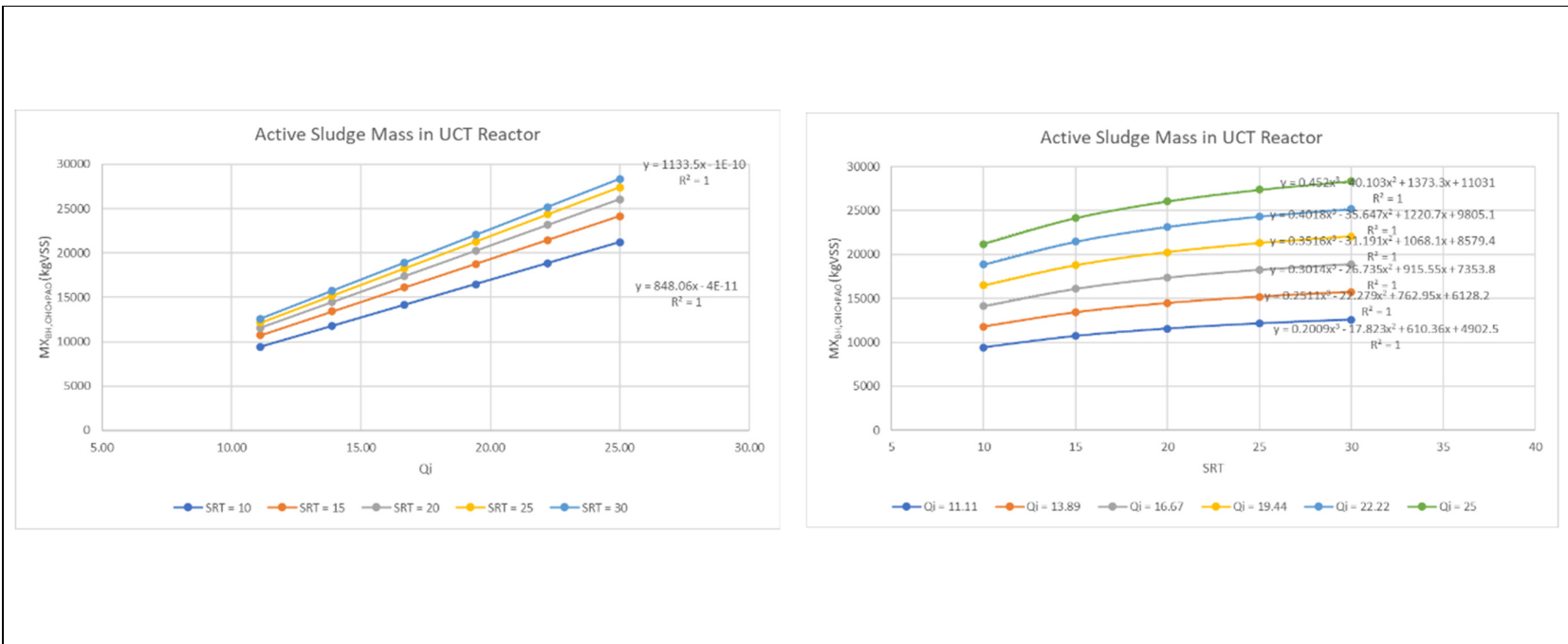


Figure 4-5: Correlation between MX_{BH} and SRT and MX_{BH} and Q_i in the UCT Reactor

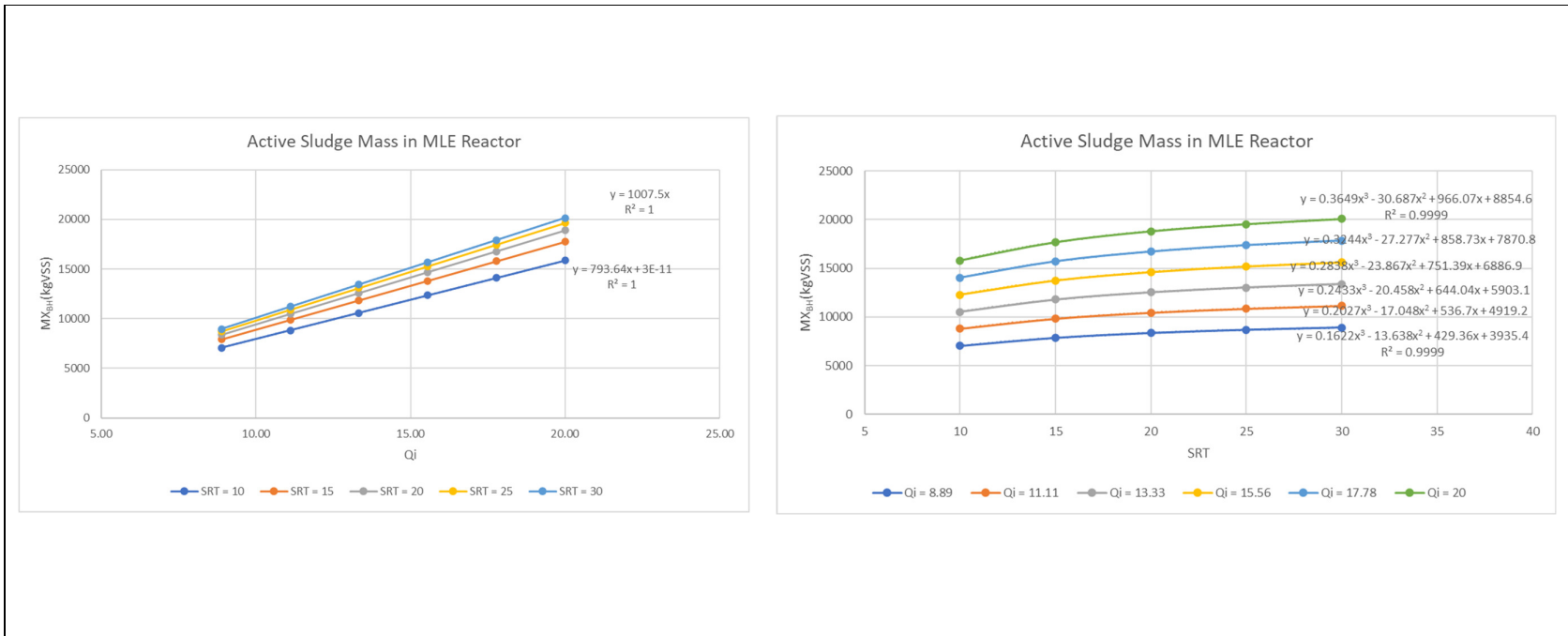


Figure 4-6: Correlation between MX_{BH} and SRT and MX_{BH} and Q_i in the MLE Reactor

It was found that the model predicted a higher active sludge mass for the UCT reactor when compared to the MLE reactor for the same inflow and SRT. This is due to the Polyphosphate Accumulating Organisms (PAOs) which are present in the UCT reactor, but not the MLE reactor. While the yield coefficient of PAOs (mgVSS/mgCOD) is similar to that of Ordinary Heterotrophic Organisms (OHOs), the endogenous respiration rate of PAOs (0.04/d at 20°C) is lower than that of OHOs (0.24/d at 20°C). The finding that the UCT system has a higher active sludge mass compared to the MLE system is therefore consistent with expectations.

Generally, the active fraction (f_{at}) of activated sludge mass will decrease with an increase in SRT, due to endogenous respiration of the organisms. Since the endogenous respiration rate of PAOs is lower than that of OHOs, the active fraction of sludge in a MLE system will decrease at higher rate than that of an UCT system as the SRT increases. The higher the active fraction present in a BNR reactor is, the higher the removal rate of COD and TKN (and TP for UCT systems) will be. While this is beneficial in a BNR reactor, a high active fraction in WAS is not generally ideal because the active biomass is largely biodegradable organics that require further sludge treatment prior to disposal. Figure 4-7 illustrates the active fractions predicted for both the MLE and UCT reactors. It is seen that the f_{at} in the UCT reactor is lower than that of the MLE reactor at SRT of 10 days, but higher at an SRT of 30 days.

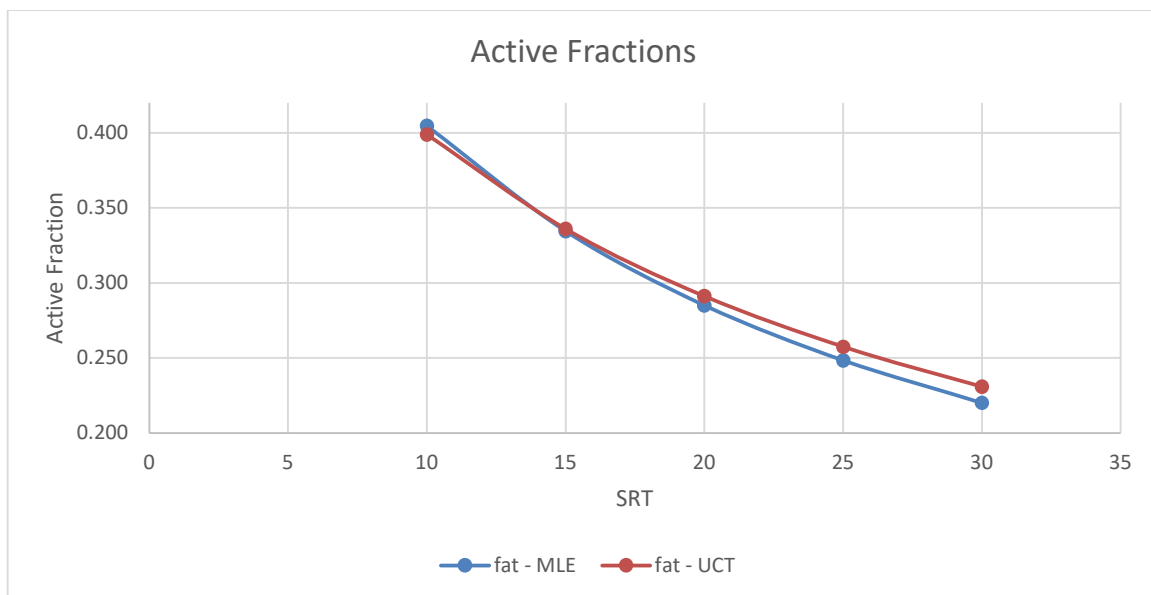


Figure 4-7: Predicted Active Fractions in MLE and UCT reactors

As previously mentioned, a high active fraction in WAS is not ideal for sludge disposal. Figure below illustrates the combined mass of active sludge wasted per day as well as the combined active fractions.

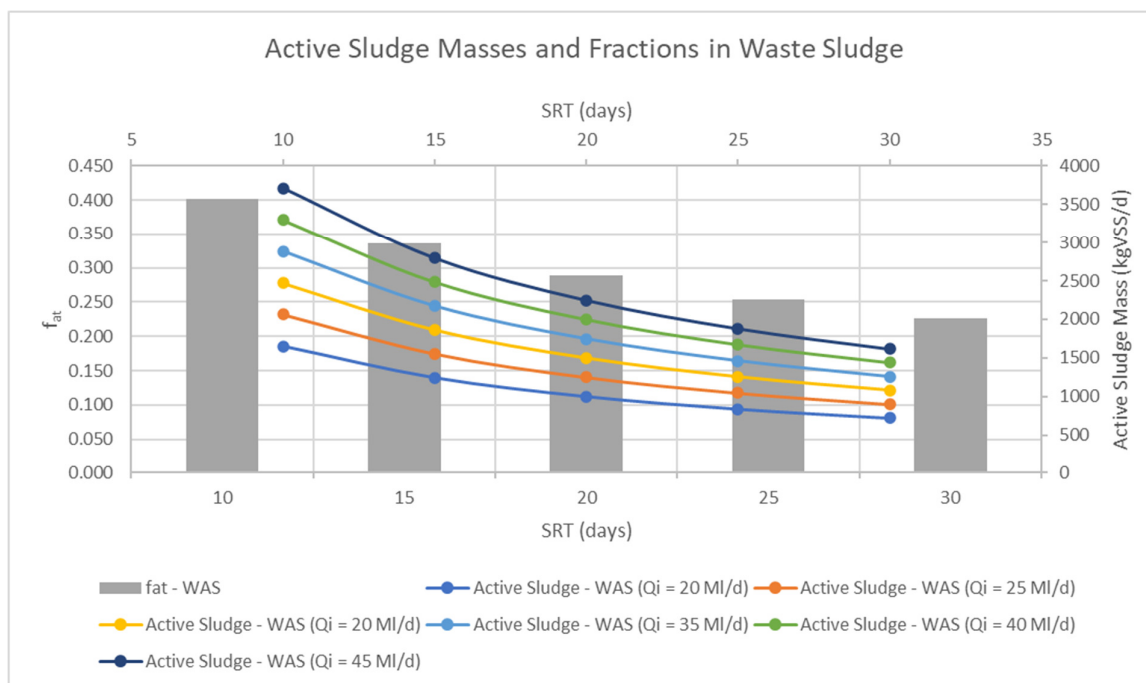


Figure 4-8: Active Sludge Masses and Fractions in Waste Sludge (Combined)

4.2.3 Aeration Requirements

The aeration requirement in a BNR reactor is determined by the total oxygen demand (FO_T). The FO_T is calculated by adding the carbonaceous oxygen flux (FO_C) and the nitrogenous oxygen flux (FO_N) and deducting the oxygen recovered by denitrification (FO_D). Figure 4-9 illustrates the FO_T in the MLE reactor at 16°C and 24°C respectively for a range of inflows and SRTs. Figure 4-10 illustrates the Total Oxygen Demand in the UCT reactor at 16°C and 24°C respectively for a range of inflows and SRTs.

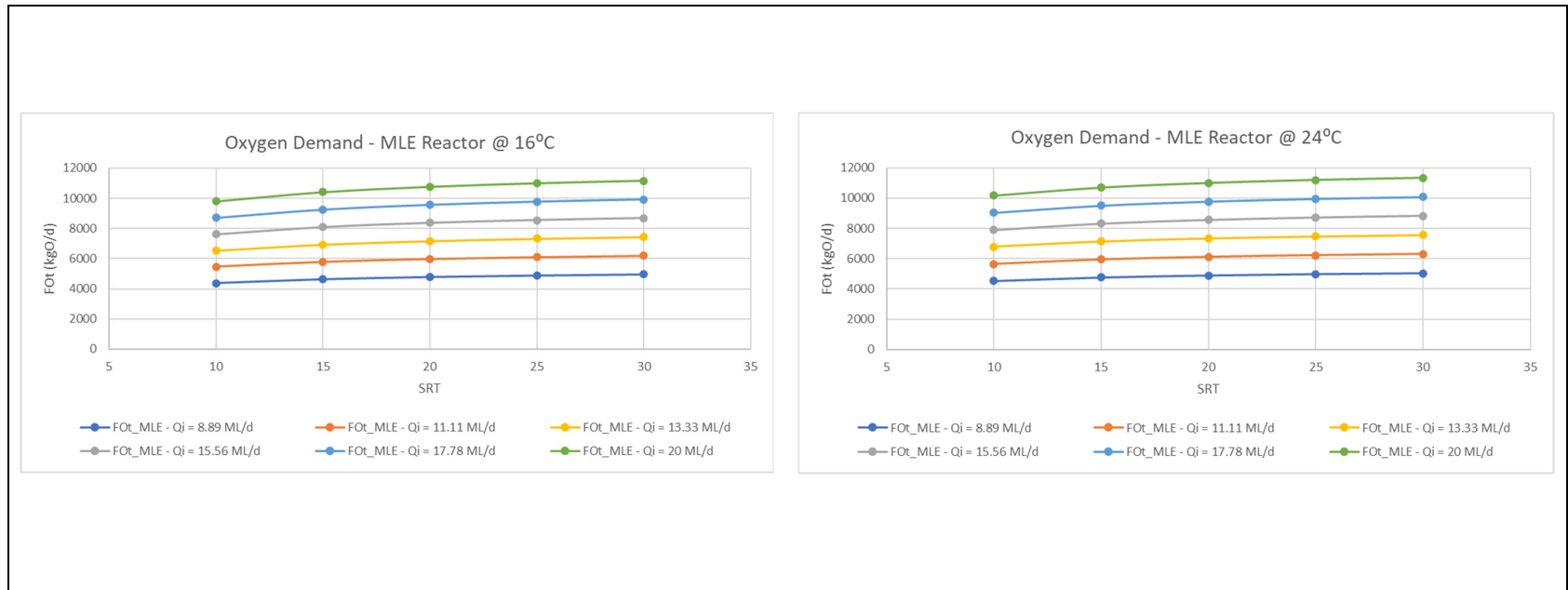


Figure 4-9: Oxygen Demand in MLE Reactor

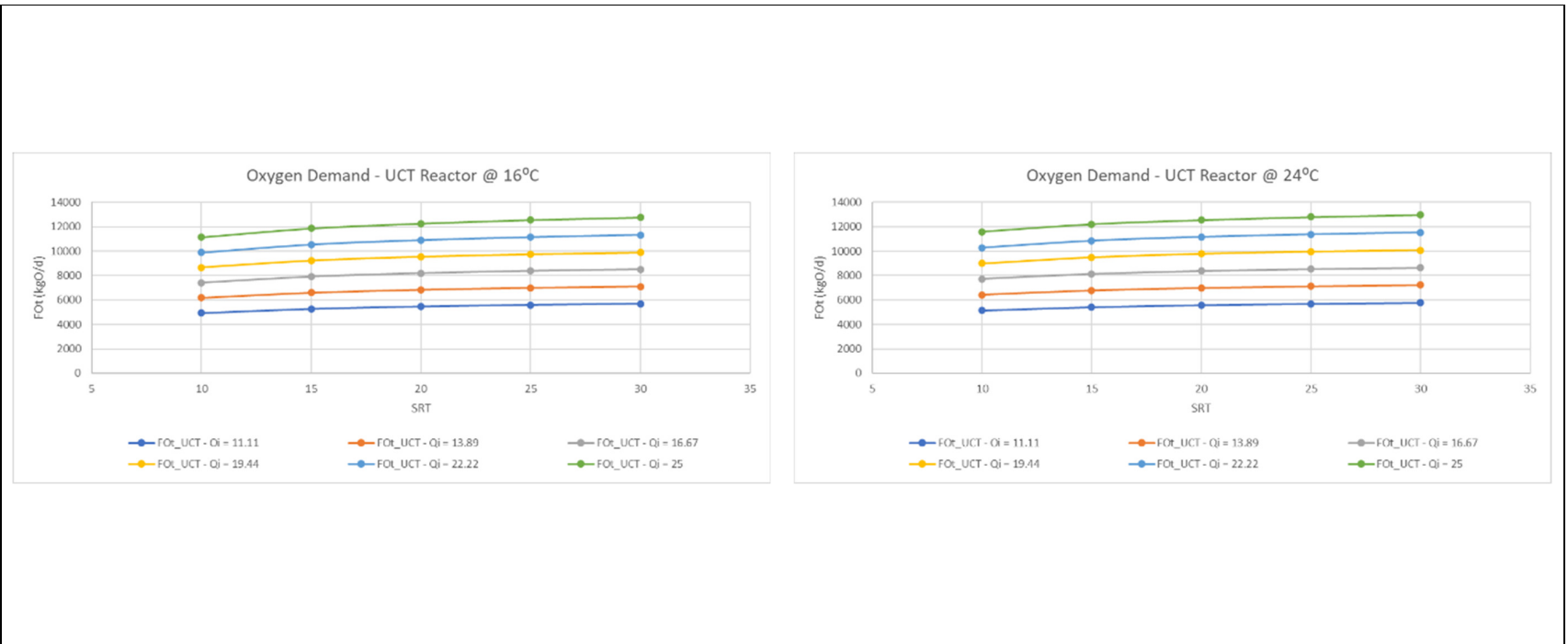


Figure 4-10: Oxygen Demand in UCT Reactor

The oxygen demand increases linearly with an increase in influent. This is due to the fact that the oxygen demand is linearly correlated to the flux of COD and TKN which enters the reactor. It is further shown that the rate of increase in oxygen demand decreases with an increase in SRT. The endogenous respiration process decreases the active fraction in the reactor with an increase in SRT. The amount of active biomass in the reactor, which utilises oxygen in the biological nutrient removal process, is proportionally lower at higher SRTs when compared to lower SRTs, and therefore rate of increase in oxygen demand decreases with an increase in SRT.

The oxygen utilization rate of the biomass will increase with an increase in the water temperature. This is due to the increase in the endogenous respiration rate of both OHO's and PAO's with an increase in temperature. However, it is notable that the percentage increase in oxygen utilization rate of the biomass, at higher temperatures, decreases as the SRT increases. This is illustrated in Figure 4-11 below.

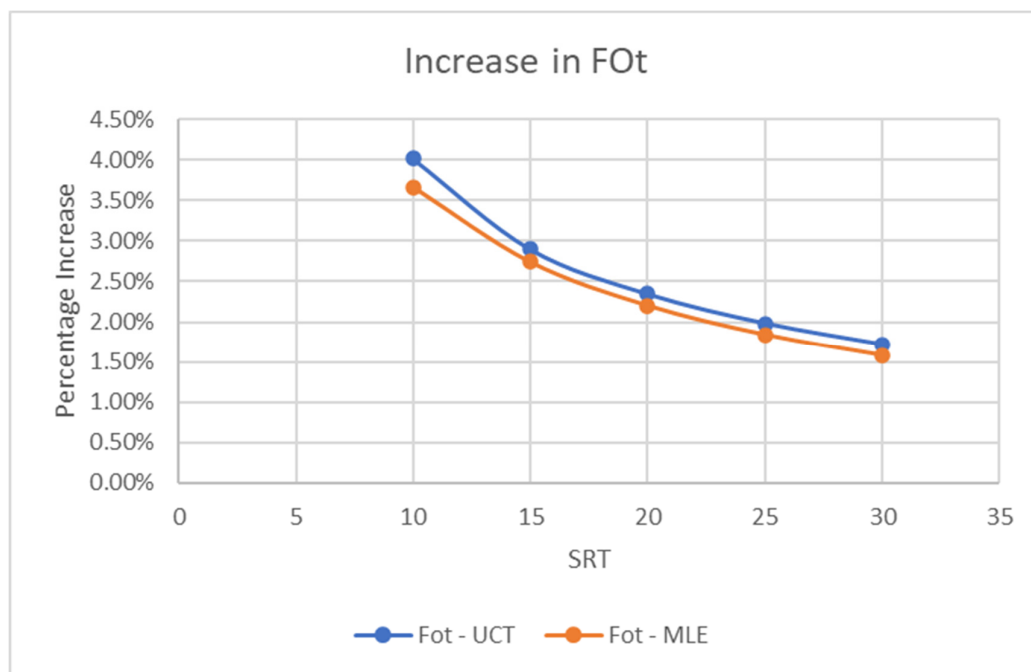


Figure 4-11: Percentage increase in FO_T at 24°C compared to 16°C

Based on the oxygen demand, the average daily power consumption was determined for the two BNR reactors, as described in Chapter 3.5. Table 4-5 and Table 4-6 illustrate the average daily power consumption for the MLE and UCT reactors respectively.

Table 4-5: Power Consumption for MLE Reactor

Flow	SRT	16°C		24°C	
		Actual Power Required (kW)	Ave Power Consumption (kWh)	Actual Power Required (kW)	Ave Power Consumption (kWh)
8.89	10	144.39	3465.37	152.18	3652.32
	15	153.24	3677.77	160.07	3841.62

Flow	SRT	16°C		24°C	
		Actual Power Required (kW)	Ave Power Consumption (kWh)	Actual Power Required (kW)	Ave Power Consumption (kWh)
	20	158.42	3802.11	164.61	3950.70
	25	161.84	3884.13	167.57	4021.68
	30	164.26	3942.36	169.65	4071.57
11.11	10	174.57	4189.60	180.97	4343.16
	15	185.27	4446.39	190.34	4568.27
	20	191.53	4596.72	195.75	4697.99
	25	195.66	4695.88	199.27	4782.40
	30	198.59	4766.27	201.74	4841.71
13.33	10	209.48	4791.20	217.16	5211.80
	15	222.32	5211.80	228.41	5481.93
	20	229.84	5481.93	234.90	5637.59
	25	234.79	5637.59	239.12	5738.88
	30	238.31	5738.88	242.09	5810.06
15.56	10	244.39	5589.73	253.35	6080.43
	15	259.37	6080.43	266.48	6395.58
	20	268.14	6395.58	274.05	6577.19
	25	273.93	6577.19	278.97	6695.36
	30	278.03	6695.36	282.43	6778.40
17.78	10	279.31	6388.26	289.54	6949.06
	15	296.43	6949.06	304.55	7309.24
	20	306.45	7309.24	313.20	7516.79
	25	313.06	7516.79	318.83	7651.84
	30	317.75	7651.84	322.78	7746.74
20	10	314.22	7186.80	325.74	7817.70
	15	333.48	7817.70	342.62	8222.89
	20	344.75	8222.89	352.35	8456.38
	25	352.19	8456.38	358.68	8608.32
	30	357.47	8608.32	363.13	8715.09

Table 4-6: Power Consumption for UCT Reactor

Flow	SRT	16°C		24°C	
		Actual Power Required (kW)	Ave Power Consumption (kWh)	Actual Power Required (kW)	Ave Power Consumption (kWh)
11.11	10	166.56	3997.39	173.26	4158.19
	15	177.60	4262.51	182.75	4386.09
	20	183.98	4415.63	188.30	4519.20
	25	188.24	4517.68	191.97	4607.19
	30	191.31	4591.54	194.60	4670.40
13.89	10	208.20	4996.74	216.57	5197.74

Flow	SRT	16°C		24°C	
		Actual Power Required (kW)	Ave Power Consumption (kWh)	Actual Power Required (kW)	Ave Power Consumption (kWh)
	15	222.01	5328.13	228.44	5482.62
	20	229.98	5519.53	235.37	5648.99
	25	235.30	5647.11	239.96	5758.98
	30	239.08	5738.04	243.19	5836.60
16.67	10	249.84	5996.08	259.89	6237.29
	15	266.41	6393.76	274.13	6579.14
	20	275.98	6623.44	282.45	6778.79
	25	282.21	6772.93	287.80	6907.11
	30	286.42	6874.05	291.34	6992.14
19.44	10	277.29	6654.91	303.20	7276.84
	15	295.68	7096.28	319.82	7675.67
	20	306.18	7348.36	329.40	7905.54
	25	312.73	7505.62	335.25	8046.00
	30	317.10	7610.43	339.05	8137.31
22.22	10	333.12	7994.78	346.52	8316.39
	15	355.21	8525.01	365.51	8772.19
	20	367.38	8817.15	376.00	9023.96
	25	375.46	9011.15	382.90	9189.71
	30	381.60	9158.50	388.16	9315.85
25	10	374.76	8994.12	389.83	9355.93
	15	399.35	9584.50	410.93	9862.38
	20	412.65	9903.53	422.33	10135.84
	25	422.64	10143.33	431.01	10344.32
	30	429.55	10309.19	436.93	10486.30

4.2.4 Sludge Production

The waste flow rate, or the amount of sludge to be wasted per day, is directly proportional to the SRT of a BNRAS reactor. The mass of sludge wasted per day is calculated as the mass of sludge in the reactor divided by the SRT (Sludge production = MX_{TSS}/SRT). The waste flow rate is then calculated by dividing the mass of sludge produced with the reactor concentration. Therefore, at lower SRTs, sludge production will be higher. Furthermore, the waste flow rate will not change with a change in the influent flow rate, only the mass of sludge that is wasted (i.e. the waste sludge has a higher concentration mgTSS/l). Table 4-7 below presents that calculated waste flow rates for the two separate process trains at MPWWTP.

Table 4-7: Calculated Waste Flow Rates

SRT	MLE Waste Flow Rate (ML/d)	UCT Waste Flow Rate (ML/d)	Total Waste Flow Rate (ML/d)
10	1.23	1.13	2.36
15	0.82	0.75	1.57
20	0.62	0.56	1.18
25	0.49	0.45	0.94
30	0.41	0.38	0.79

It is seen from Table 4-7 that the waste flow rates decrease significantly with an increase in SRT. The waste flow rate at an SRT of 30 days decreases 66.7% when compared to the waste flow rate at an SRT of 10 days.

Figure 4-12 below presents the mass of sludge wasted per day for the two different reactors at a range of inflows at various SRTs. It clearly illustrates the decrease in the mass of sludge wasted per day with an increase in SRT. For the MLE reactor, the mass of sludge wasted per day at an SRT of 30 days decreases by 22.2% when compared to the mass of sludge wasted per day at an SRT of 10 days. The corresponding value for the UCT reactor is very similar, with a 22.7% decrease in mass of waste sludge.

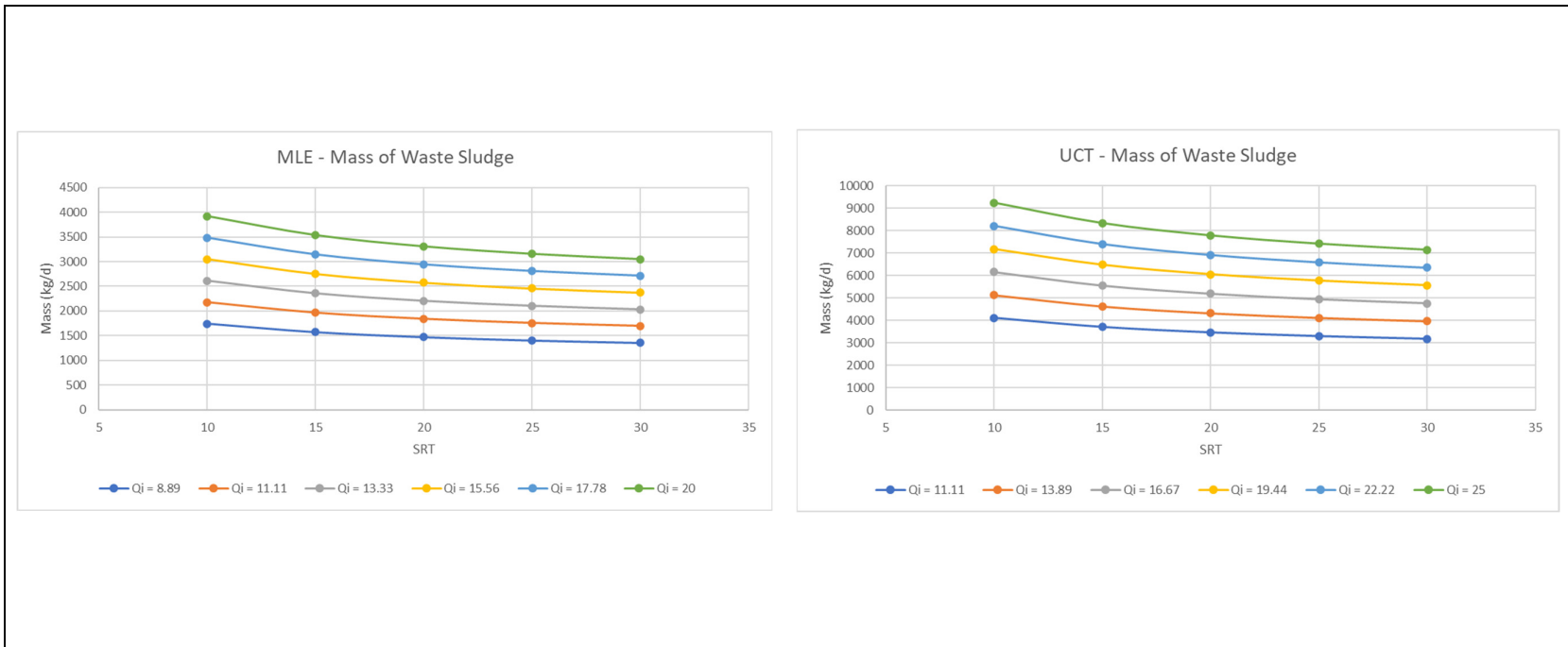


Figure 4-12: Mass of waste sludge per day for the MLE and UCT reactors at various flow rates and SRTs

4.3 Performance Evaluation

4.3.1 Effluent Quality (EQI)

The effluent quality index (EQI) equation, as described in Chapter 3.7.2.1, was applied to the range of flows over the various SRTs. Figure 4-13 illustrates the EQI for the various influent flow rates over a range of SRTs. The modelled results from the MLE and UCT reactor were combined to determine the combined EQI. It is seen that the EQI decreases with an increase in sludge age. Furthermore, as the model only simulates a steady state, the effluent concentrations for the various constituents does not change with a change in influent flow rate. The EQI increases with flow rate as the effluent flow rate, hence pollutant loading, increases.

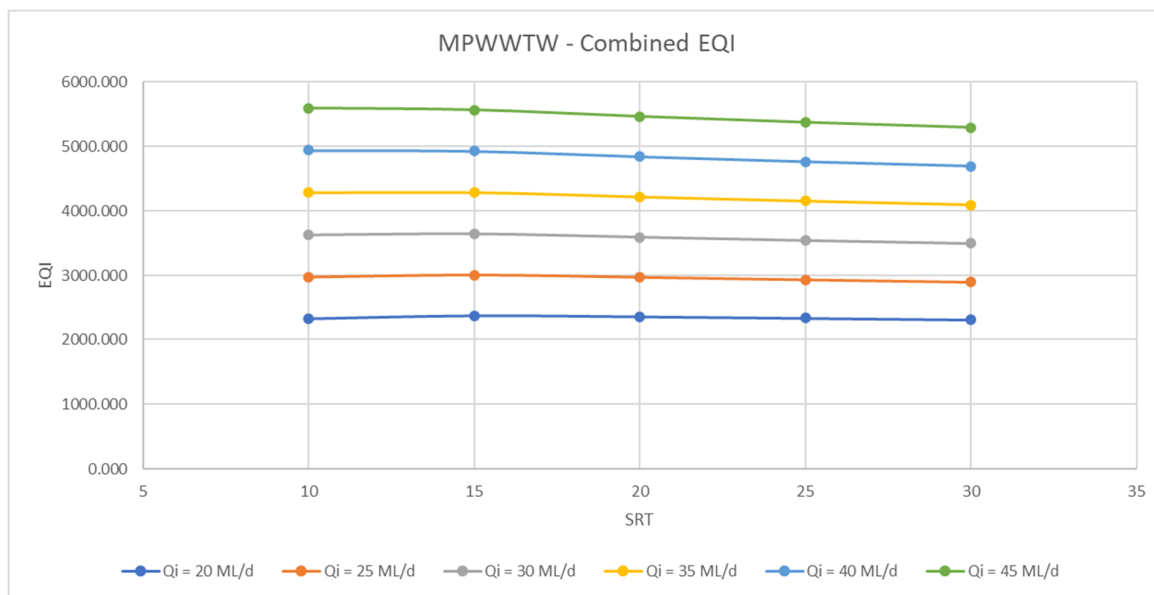


Figure 4-13: MPWWTP Modelled EQI

It was seen that the effluent from the MLE reactor negatively affected the effluent quality of the overall plant, specifically the effluent concentrations of nitrates and ortho-phosphates. An MLE configuration is not designed for the treatment of phosphorus (P), the only reduction in P is via the small contribution of P as a nutrient required for biomass growth. The P that forms part of the biomass then exits the system via the waste flow. Hence the increased quantity of active biomass results in higher P used as a growth nutrient. Therefore, since at higher SRT's there is a notable increase in active sludge mass (see Figure 4-5), the EQI reduces with an increase in SRT. The absence of an a-recycle flow as well as the low amount of VFA's in the influent flow was seen as the main contributing factors to the high concentration of nitrates in the effluent.

It was found that the effluent quality of the UCT reactor complies with the discharge limits, and therefore only yielded positive EQI values. The positive and negative EQI values, as well as

the modelled effluent concentrations for the two reactors, at an overall influent flow of 45 ML/d is illustrated in Table 4-8 below.

Table 4-8: Effluent Concentrations and EQI values for the MLE and UCT reactors at MPWWTP

		MLE					UCT				
Flow		20					25				
SRT		10	15	20	25	30	10	15	20	25	30
Pollutant	Limit										
Effluent COD (mgCOD/l)	75	36.30	36.30	36.30	36.30	36.30	36.30	36.30	36.30	36.30	36.30
Effluent FSA (mgN/l)	10	0.81	0.46	0.35	0.29	0.25	1.78	0.79	0.55	0.44	0.38
Effluent NO ₃ (mgN/l)	15	16.61	17.59	18.13	18.47	18.72	3.97	4.30	4.45	4.55	4.62
Effluent OP (mgP/l)	10	11.58	11.99	12.23	12.38	12.50	8.67	9.57	10.15	10.58	10.94
EQI _{Positive}		2019.86	2113.83	2153.52	2175.84	2190.23	3949.6	3988.8	3939.1	3886.1	3834.9
EQI _{Negative}		-373.54	-533.71	-626.50	-687.66	-731.09	-	-	-	-	-

4.3.2 Operational Cost (OCI)

The operational costs for the various inflows and SRT's were calculated based on the OCI equation as described in Chapter 3.7.2.2. As the model simulates the steady state, the operational cost are provided as a R/ML value to assess the effect of SRT on the simulated operational cost of MPWWTP.

The steady state model produced a constant R/ML value for all parameters except the energy required for mixing, due to the fact that the mixing energy does not change with the inflow but is a factor of the reactor volume. The detailed operational cost breakdown is provided in Annexure C.

Table 4-9 below illustrates the simulated daily operational costs at MPWWTP at varying SRT's at an overall influent flow of 45 ML/d.

Table 4-9: Overview of Major OCI drivers

	Fow (ML/d)	SRT	Aeration Energy (kWh/d)	Pumping Energy (kWh/d)	Mixing Energy (kWh/d)	Dewatering Energy (kWh/d)	Polymer Usage (kg/d)	Sludge disposal (m ³ /day)	OCI Total Cost (R/d)
MLE	20	10	7541	502.1	219.4	208.3	29.4	21.8	R23 684.41
		15	8003	499.5	219.4	187.9	26.5	18.7	R23 824.07
		20	8274	498.3	219.4	175.8	24.8	17.8	R24 083.18
		25	8453	497.6	219.4	167.8	23.7	17.1	R24 242.50
		30	8579	497.2	219.4	162.1	22.9	16.6	R24 350.24
UCT	25	10	8994	960.3	585.6	282.3	69.3	29.5	R32 489.82
		15	9584	959.1	585.6	254.5	62.5	26.6	R32 685.17
		20	9904	958.6	585.6	237.5	58.4	24.8	R32 722.88
		25	10143	958.3	585.6	226.0	55.6	23.6	R32 796.29
		30	10309	958.2	585.6	217.3	53.6	22.7	R32 827.07
Total	45	10	16535	1462.4	805	490.6	98.7	51.3	R56 174.23
		15	17587	1458.6	805	442.4	89	45.3	R56 509.24
		20	18178	1456.9	805	413.3	83.2	42.6	R56 806.06
		25	18596	1455.9	805	393.8	79.3	40.7	R57 038.79
		30	18888	1455.4	805	379.4	76.5	39.3	R57 177.31

As previously mentioned, all of the above parameters, with the exception of Mixing Energy, have a constant R/ML value for varying inflows at a constant SRT. The R/ML values are illustrated in Table 4-10 below.

Table 4-10: Operational Costs in Rand per ML

	SRT	Aeration Cost (R/ML)	Pumping Cost (R/ML)	Mixing Cost (R/ML)*	Dewatering Cost (R/ML)	Polymer Cost (R/ML)	Sludge disposal Cost (R/ML)	OCI Total Cost (R/ML)
MLE	10	R786.63	R52.37	R22.88	R21.73	R88.22	R212.38	R1 184.22
	15	R834.84	R52.10	R22.88	R19.60	R79.60	R182.17	R1 191.20
	20	R863.07	R51.98	R22.88	R18.34	R74.47	R173.42	R1 204.16
	25	R881.69	R51.91	R22.88	R17.50	R71.07	R167.07	R1 212.12
	30	R894.91	R51.87	R22.88	R16.91	R68.65	R162.30	R1 217.51
UCT	10	R750.54	R80.14	R48.87	R23.56	R166.23	R230.27	R1 299.59
	15	R799.81	R80.04	R48.87	R21.23	R149.90	R207.56	R1 307.41
	20	R826.43	R79.99	R48.87	R19.82	R140.06	R193.75	R1 308.92
	25	R846.44	R79.97	R48.87	R18.86	R133.41	R184.31	R1 311.85
	30	R860.28	R79.96	R48.87	R18.14	R128.56	R177.28	R1 313.08
Total	10	R1 537.17	R132.51	R71.75	R45.28	R254.45	R442.65	R2 483.81
	15	R1 634.65	R132.14	R71.75	R40.84	R229.50	R389.74	R2 498.61
	20	R1 689.50	R131.97	R71.75	R38.16	R214.53	R367.17	R2 513.07
	25	R1 728.13	R131.88	R71.75	R36.36	R204.48	R351.38	R2 523.98
	30	R1 755.19	R131.83	R71.75	R35.04	R197.21	R339.58	R2 530.59

*The Mixing cost remains constant with SRT, but changes with inflow as it is based on the volume of the reactor.

From Table 4-10 it is clearly seen that the model predicted operational costs will increase with an increase in SRT. The predicted operational costs in R/ML are approximately 2.8% higher for an SRT of 30 days when compared to a SRT of 10 Days. The cost of all the major OCI drivers, with the exception of aeration costs, reduces with an increase in SRT, but the aeration costs at higher SRT's increases at such a rate that the overall operational costs of the WWTP increase with an increase in SRT. At an SRT of 10 days, aeration costs account for approximately 61.9% of the overall operational costs. At an SRT of 30 days, this percentage increases to approximately 69.4%. The percentage contribution of aeration costs roughly correlates with the findings of (Van Niekerk, 2022), described in Chapter 2.3.2. The proportional make-up of the major OCI drivers is illustrated in Figure 4-14.

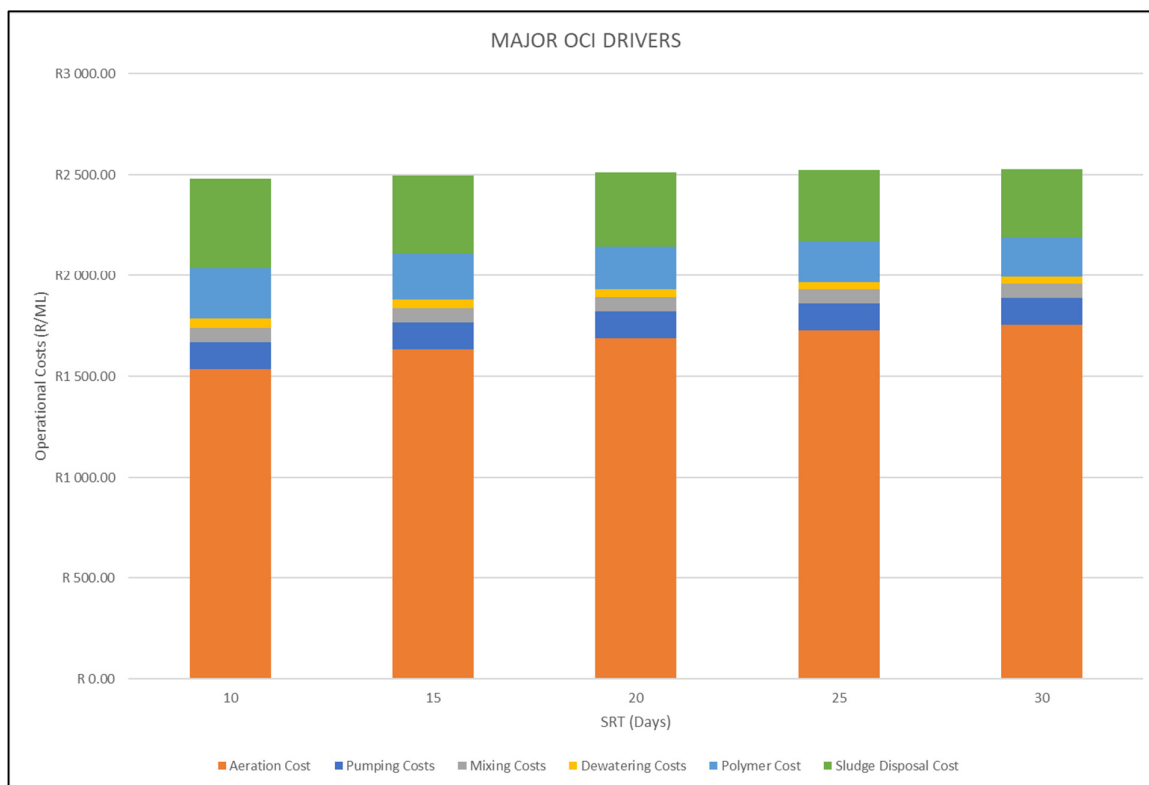


Figure 4-14: Major OCI Drivers

The aeration costs can be reduced by dosing VFA's as this will increase the oxygen demand recovery that materializes from denitrification. The addition of VFA dosing will however add an additional OCI driver. The effect of VFA dosing on the overall OCI of the WWTP was not considered during this study but could be investigated in the future to determine possible operational cost savings.

Furthermore, the addition of VFA's could positively impact the effluent quality that can be achieved by the process, especially at the MLE reactor. To achieve a better effluent quality at the MLE reactor through means of VFA dosing, the additional of an A-recycle will however be required.

5 Conclusions and Recommendations

5.1 Conclusion

The aim of this study is to find the correlation between electrical energy consumption cost and the operational cost of sludge handling to solids retention times (SRT) to determine the effect of operation of AS plants at extended SRT's on the overall operational costs.

This was done by developing a steady state model to replicate the individual process units at Mitchells Plain WWTP (MPWWTP) and simulating various SRT's at various influent flow rates. The lowest SRT assessed was selected based on the minimum amount of time required for nitrification, while the maximum SRT was selected based on the capacity of the secondary settling tanks, thus ensuring a comparable effluent quality.

The various scenarios were evaluated using the EQI and OCI performance indices developed by the IWA benchmark simulation task group (Copp, 2002, Nopens *et al.*, 2010), and modified by (De Ketele, Davister & Ikumi, 2018). These performance indices were then further modified, as described in Chapter 3.7.2, to be improve the relevance to this study.

The study found that the average electrical energy (kWh) required for aeration in the MLE reactor increased by 13.8% from a SRT of 10 days to a SRT of 30 days. The average electrical energy (kWh) for aeration in the UCT reactor increase by 14.7% over the same SRT periods (refer to Section 4.2.3). It was further found that the average electrical energy required for pumping, decreased between a range of 2.1% and 1% from a SRT of 10 days to a SRT of 30 days over the range of flows considered. Electrical energy required for dewatering was also found to decrease with an increase in SRT (22% from 10 days to 30 days), while mixing energy remains constant. Since the majority of the electrical consumption can be attributed to aeration, the increase of electrical energy consumption with SRT of aeration is not offset be the decrease with SRT of the other OCI drivers. The study found that the electrical energy consumption cost increases by 11.6% from an SRT of 10 days to an SRT of 30 days. The rate of increase, however, decreases at higher SRT's, as can be seen in Table 4-10.

The study further confirmed that the operational costs of sludge handling, which includes dewatering energy consumption, chemical usage, and sludge disposal, decreases with an increase in SRT. The study found that the operational costs of sludge handling decreased by 23% from an SRT of 10 days to an SRT of 30 days. As with electrical energy, the rate of decrease in operational costs, decreases at higher SRT's (refer to Table 4-10).

In conclusion, study found that although most of the OCI drivers became more cost effective at higher SRT's the increased cost of electricity consumption of aeration at higher SRT's leads to higher overall operating costs at higher SRT's. This confirms the hypothesis that the increase in electrical energy consumption cost will outweigh the savings in operational costs of sludge handling, and therefore it is more economical to operate AS reactors at lower SRTs.

5.2 Recommendations

Based on the above conclusion and the findings of this study, the following recommendations are made:

- Where sludge dewatering and disposal facilities allows, as is the case with MPWWTP, Activated Sludge Plants should be operated at the lowest possible SRT, without compromising effluent quality, to ensure that operational costs are kept to a minimum.
- The dosing of VFA's at MPWWTP could reduce the overall operational costs at MPWWTP. Further investigation into the effect of dosing VFA's on the overall operational costs may prove beneficial.
- The retrofitting of the MLE system at MPWWTP, to include an A-recycle stream, should be further investigated. This should improve the performance of in terms of effluent quality of the process train.
- This study only considered the simulation of MPWWTP in a steady state model. The implication of the time of use electricity tariff, which is in place at MPWWTP, could therefore not be fully investigated. A dynamic simulation of the Activated Sludge process will provide a more accurate representation of the effect of aeration electricity consumption at MPWWTP. With peak hydraulic and organic loads often coinciding with peak-use tariffs, this may lead to an even higher proportion of the overall operation costs being attributable to aeration costs.
- This study only considered the MPWWTP. Comparative analysis with other wastewater treatment facilities to provide a broader perspective on the findings and implications would further enhance this study. Including data from other facilities could enhance the generalizability of the results and recommendations and should be considered for future studies.
- This study did not fully evaluate the environmental impact of the operational strategies proposed. Further studies assessing the sustainability and environmental footprint of the suggested scenarios would provide valuable insights.

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Annexure A - Detailed Reactor Model

Annexure A1 – Detailed Reactor Model for Influent Flow of 20 ML/d

MLE Reactor @ 10 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	8.9 Ml/d
Sludge Age	SRT	10.0 days
Reactor TSS concentration	X _r	1414 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	619	5501
BPO COD	Sbpi	479	4257
UPO COD	Supi	29	255
	fS'up		0.0464
VFA COD	Sbsi,a	0.0	0
FBSO COD	Sbsfi	75	667
BSO COD	Sbsi	75	667
USO COD	Susi	36.3	323
	fS'us		0.0587
BO COD	Sbi	554	4924
UO COD	Sui	65	578
TSS		241	2140
ISS		51.4	457
VSS		189	1683
UPO VSS		19.4	172
BPO VSS		170	1510
TKN	Nti	48.2	428
Org N	Noi	13.8	123
FSA	Nai	34.4	306
BSO	Nobsi	2.90	26
USO	Nousi	0.90	8
BPO	Nobpi	8.70	77
UPO	Noupi	1.30	12
Total P	Pti	15.50	138
OP	Pai	12.80	114
Org P	Poi	2.70	24
BSO	Pobsi	0.70	6
USO	Pousi	0.60	5
BPO	Pobpi	0.78	7
UPO	Poupi	0.62	6

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{ti}	0.2
ISS content of OHO's	f _{i(OH)}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bsso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,uipo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,uipo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,uipo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{i(20)}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2141 /d
	μ _{A(m20)}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{A(mT)}	0.2829 /d
	b _{A(20)}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0357 /d
	K _{i(20)}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{i(T)}	0.6288 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{oh}	7055 kgVSS
Endogenous Residue VSS	MX _{eh}	3020 kgVSS
Unbiodegradeable Organic VSS	MX _{uv}	1724 kgVSS
Total VSS	MX _v	11799 kgVSS
ISS from influent		4570 kgISS
ISS of OHO's		1058 kgISS
ISS	MX _(O)	5628 kgISS
TSS	MX _t	17426 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{h(n)}	33.3 hr

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	8.9 Ml/d
Sludge Age	SRT	10.0 days
Reactor TSS concentration	X _T	1333 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	618.9	5501
BPO COD	Sbpi	479	4257
UPO COD	Supi	29	255
	fS'up		0.04637
VFA COD	Sbsi,a	0	0
FBSO COD	Sbsfi	75	667
BSO COD	Sbsi	75	667
USO COD	Susi	36.3	323
	fS'us		0.05865
BO COD	Sbi	554	4924
UO COD	Sui	65	578
TSS		240.7272727	2140
ISS		51.4	457
VSS		189.3181818	1683
UPO VSS		19.39	172
BPO VSS		170	1510
TKN	Nti	48.2	428
Org N	Noi	13.8	123
FSA	Nai	34.4	306
BSO	Nobsi	2.90	25.8
USO	Nousi	0.90	8.0
BPO	Nobpi	8.70	77
UPO	Noupi	1.30	12
Total P	Pti	15.5	138
OP	Pai	12.8	114
Org P	Poi	2.7	24.0
BSO	Pobsi	0.7	6.2
USO	Pousi		
BPO	Pobpi	0.78	7
UPO	Poupi	0.62	5.52

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{ti}	0.2
ISS content of OHO's	f _{i(OH)}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bsso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,uipo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,uipo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,uipo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{i(20)}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2691 /d
	μ _{A(m20)}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{A(mT)}	0.7157 /d
	b _{A(20)}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0448 /d
	K _{i(20)}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{i(T)}	1.5904 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{oh}	6003 kgVSS
Endogenous Residue VSS	MX _{eh}	3231 kgVSS
Unbiodegradeable Organic VSS	MX _{uv}	1724 kgVSS
Total VSS	MX _v	10957 kgVSS
ISS from influent		4570 kgISS
ISS of OHO's		900 kgISS
ISS	MX _(O)	5470 kgISS
TSS	MX _t	16428 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{h(n)}	33.3 hr

MLE Reactor @ 10 Days SRT

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	573 mgVSS/l
Endogenous Residue VSS	X_{CH}	245 mgVSS/l
Unbiodegradeable Organic VSS	X_I	140 mgVSS/l
Total VSS	X_v	958 mgVSS/l
Influent Biodegradeable ISS	X_{IOI}	457 mgISS/l
TSS	X_t	1414 mgTSS/l

Active fraction of VSS	f_{av}	0.598 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.405 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.677 kgVSS/kgTSS

Waste Flow Rate	Q_w	1232 m ³ /d
TSS wasted per day		1743 kgTSS/d
VSS wasted per day		1180 kgVSS/d

Flux of N in waste VSS	FN_s	118 kgN/d
Equiv conc in influent	N_i	13.27 mgN/l influent
Effluent Sol Unbiol Org N	N_{outE}	0.90 mgN/l

Factor of safety reducing μ_{denT}	Sf	1.25
total unaerated mass fraction	f_{xt}	0.148
Minimum sludge age for nitrification	SRT_m	4.87 days
SRT_m with Safety factor	$SRT_m (Sf)$	6.09 Nitrifies!

If no nitrification		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{ne}	34.9 mgTKN-N/l
Effluent FSA-N	$N_{ne} = N_{an}$	34.0 mgFSA-N/l

If complete nitrification		
Effluent NO ₃	N_{ne}	34.0 mgNO ₃ -N/l
Effluent TKN-N	N_{ne}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ne}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	33.22 mgNO ₃ -N/l
Effluent TKN-N	N_{ne}	1.71 mgTKN-N/l
(calculated N_{ne})	(N_{ne})	0.810 mgFSA-N/l
Effluent FSA-N	N_{ne}	0.810 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	217.6 kgVSS

Denitrification	$K_{D(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	θ	1.2
	K_{1T}	0.3472 mgFSA/l
Denitrification	$K_{D(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	θ	1.08
	K_{2T}	0.0742 mgFSA/l

s-recycle ratio	s	1.00 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.401
Anoxic sludge mass fraction	f_{x1}	0.148 set = f_{xm} for balanced MLE
Min anoxic sludge mass fraction	f_{x1min}	0.032
Influent RBCOD fraction (Sbs/Sbi)	$f_{Sb/s}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	8.74 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	17.49 mgNO ₃ -N/l influent

	A	0.6993
	B	17.4756
	C	1.062
Optimal a-recycle ratio	a_{opt}	0.06
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00 set = a_{opt} for balanced MLE
	recycle limited	

Effluent Nitrate if recycle limited		16.61 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		16.08 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	16.61 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{de}$	18.32 mgN/l
N removal		62.0%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	487 mgVSS/l
Endogenous Residue VSS	X_{CH}	262 mgVSS/l
Unbiodegradeable Organic VSS	X_I	140 mgVSS/l
Total VSS	X_v	889 mgVSS/l
Influent Biodegradeable ISS	X_{IOI}	444 mgISS/l
TSS	X_t	1333 mgTSS/l

Active fraction of VSS	f_{av}	0.548 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.365 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.667 kgVSS/kgTSS

Waste Flow Rate	Q_w	1232 m ³ /d
TSS wasted per day		1643 kgTSS/d
VSS wasted per day		1096 kgVSS/d

Flux of N in waste VSS	FN_s	110 kgN/d
Equiv conc in influent	N_i	12.33 mgN/l influent
Effluent Sol Unbiol Org N	N_{outE}	0.90 mgN/l

Factor of safety reducing μ_{denT}	Sf	1.25
total unaerated mass fraction	f_{xt}	0.148
Minimum sludge age for nitrification	SRT_m	1.77 days
SRT_m with Safety factor	$SRT_m (Sf)$	2.21 Nitrifies!

If no nitrification		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{ne}	35.9 mgTKN-N/l
Effluent FSA-N	$N_{ne} = N_{an}$	35.0 mgFSA-N/l

If complete nitrification		
Effluent NO ₃	N_{ne}	35.0 mgNO ₃ -N/l
Effluent TKN-N	N_{ne}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ne}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	34.48 mgNO ₃ -N/l
Effluent TKN-N	N_{ne}	1.40 mgTKN-N/l
(calculated N_{ne})	(N_{ne})	0.496 mgFSA-N/l
Effluent FSA-N	N_{ne}	0.496 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	211.6 kgVSS

Denitrification	$K_{D(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	θ	1.2
	K_{1T}	1.4930 mgFSA/l
Denitrification	$K_{D(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	θ	1.08
	K_{2T}	0.1374 mgFSA/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.747
Anoxic sludge mass fraction	f_{x1}	0.148
Min anoxic sludge mass fraction	f_{x1min}	0.009
Influent RBCOD fraction (Sbs/Sbi)	$f_{Sb/s}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	13.77 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	22.52 mgNO ₃ -N/l influent

	A	0.6993
	B	13.7091
	C	9.856
Optimal a-recycle ratio	a_{opt}	0.69
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00
	recycle limited	

Effluent Nitrate if recycle limited		17.24 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		12.31 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	17.24 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{de}$	18.63 mgN/l
N removal		61.3%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

MLE Reactor @ 10 Days SRT

Carbonaceous Oxygen flux	FO_c	3431 kgO/d
Nitrogenous Oxygen flux	FO_N	1349 kgO/d
Oxygen dmdnd recover by denitrification	FO_D	422 kgO/d
Total Oxygen Demand ($FO_c + FO_N - FO_D$)	FO_T	4359 kgO/d
Oxygen utilisation rate	O_r	17.3 mgO/L.h

Alkalinity consumed by nitrification	237 mg $CaCO_3$
Alkalinity recovered by denitrification	59 mg $CaCO_3$
Total Alkalinity consumption	178 mg $CaCO_3$

COD mass balance	
COD in (influent)	5501.3 kgCOD/d
COD out	5501.5 kgCOD/d
$Q_w S_{se} + Q_w S_{te}$	322.7 kgCOD/d
$Q_w X_r f_{cv}$	1747.4 kgCOD/d
$V_p O_c$	3431.5 kgO/d

N mass balance	
N in (influent)	428.4 kgTKN-N/d
N out	428.4 kgTKN-N/d
$Q_w N_{se} + Q_w N_{te}$	15.2 kgTKN-N/d
$Q_r N_s$	118.0 kgTKN-N/d
$Q_r N_{oe}$	295.3 kgNO3-N/d

TOD balance	
TOD in (influent)	7459.32 kgTOD/d
TOD out	7459.50 kgTOD/d
$TOD_{effluent}$	337.79 kgTOD/d
TOD_{waste}	2340.91 kgTOD/d
TOD_{N2-gas}	422.22 kgTOD/d
FO_T	4358.58 kgTOD/d

Flux of P in waste VSS	FP_s	29 kgP/d
Equiv concn in influent	P_i	3.32 mgP/l
Effluent Sol Unbiol Org P	P_{ouse}	0.60 mgP/l
Effluent TP	P_{te}	12.18 mgP/l
Effluent Ortho-P as P	P_{oe}	11.58 mgOP-P/l

Carbonaceous Oxygen flux	FO_c	3556 kgO/d	148.1685
Nitrogenous Oxygen flux	FO_N	1401 kgO/d	58.35572
Oxygen dmdnd recover by denitrification	FO_D	438 kgO/d	
Total Oxygen Demand ($FO_c + FO_N - FO_D$)	FO_T	4518 kgO/d	188.2642
Oxygen utilisation rate	O_r	17.9 mgO/L.h	

Alkalinity consumed by nitrification	246 mg $CaCO_3$
Alkalinity recovered by denitrification	62 mg $CaCO_3$
Total Alkalinity consumption	185 mg $CaCO_3$

COD mass balance	
COD in (influent)	5501.3 kgCOD/d
COD out	5501.5 kgCOD/d
$Q_w S_{se} + Q_w S_{te}$	322.7 kgCOD/d
$Q_w X_r f_{cv}$	1622.8 kgCOD/d
$V_p O_c$	3556.0 kgO/d

N mass balance	
N in (influent)	428.4 kgTKN-N/d
N out	428.4 kgTKN-N/d
$Q_w N_{se} + Q_w N_{te}$	12.4 kgTKN-N/d
$Q_r N_s$	109.6 kgTKN-N/d
$Q_r N_{oe}$	306.5 kgNO3-N/d

TOD balance	
TOD in (influent)	7459.32 kgTOD/d
TOD out	7459.50 kgTOD/d
$TOD_{effluent}$	326.79 kgTOD/d
TOD_{waste}	2176.13 kgTOD/d
TOD_{N2-gas}	438.24 kgTOD/d
FO_T	4518.34 kgTOD/d

Flux of P in waste VSS	FP_s	27 kgP/d
Equiv concn in influent	P_i	3.08 mgP/l
Effluent Sol Unbiol Org P	P_{ouse}	0.00 mgP/l
Effluent TP	P_{te}	12.42 mgP/l
Effluent Ortho-P as P	P_{oe}	12.42 mgOP-P/l

Effluent Concentrations				General	Special	Unit	Effluent Concentrations				General	Special	Unit
Unbiol Sol COD	S_{use}	36.30	<75	<30	mgCOD/l		Unbiol Sol COD	S_{use}	36.30	<75	<30	mgCOD/l	
Undioid Sol Org N	N_{ouse}	0.90	-	-	mgN/l		Undioid Sol Org N	N_{ouse}	0.90	-	-	mgN/l	
FSA-N	N_{se}	0.81	<6	<2	mgFSA-N/l		FSA-N	N_{se}	0.50	<6	<2	mgFSA-N/l	
TKN-N	N_{te}	1.71	-	-	mgTKN-N/l		TKN-N	N_{te}	1.40	-	-	mgTKN-N/l	
Nitrate	N_{oe}	16.61	<15	<1.5	mgNO ₃ -N/l		Nitrate	N_{oe}	17.24	<15	<1.5	mgNO ₃ -N/l	
Undioid Sol Org P	P_{ouse}	0.60	-	-	mgP/l		Undioid Sol Org P	P_{ouse}	0.00	-	-	mgP/l	
Ortho P as P	P_{oe}	11.58	<10	<2.5	mgOP-P/l		Ortho P as P	P_{oe}	12.42	<10	<2.5	mgOP-P/l	
TP	P_{te}	12.18	-	-	mgP/l		TP	P_{te}	12.42	-	-	mgP/l	

MLE Reactor @ 15 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	8.9 Ml/d
Sludge Age	SRT	15.0 days
Reactor TSS concentration	X _r	1914 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	619	5501
BPO COD	Sbpi	479	4257
UPO COD	Supi	29	255
	fS'up		0.0464
VFA COD	Sbsi,a	0.0	0
FBSO COD	Sbsfi	75	667
BSO COD	Sbsi	75	667
USO COD	Susi	36.3	323
	fS'us		0.0587
BO COD	Sbi	554	4924
UO COD	Sui	65	578
TSS		241	2140
ISS		51.4	457
VSS		189	1683
UPO VSS		19.4	172
BPO VSS		170	1510
TKN	Nti	48.2	428
Org N	Noi	13.8	123
FSA	Nai	34.4	306
BSO	Nobsi	2.90	26
USO	Nousi	0.90	8
BPO	Nobpi	8.70	77
UPO	Noupi	1.30	12
Total P	Pti	15.50	138
OP	Pai	12.80	114
Org P	Poi	2.70	24
BSO	Pobsi	0.70	6
USO	Pousi	0.60	5
BPO	Pobpi	0.78	7
UPO	Poupi	0.62	6

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{COHO}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bsso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{N,UPO}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{P,UPO}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{C,UPO}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{H20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{H,T}	0.2141 /d
	μ _{A,m20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{A,mT}	0.2829 /d
	b _{A20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{A,T}	0.0357 /d
	K _{H20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{H,T}	0.6288 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{OH}	7892 kgVSS
Endogenous Residue VSS	MX _{EH}	5068 kgVSS
Unbiodegradeable Organic VSS	MX _{UV}	2586 kgVSS
Total VSS	MX _v	15546 kgVSS
ISS from influent		6855 kgISS
ISS of OHO's		1184 kgISS
ISS	MX _{CO}	8038 kgISS
TSS	MX _t	23584 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{h,n}	33.3 hr

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	8.9 Ml/d
Sludge Age	SRT	15.0 days
Reactor TSS concentration	X _T	1815 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	618.9	5501
BPO COD	Sbpi	479	4257
UPO COD	Supi	29	255
	fS'up		0.04637
VFA COD	Sbsi,a	0	0
FBSO COD	Sbsfi	75	667
BSO COD	Sbsi	75	667
USO COD	Susi	36.3	323
	fS'us		0.05865
BO COD	Sbi	554	4924
UO COD	Sui	65	578
TSS		240.7272727	2140
ISS		51.4	457
VSS		189.3181818	1683
UPO VSS		19.39	172
BPO VSS		170	1510
TKN	Nti	48.2	428
Org N	Noi	13.8	123
FSA	Nai	34.4	306
BSO	Nobsi	2.90	25.8
USO	Nousi	0.90	8.0
BPO	Nobpi	8.70	77
UPO	Noupi	1.30	12
Total P	Pti	15.5	138
OP	Pai	12.8	114
Org P	Poi	2.7	24.0
BSO	Pobsi	0.7	6.2
USO	Pousi		
BPO	Pobpi	0.78	7
UPO	Poupi	0.62	5.52

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{COHO}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bsso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{N,UPO}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{P,UPO}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{C,UPO}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{H20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{H,T}	0.2691 /d
	μ _{A,m20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{A,mT}	0.7157 /d
	b _{A20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{A,T}	0.0448 /d
	K _{H20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{H,T}	1.5904 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{OH}	6599 kgVSS
Endogenous Residue VSS	MX _{EH}	5327 kgVSS
Unbiodegradeable Organic VSS	MX _{UV}	2586 kgVSS
Total VSS	MX _v	14512 kgVSS
ISS from influent		6855 kgISS
ISS of OHO's		990 kgISS
ISS	MX _{CO}	7844 kgISS
TSS	MX _t	22356 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{h,n}	33.3 hr

MLE Reactor @ 15 Days SRT

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	641 mgVSS/l
Endogenous Residue VSS	X_{CH}	411 mgVSS/l
Unbiodegradeable Organic VSS	X_I	210 mgVSS/l
Total VSS	X_v	1262 mgVSS/l
Influent Biodegradeable ISS	X_{IOI}	652 mgISS/l
TSS	X_t	1914 mgTSS/l

Active fraction of VSS	f_{av}	0.508 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.335 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.659 kgVSS/kgTSS

Waste Flow Rate	Q_w	821 m ³ /d
TSS wasted per day		1572 kgTSS/d
VSS wasted per day		1036 kgVSS/d

Flux of N in waste VSS	FN_k	104 kgN/d
Equiv conc in influent	N_i	11.66 mgN/l influent
Effluent Sol Unbiol Org N	N_{unbio}	0.90 mgN/l

Factor of safety reducing μ_{denT}	Sf	1.25
total unaerated mass fraction	f_{xt}	0.148
Minimum sludge age for nitrification	SRT_m	4.87 days
SRT_m with Safety factor	$SRT_m (Sf)$	6.09 Nitrifies!

If no nitrification		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{ne}	36.5 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	35.6 mgFSA-N/l

If complete nitrification		
Effluent NO ₃	N_{ne}	35.6 mgNO ₃ -N/l
Effluent TKN-N	N_{ne}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ne}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	35.18 mgNO ₃ -N/l
Effluent TKN-N	N_{ne}	1.36 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.464 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.464 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	305.5 kgVSS

Denitrification	$K_{d(D)}$	0.72 mgFSA/l
Half Saturation Coefficient	θ	1.2
	K_{1T}	0.3472 mgFSA/l
Denitrification	$K_{d(D)}$	0.101 mgFSA/l
Half Saturation Coefficient	θ	1.08
	K_{2T}	0.0742 mgFSA/l

s-recycle ratio	s	1.00 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.548
Anoxic sludge mass fraction	f_{x1}	0.148 set = f_{xm} for balanced MLE
Min anoxic sludge mass fraction	f_{x1min}	0.028
Influent RBCOD fraction (Sbs/Sbi)	$f_{Sb/s}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	9.78 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	18.53 mgNO ₃ -N/l influent

	A	0.6993
	B	18.3974
	C	1.179
Optimal a-recycle ratio	a_{opt}	0.06
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00 set = a_{opt} for balanced MLE
	recycle limited	

Effluent Nitrate if recycle limited		17.59 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		17.00 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	17.59 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{n}$	18.95 mgN/l
N removal		60.7%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	536 mgVSS/l
Endogenous Residue VSS	X_{CH}	432 mgVSS/l
Unbiodegradeable Organic VSS	X_I	210 mgVSS/l
Total VSS	X_v	1178 mgVSS/l
Influent Biodegradeable ISS	X_{IOI}	637 mgISS/l
TSS	X_t	1815 mgTSS/l

Active fraction of VSS	f_{av}	0.455 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.295 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.649 kgVSS/kgTSS

Waste Flow Rate	Q_w	821 m ³ /d
TSS wasted per day		1490 kgTSS/d
VSS wasted per day		967 kgVSS/d

Flux of N in waste VSS	FN_k	97 kgN/d
Equiv conc in influent	N_i	10.88 mgN/l influent
Effluent Sol Unbiol Org N	N_{unbio}	0.90 mgN/l

Factor of safety reducing μ_{denT}	Sf	1.25
total unaerated mass fraction	f_{xt}	0.148
Minimum sludge age for nitrification	SRT_m	1.77 days
SRT_m with Safety factor	$SRT_m (Sf)$	2.21 Nitrifies!

If no nitrification		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{ne}	37.3 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	36.4 mgFSA-N/l

If complete nitrification		
Effluent NO ₃	N_{ne}	36.4 mgNO ₃ -N/l
Effluent TKN-N	N_{ne}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ne}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	36.06 mgNO ₃ -N/l
Effluent TKN-N	N_{ne}	1.26 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.356 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.356 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	287.4 kgVSS

Denitrification	$K_{d(D)}$	0.72 mgFSA/l
Half Saturation Coefficient	θ	1.2
	K_{1T}	1.4930 mgFSA/l
Denitrification	$K_{d(D)}$	0.101 mgFSA/l
Half Saturation Coefficient	θ	1.08
	K_{2T}	0.1374 mgFSA/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.805
Anoxic sludge mass fraction	f_{x1}	0.148
Min anoxic sludge mass fraction	f_{x1min}	0.008
Influent RBCOD fraction (Sbs/Sbi)	$f_{Sb/s}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	15.14 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	23.88 mgNO ₃ -N/l influent

	A	0.6993
	B	13.9251
	C	11.007
Optimal a-recycle ratio	a_{opt}	0.76
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00
	recycle limited	

Effluent Nitrate if recycle limited		18.03 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		12.53 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	18.03 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{n}$	19.29 mgN/l
N removal		60.0%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

MLE Reactor @ 15 Days SRT

Carbonaceous Oxygen flux	FO_c	3644 kgO/d
Nitrogenous Oxygen flux	FO_N	1429 kgO/d
Oxygen dmnd recover by denitrification	FO_D	447 kgO/d
Total Oxygen Demand ($FO_c + FO_N - FO_D$)	FO_T	4626 kgO/d
Oxygen utilisation rate	O_r	18.4 mgO/l.h

Alkalinity consumed by nitrification	251 mg $CaCO_3$
Alkalinity recovered by denitrification	63 mg $CaCO_3$
Total Alkalinity consumption	188 mg $CaCO_3$

COD mass balance	
COD in (influent)	5501.3 kgCOD/d
COD out	5501.5 kgCOD/d
$Q_{25}S_{10} + Q_{20}S_{10}$	322.7 kgCOD/d
$Q_{20}X_r f_{cv}$	1534.9 kgCOD/d
$V_p O_c$	3643.9 kgO/d

N mass balance	
N in (influent)	428.4 kgTKN-N/d
N out	428.4 kgTKN-N/d
$Q_{25}N_{10} + Q_{20}N_{10}$	12.1 kgTKN-N/d
$Q_r N_s$	103.6 kgTKN-N/d
$Q_r N_{oe}$	312.7 kgNO3-N/d

TOD balance	
TOD in (influent)	7459.32 kgTOD/d
TOD out	7459.50 kgTOD/d
$TOD_{effluent}$	343.15 kgTOD/d
TOD_{waste}	2043.49 kgTOD/d
TOD_{N2-gas}	447.13 kgTOD/d
FO_T	4625.72 kgTOD/d

Flux of P in waste VSS	FP_s	26 kgP/d
Equiv conc in influent	P_i	2.91 mgP/l
Effluent Sol Unbiod Org P	P_{ouise}	0.60 mgP/l
Effluent TP	P_{10}	12.59 mgP/l
Effluent Ortho-P as P	P_{oe}	11.99 mgOP-P/l

Carbonaceous Oxygen flux	FO_c	3746 kgO/d	156.0855
Nitrogenous Oxygen flux	FO_N	1465 kgO/d	61.03505
Oxygen dmnd recover by denitrification	FO_D	458 kgO/d	
Total Oxygen Demand ($FO_c + FO_N - FO_D$)	FO_T	4753 kgO/d	198.022
Oxygen utilisation rate	O_r	18.9 mgO/l.h	

Alkalinity consumed by nitrification	257 mg $CaCO_3$
Alkalinity recovered by denitrification	64 mg $CaCO_3$
Total Alkalinity consumption	193 mg $CaCO_3$

COD mass balance	
COD in (influent)	5501.3 kgCOD/d
COD out	5501.5 kgCOD/d
$Q_{25}S_{10} + Q_{20}S_{10}$	322.7 kgCOD/d
$Q_{20}X_r f_{cv}$	1432.8 kgCOD/d
$V_p O_c$	3746.1 kgO/d

N mass balance	
N in (influent)	428.4 kgTKN-N/d
N out	428.4 kgTKN-N/d
$Q_{25}N_{10} + Q_{20}N_{10}$	11.2 kgTKN-N/d
$Q_r N_s$	96.7 kgTKN-N/d
$Q_r N_{oe}$	320.5 kgNO3-N/d

TOD balance	
TOD in (influent)	7459.32 kgTOD/d
TOD out	7459.50 kgTOD/d
$TOD_{effluent}$	339.16 kgTOD/d
TOD_{waste}	1909.44 kgTOD/d
TOD_{N2-gas}	458.36 kgTOD/d
FO_T	4752.53 kgTOD/d

Flux of P in waste VSS	FP_s	24 kgP/d
Equiv conc in influent	P_i	2.72 mgP/l
Effluent Sol Unbiod Org P	P_{ouise}	0.00 mgP/l
Effluent TP	P_{10}	12.78 mgP/l
Effluent Ortho-P as P	P_{oe}	12.78 mgOP-P/l

Effluent Concentrations				General	Special	Unit	Effluent Concentrations				General	Special	Unit
Unbiod Sol COD	S_{10}	36.30	<75	<30	mgCOD/l		Unbiod Sol COD	S_{10}	36.30	<75	<30	mgCOD/l	
Undiod Sol Org N	N_{ouise}	0.90	-	-	mgN/l		Undiod Sol Org N	N_{ouise}	0.90	-	-	mgN/l	
FSA-N	N_{se}	0.46	<6	<2	mgFSA-N/l		FSA-N	N_{se}	0.36	<6	<2	mgFSA-N/l	
TKN-N	N_{10}	1.36	-	-	mgTKN-N/l		TKN-N	N_{10}	1.26	-	-	mgTKN-N/l	
Nitrate	N_{10e}	17.59	<15	<1.5	mgNO ₃ -N/l		Nitrate	N_{10e}	18.03	<15	<1.5	mgNO ₃ -N/l	
Undiod Sol Org P	P_{ouise}	0.60	-	-	mgP/l		Undiod Sol Org P	P_{ouise}	0.00	-	-	mgP/l	
Ortho P as P	P_{oe}	11.99	<10	<2.5	mgOP-P/l		Ortho P as P	P_{oe}	12.78	<10	<2.5	mgOP-P/l	
TP	P_{10}	12.59	-	-	mgP/l		TP	P_{10}	12.78	-	-	mgP/l	

MLE Reactor @ 20 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q_i	8.9 Ml/d
Sludge Age	SRT	20.0 days
Reactor TSS concentration	X_T	2388 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	619	5501
BPO COD	Sbpi	479	4257
UPO COD	Supi	29	255
	fs'up		0.0464
VFA COD	Sbsi,a	0.0	0
FBSO COD	Sbsfi	75	667
BSO COD	Sbsi	75	667
USO COD	Susi	36.3	323
	fs'us		0.0587
BO COD	Sbi	554	4924
UO COD	Sui	65	578
TSS		241	2140
ISS		51.4	457
VSS		189	1683
UPO VSS		19.4	172
BPO VSS		170	1510
TKN	Nti	48.2	428
Org N	Noi	13.8	123
FSA	Nai	34.4	306
BSO	Nobsi	2.90	26
USO	Nousi	0.90	8
BPO	Nobpi	8.70	77
UPO	Noupi	1.30	12
Total P	Pti	15.50	138
OP	Pai	12.80	114
Org P	Poi	2.70	24
BSO	Pobsi	0.70	6
USO	Pousi	0.60	5
BPO	Pobpi	0.78	7
UPO	Poupi	0.62	6

Constants

COD/VSS ratio	f_{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y_H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y_{HV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_H	0.2
ISS content of OHO's	f_{iOHO}	0.15
Yield coefficient of ANO's	Y_A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	$f_{cm,FBSO}$	1.42 mgCOD/mg
COD per mass fraction of USO	$f_{cm,USO}$	1.493 mgCOD/mg
N Content of UPO and biomass VSS	$f_{n,uipo}$	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	$f_{p,uipo}$	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	$f_{c,uipo}$	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b_{H20}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b_{HT}	0.2141 /d
	μ_{Am20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ_{AmT}	0.2829 /d
	b_{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b_{AT}	0.0357 /d
	K_{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K_{nT}	0.6288 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX_{BH}	8390 kgVSS
Endogenous Residue VSS	MX_{EH}	7184 kgVSS
Unbiodegradable Organic VSS	MX_{iv}	3447 kgVSS
Total VSS	MX_v	19022 kgVSS
ISS from influent		9139 kgISS
ISS of OHO's		1259 kgISS
ISS	MX_{iOI}	10398 kgISS
TSS	MX_t	29420 kgTSS

Reactor Volume	V_p	12320 m ³
Nominal hydraulic retention time	R_{in}	33.3 hr

TEMPERATURE	T	24 °C
Influent Flow Rate	Q_i	8.9 Ml/d
Sludge Age	SRT	20.0 days
Reactor TSS concentration	X_T	2276 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	618.9	5501
BPO COD	Sbpi	479	4257
UPO COD	Supi	29	255
	fs'up		0.04637
VFA COD	Sbsi,a	0	0
FBSO COD	Sbsfi	75	667
BSO COD	Sbsi	75	667
USO COD	Susi	36.3	323
	fs'us		0.05865
BO COD	Sbi	554	4924
UO COD	Sui	65	578
TSS		240.72727	2140
ISS		51.4	457
VSS		189.31818	1683
UPO VSS		19.39	172
BPO VSS		170	1510
TKN	Nti	48.2	428
Org N	Noi	13.8	123
FSA	Nai	34.4	306
BSO	Nobsi	2.90	25.8
USO	Nousi	0.90	8.0
BPO	Nobpi	8.70	77
UPO	Noupi	1.30	12
Total P	Pti	15.5	138
OP	Pai	12.8	114
Org P	Poi	2.7	24.0
BSO	Pobsi	0.7	6.2
USO	Pousi		
BPO	Pobpi	0.78	7
UPO	Poupi	0.62	5.52

Constants

COD/VSS ratio	f_{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y_H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y_{HV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_H	0.2
ISS content of OHO's	f_{iOHO}	0.15
Yield coefficient of ANO's	Y_A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	$f_{cm,FBSO}$	1.42 mgCOD/mg
COD per mass fraction of USO	$f_{cm,USO}$	1.493 mgCOD/mg
N Content of UPO and biomass VSS	$f_{n,uipo}$	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	$f_{p,uipo}$	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	$f_{c,uipo}$	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b_{H20}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b_{HT}	0.2691 /d
	μ_{Am20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ_{AmT}	0.7157 /d
	b_{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b_{AT}	0.0448 /d
	K_{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K_{nT}	1.5904 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX_{BH}	6944 kgVSS
Endogenous Residue VSS	MX_{EH}	7474 kgVSS
Unbiodegradable Organic VSS	MX_{iv}	3447 kgVSS
Total VSS	MX_v	17865 kgVSS
ISS from influent		9139 kgISS
ISS of OHO's		1042 kgISS
ISS	MX_{iOI}	10181 kgISS
TSS	MX_t	28046 kgTSS

Reactor Volume	V_p	12320 m ³
Nominal hydraulic retention time	R_{in}	33.3 hr

MLE Reactor @ 20 Days SRT

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	681 mgVSS/l
Endogenous Residue VSS	X_{EH}	583 mgVSS/l
Unbiodegradeable Organic VSS	X_I	280 mgVSS/l
Total VSS	X_U	1544 mgVSS/l
Influent Biodegradeable ISS	X_{DI}	844 mgISS/l
TSS	X_t	2388 mgTSS/l

Active fraction of VSS	f_{av}	0.441 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.285 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.647 kgVSS/kgTSS

Waste Flow Rate	Q_w	616 m ³ /d
TSS wasted per day		1471 kgTSS/d
VSS wasted per day		951 kgVSS/d

Flux of N in waste VSS	FN_L	95 kgN/d
Equiv conc in influent	N_s	10.70 mgN/l influent
Effluent Sol Unbiol Org N	N_{ouse}	0.90 mgN/l

Factor of safety reducing μ_{AINT}	Sf	1.25
total unaerated mass fraction	f_{xt}	0.148
Minimum sludge age for nitrification	SRT_m	4.87 days
SRT_m with Safety factor	$SRT_{m(SF)}$	6.09 Nitrifies!

<u>If no nitrification</u>		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	37.5 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	36.6 mgFSA-N/l

<u>If complete nitrification</u>		
Effluent NO ₃	N_{ne}	36.6 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ae}	0.0 mgFSA-N/l

<u>Nitrification Results</u>		
Effluent NO ₃ if no denitrification	$N_{ne} = N_L$	36.25 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	1.25 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.347 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.347 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	376.1 kgVSS

Denitrification	$K_{1(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	θ	1.2
	K_{1T}	0.3472 mgFSA/l
Denitrification	$K_{2(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	θ	1.08
	K_{2T}	0.0742 mgFSA/l

s-recycle ratio	s	1.00 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.621
Anoxic sludge mass fraction	f_{x1}	0.148 set = f_{xm} for balanced MLE
Min anoxic sludge mass fraction	f_{x1min}	0.027

Influent RBCOD fraction (Sbsi/Sbi)	$f_{Sb's}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	10.40 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	19.14 mgNO ₃ -N/l influent

	A	0.6993
	B	18.8571
	C	1.336
Optimal a-recycle ratio	a_{opt}	0.07
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00 set = a_{opt} for balanced MLE
	recycle limited	

Effluent Nitrate if recycle limited		18.13 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		17.46 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	18.13 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{te}$	19.37 mgN/l
N removal		59.8%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	564 mgVSS/l
Endogenous Residue VSS	X_{EH}	607 mgVSS/l
Unbiodegradeable Organic VSS	X_I	280 mgVSS/l
Total VSS	X_U	1450 mgVSS/l
Influent Biodegradeable ISS	X_{DI}	826 mgISS/l
TSS	X_t	2276 mgTSS/l

Active fraction of VSS	f_{av}	0.389 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.248 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.637 kgVSS/kgTSS

Waste Flow Rate	Q_w	616 m ³ /d
TSS wasted per day		1402 kgTSS/d
VSS wasted per day		893 kgVSS/d

Flux of N in waste VSS	FN_L	89 kgN/d
Equiv conc in influent	N_s	10.05 mgN/l influent
Effluent Sol Unbiol Org N	N_{ouse}	0.90 mgN/l

Factor of safety reducing μ_{AINT}	Sf	1.25
total unaerated mass fraction	f_{xt}	0.148
Minimum sludge age for nitrification	SRT_m	1.77 days
SRT_m with Safety factor	$SRT_{m(SF)}$	2.21 Nitrifies!

<u>If no nitrification</u>		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	38.2 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	37.3 mgFSA-N/l

<u>If complete nitrification</u>		
Effluent NO ₃	N_{ne}	37.3 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ae}	0.0 mgFSA-N/l

<u>Nitrification Results</u>		
Effluent NO ₃ if no denitrification	$N_{ne} = N_L$	36.96 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	1.19 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.293 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.293 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	346.4 kgVSS

Denitrification	$K_{1(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	θ	1.2
	K_{1T}	1.4930 mgFSA/l
Denitrification	$K_{2(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	θ	1.08
	K_{2T}	0.1374 mgFSA/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.834
Anoxic sludge mass fraction	f_{x1}	0.148
Min anoxic sludge mass fraction	f_{x1min}	0.007

Influent RBCOD fraction (Sbsi/Sbi)	$f_{Sb's}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	15.93 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	24.67 mgNO ₃ -N/l influent

	A	0.6993
	B	14.0322
	C	11.691
Optimal a-recycle ratio	a_{opt}	0.80
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00
	recycle limited	

Effluent Nitrate if recycle limited		18.48 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		12.63 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	18.48 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{te}$	19.67 mgN/l
N removal		59.2%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

MLE Reactor @ 20 Days SRT

Carbonaceous Oxygen flux	FO_c	3770 kgO/d
Nitrogenous Oxygen flux	FO_N	1473 kgO/d
Oxygen dmnd recover by denitrification	FO_D	461 kgO/d
Total Oxygen Demand ($FO_c + FO_N - FO_D$)	FO_T	4782 kgO/d
Oxygen utilisation rate	O_T	19.0 mgO/l.h

Alkalinity consumed by nitrification	259 mg $CaCO_3$
Alkalinity recovered by denitrification	65 mg $CaCO_3$
Total Alkalinity consumption	194 mg $CaCO_3$

COD mass balance	
COD in (influent)	5502 kgCOD/d
COD out	5502 kgCOD/d
$Q_e S_{te} + Q_w S_{te}$	323 kgCOD/d
$Q_w X_v f_{cv}$	1409 kgCOD/d
$V_p O_c$	3770 kgO/d

N mass balance	
N in (influent)	428.4 kgTKN-N/d
N out	428.4 kgTKN-N/d
$Q_e N_{te} + Q_w N_{te}$	11.1 kgTKN-N/d
$Q_i N_i$	95.1 kgTKN-N/d
$Q_i N_{ne}$	322.3 kgNO3-N/d

TOD balance	
TOD in (influent)	7460 kgTOD/d
TOD out	7459 kgTOD/d
$TOD_{effluent}$	347 kgTOD/d
TOD_{waste}	1869 kgTOD/d
TOD_{N2-gas}	461 kgTOD/d
FO_t	4782 kgTOD/d

Flux of P in waste VSS	FP_s	24 kgP/d
Equiv conc in influent	P_s	2.67 mgP/l
Effluent Sol Unbiod Org P	P_{ouse}	0.60 mgP/l
Effluent TP	P_{te}	12.83 mgP/l
Effluent Ortho-P as P	P_{oe}	12.23 mgOP-P/l

Carbonaceous Oxygen flux	FO_c	3856 kgO/d	160.6643
Nitrogenous Oxygen flux	FO_N	1501 kgO/d	62.55465
Oxygen dmnd recover by denitrification	FO_D	470 kgO/d	
Total Oxygen Demand ($FO_c + FO_N - FO_D$)	FO_T	4887 kgO/d	203.6449
Oxygen utilisation rate	O_T	19.4 mgO/l.h	

Alkalinity consumed by nitrification	264 mg $CaCO_3$
Alkalinity recovered by denitrification	66 mg $CaCO_3$
Total Alkalinity consumption	198 mg $CaCO_3$

COD mass balance	
COD in (influent)	5502 kgCOD/d
COD out	5502 kgCOD/d
$Q_e S_{te} + Q_w S_{te}$	322.7 kgCOD/d
$Q_w X_v f_{cv}$	1322.9 kgCOD/d
$V_p O_c$	3855.9 kgO/d

N mass balance	
N in (influent)	428.4 kgTKN-N/d
N out	428.4 kgTKN-N/d
$Q_e N_{te} + Q_w N_{te}$	10.6 kgTKN-N/d
$Q_i N_i$	89.3 kgTKN-N/d
$Q_i N_{ne}$	328.5 kgNO3-N/d

TOD balance	
TOD in (influent)	7460 kgTOD/d
TOD out	7459 kgTOD/d
$TOD_{effluent}$	345 kgTOD/d
TOD_{waste}	1757 kgTOD/d
TOD_{N2-gas}	470 kgTOD/d
FO_t	4887 kgTOD/d

Flux of P in waste VSS	FP_s	22 kgP/d
Equiv conc in influent	P_s	2.51 mgP/l
Effluent Sol Unbiod Org P	P_{ouse}	0.00 mgP/l
Effluent TP	P_{te}	12.99 mgP/l
Effluent Ortho-P as P	P_{oe}	12.99 mgOP-P/l

Effluent Concentrations			General	Special	Unit	Effluent Concentrations			General	Special	Unit
Unbiod Sol COD	S_{use}	36.30	<75	<30	mgCOD/l	Unbiod Sol COD	S_{use}	36.30	<75	<30	mgCOD/l
Undiod Sol Org N	N_{ouse}	0.90	-	-	mgN/l	Undiod Sol Org N	N_{ouse}	0.90	-	-	mgN/l
FSA-N	N_{ae}	0.35	<6	<2	mgFSA-N/l	FSA-N	N_{ae}	0.29	<6	<2	mgFSA-N/l
TKN-N	N_{te}	1.25	-	-	mgTKN-N/l	TKN-N	N_{te}	1.19	-	-	mgTKN-N/l
Nitrate	N_{ne}	18.13	<15	<1.5	mgNO ₃ -N/l	Nitrate	N_{ne}	18.48	<15	<1.5	mgNO ₃ -N/l
Undiod Sol Org P	P_{ouse}	0.60	-	-	mgP/l	Undiod Sol Org P	P_{ouse}	0.00	-	-	mgP/l
Ortho P as P	P_{oe}	12.23	<10	<2.5	mgOP-P/l	Ortho P as P	P_{oe}	12.99	<10	<2.5	mgOP-P/l
TP	P_{te}	12.83	-	-	mgP/l	TP	P_{te}	12.99	-	-	mgP/l

MLE Reactor @ 25 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	8.9 Ml/d
Sludge Age	SRT	25.0 days
Reactor TSS concentration	X _r	2849 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	619	5501
BPO COD	Sbpi	479	4257
UPO COD	Supi	29	255
	fS'up		0.0464
VFA COD	Sbsi,a	0.0	0
FBSO COD	Sbsfi	75	667
BSO COD	Sbsi	75	667
USO COD	Susi	36.3	323
	fS'us		0.0587
BO COD	Sbi	554	4924
UO COD	Sui	65	578
TSS		241	2140
ISS		51.4	457
VSS		189	1683
UPO VSS		19.4	172
BPO VSS		170	1510
TKN	Nti	48.2	428
Org N	Noi	13.8	123
FSA	Nai	34.4	306
BSO	Nobsi	2.90	26
USO	Nousi	0.90	8
BPO	Nobpi	8.70	77
UPO	Noupi	1.30	12
Total P	Pti	15.50	138
OP	Pai	12.80	114
Org P	Poi	2.70	24
BSO	Pobsi	0.70	6
USO	Pousi	0.60	5
BPO	Pobpi	0.78	7
UPO	Poupi	0.62	6

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{ti}	0.2
ISS content of OHO's	f _{i(OH)}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bsso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,uppo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,uppo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,uppo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{i(20)}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2141 /d
	μ _{Am(20)}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.2829 /d
	b _{A(20)}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0357 /d
	K _{i(20)}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{i,T}	0.6288 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{oh}	8721 kgVSS
Endogenous Residue VSS	MX _{eh}	9334 kgVSS
Unbiodegradeable Organic VSS	MX _{ov}	4309 kgVSS
Total VSS	MX _v	22364 kgVSS
ISS from influent		11424 kgISS
ISS of OHO's		1308 kgISS
ISS	MX _(O)	12732 kgISS
TSS	MX _t	35096 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{en}	33.3 hr

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	8.9 Ml/d
Sludge Age	SRT	25.0 days
Reactor TSS concentration	X _T	2729 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	618.9	5501
BPO COD	Sbpi	479	4257
UPO COD	Supi	29	255
	fS'up		0.04637
VFA COD	Sbsi,a	0	0
FBSO COD	Sbsfi	75	667
BSO COD	Sbsi	75	667
USO COD	Susi	36.3	323
	fS'us		0.05865
BO COD	Sbi	554	4924
UO COD	Sui	65	578
TSS		240.73	2140
ISS		51.4	457
VSS		189.32	1683
UPO VSS		19.39	172
BPO VSS		170	1510
TKN	Nti	48.2	428
Org N	Noi	13.8	123
FSA	Nai	34.4	306
BSO	Nobsi	2.90	25.8
USO	Nousi	0.90	8.0
BPO	Nobpi	8.70	77
UPO	Noupi	1.30	12
Total P	Pti	15.5	138
OP	Pai	12.8	114
Org P	Poi	2.7	24.0
BSO	Pobsi	0.7	6.2
USO	Pousi		
BPO	Pobpi	0.78	7
UPO	Poupi	0.62	5.52

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{ti}	0.2
ISS content of OHO's	f _{i(OH)}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bsso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,uppo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,uppo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,uppo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{i(20)}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2691 /d
	μ _{Am(20)}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.7157 /d
	b _{A(20)}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0448 /d
	K _{i(20)}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{i,T}	1.5904 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{oh}	7168 kgVSS
Endogenous Residue VSS	MX _{eh}	9644 kgVSS
Unbiodegradeable Organic VSS	MX _{ov}	4309 kgVSS
Total VSS	MX _v	21122 kgVSS
ISS from influent		11424 kgISS
ISS of OHO's		1075 kgISS
ISS	MX _(O)	12500 kgISS
TSS	MX _t	33622 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{en}	33.3 hr

MLE Reactor @ 25 Days SRT

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	708 mgVSS/l
Endogenous Residue VSS	X_{CH}	758 mgVSS/l
Unbiodegradeable Organic VSS	X_i	350 mgVSS/l
Total VSS	X_v	1815 mgVSS/l
Influent Biodegradeable ISS	X_{IOI}	1033 mgISS/l
TSS	X_t	2849 mgTSS/l

Active fraction of VSS	f_{av}	0.390 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.248 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.637 kgVSS/kgTSS

Waste Flow Rate	Q_w	493 m ³ /d
TSS wasted per day		1404 kgTSS/d
VSS wasted per day		895 kgVSS/d

Flux of N in waste VSS	FN_s	89 kgN/d
Equiv conc in influent	N_i	10.06 mgN/l influent
Effluent Sol Unbiol Org N	N_{unbio}	0.90 mgN/l

Factor of safety reducing $\mu_{k_{ent}}$	Sf	1.25
total unaerated mass fraction	f_{xt}	0.148
Minimum sludge age for nitrification	SRT_m	4.87 days
SRT_m with Safety factor	$SRT_m (Sf)$	6.09 Nitrifies!

If no nitrification		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{ne}	38.1 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	37.2 mgFSA-N/l

If complete nitrification		
Effluent NO ₃	N_{ne}	37.2 mgNO ₃ -N/l
Effluent TKN-N	N_{ne}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ne}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	36.95 mgNO ₃ -N/l
Effluent TKN-N	N_{ne}	1.19 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.288 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.288 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	434.0 kgVSS

Denitrification	$K_{d(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	θ	1.2
	K_{1T}	0.3472 mgFSA/l
Denitrification	$K_{d(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	θ	1.08
	K_{2T}	0.0742 mgFSA/l

s-recycle ratio	s	1.00 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.666
Anoxic sludge mass fraction	f_{x1}	0.148 set = f_{xm} for balanced MLE
Min anoxic sludge mass fraction	f_{x1min}	0.026

Influent RBCOD fraction (Sbs/Sbi)	$f_{Sb/s}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	10.81 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	19.55 mgNO ₃ -N/l influent

	A	0.6993
	B	19.1432
	C	1.459
Optimal a-recycle ratio	a_{opt}	0.08
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00 set = a_{opt} for balanced MLE
recycle limited		

Effluent Nitrate if recycle limited		18.47 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		17.74 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	18.47 mgNO ₃ -N/l

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	582 mgVSS/l
Endogenous Residue VSS	X_{CH}	783 mgVSS/l
Unbiodegradeable Organic VSS	X_i	350 mgVSS/l
Total VSS	X_v	1714 mgVSS/l
Influent Biodegradeable ISS	X_{IOI}	1015 mgISS/l
TSS	X_t	2729 mgTSS/l

Active fraction of VSS	f_{av}	0.339 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.213 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.628 kgVSS/kgTSS

Waste Flow Rate	Q_w	493 m ³ /d
TSS wasted per day		1345 kgTSS/d
VSS wasted per day		845 kgVSS/d

Flux of N in waste VSS	FN_s	84 kgN/d
Equiv conc in influent	N_i	9.50 mgN/l influent
Effluent Sol Unbiol Org N	N_{unbio}	0.90 mgN/l

Factor of safety reducing $\mu_{k_{ent}}$	Sf	1.25
total unaerated mass fraction	f_{xt}	0.148
Minimum sludge age for nitrification	SRT_m	1.77 days
SRT_m with Safety factor	$SRT_m (Sf)$	2.21 Nitrifies!

If no nitrification		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{ne}	38.7 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	37.8 mgFSA-N/l

If complete nitrification		
Effluent NO ₃	N_{ne}	37.8 mgNO ₃ -N/l
Effluent TKN-N	N_{ne}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ne}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	37.54 mgNO ₃ -N/l
Effluent TKN-N	N_{ne}	1.16 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.257 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.257 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	393.3 kgVSS

Denitrification	$K_{d(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	θ	1.2
	K_{1T}	1.4930 mgFSA/l
Denitrification	$K_{d(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	θ	1.08
	K_{2T}	0.1374 mgFSA/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.852
Anoxic sludge mass fraction	f_{x1}	0.148
Min anoxic sludge mass fraction	f_{x1min}	0.007

Influent RBCOD fraction (Sbs/Sbi)	$f_{Sb/s}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	16.44 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	25.19 mgNO ₃ -N/l influent

	A	0.6993
	B	14.0969
	C	12.141
Optimal a-recycle ratio	a_{opt}	0.83
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00
recycle limited		

Effluent Nitrate if recycle limited		18.77 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		12.70 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	18.77 mgNO ₃ -N/l

MLE Reactor @ 25 Days SRT

Effluent total N (TKN + NO ₃)	N _{re} + N _{le}	19.66 mgN/l
N removal		59.2%

Volume of Primary Anoxic Tank	V _{anox}	1828 m ³
Volume of Aerobic Tank	V _{aer}	10492 m ³

Carbonaceous Oxygen flux	FO _c	3854 kgO/d
Nitrogenous Oxygen flux	FO _N	1501 kgO/d
Oxygen dmnd recover by denitrification	FO _D	470 kgO/d
Total Oxygen Demand (FO _c + FO _N - FO _D)	FO _T	4885 kgO/d
Oxygen utilisation rate	O _r	19.4 mgO/l.h

Alkalinity consumed by nitrification		264 mg CaCO ₃
Alkalinity recovered by denitrification		66 mg CaCO ₃
Total Alkalinity consumption		198 mg CaCO ₃

COD mass balance		
COD in (influent)		5501.3 kgCOD/d
COD out		5501.5 kgCOD/d
Q _{le} S _{le} + Q _{de} S _{de}		322.7 kgCOD/d
Q _{wa} X _r f _{cv}		1324.8 kgCOD/d
V _o O ₂		3854.0 kgO/d

N mass balance		
N in (influent)		428.4 kgTKN-N/d
N out		428.4 kgTKN-N/d
Q _{le} N _{le} + Q _{de} N _{de}		10.6 kgTKN-N/d
Q _N N ₃		89.5 kgTKN-N/d
Q _N N _{re}		328.4 kgNO ₃ -N/d

TOD balance		
TOD in (influent)		7459.32 kgTOD/d
TOD out		7459.50 kgTOD/d
TOD _{effluent}		350.36 kgTOD/d
TOD _{waste}		1754.20 kgTOD/d
TOD _{N2 gas}		469.66 kgTOD/d
FO _l		4885.28 kgTOD/d

Flux of P in waste VSS	FP _s	22 kgP/d
Equiv conc in influent	P _s	2.52 mgP/l
Effluent Sol Unbiod Org P	P _{ouise}	0.60 mgP/l
Effluent TP	P _{le}	12.98 mgP/l
Effluent Ortho-P as P	P _{oe}	12.38 mgOP-P/l

Effluent total N (TKN + NO ₃)	N _{re} + N _{le}	19.93 mgN/l
N removal		58.7%

Volume of Primary Anoxic Tank	V _{anox}	1828 m ³
Volume of Aerobic Tank	V _{aer}	10492 m ³

Carbonaceous Oxygen flux	FO _c	3928 kgO/d
Nitrogenous Oxygen flux	FO _N	1525 kgO/d
Oxygen dmnd recover by denitrification	FO _D	477 kgO/d
Total Oxygen Demand (FO _c + FO _N - FO _D)	FO _T	4975 kgO/d
Oxygen utilisation rate	O _r	19.8 mgO/l.h

Alkalinity consumed by nitrification		268 mg CaCO ₃
Alkalinity recovered by denitrification		67 mg CaCO ₃
Total Alkalinity consumption		201 mg CaCO ₃

COD mass balance		
COD in (influent)		5501.3 kgCOD/d
COD out		5501.5 kgCOD/d
Q _{le} S _{le} + Q _{de} S _{de}		322.7 kgCOD/d
Q _{wa} X _r f _{cv}		1251.3 kgCOD/d
V _o O ₂		3927.6 kgO/d

N mass balance		
N in (influent)		428.4 kgTKN-N/d
N out		428.4 kgTKN-N/d
Q _{le} N _{le} + Q _{de} N _{de}		10.3 kgTKN-N/d
Q _N N ₃		84.5 kgTKN-N/d
Q _N N _{re}		333.7 kgNO ₃ -N/d

TOD balance		
TOD in (influent)		7459.32 kgTOD/d
TOD out		7459.50 kgTOD/d
TOD _{effluent}		349.18 kgTOD/d
TOD _{waste}		1657.88 kgTOD/d
TOD _{N2 gas}		477.15 kgTOD/d
FO _l		4975.29 kgTOD/d

Flux of P in waste VSS	FP _s	21 kgP/d
Equiv conc in influent	P _s	2.38 mgP/l
Effluent Sol Unbiod Org P	P _{ouise}	0.00 mgP/l
Effluent TP	P _{le}	13.12 mgP/l
Effluent Ortho-P as P	P _{oe}	13.12 mgOP-P/l

Effluent Concentrations			General	Special	Unit	Effluent Concentrations			General	Special	Unit
Unbiod Sol COD	S _{ouise}	36.30	<75	<30	mgCOD/l	Unbiod Sol COD	S _{ouise}	36.30	<75	<30	mgCOD/l
Undiod Sol Org N	N _{ouise}	0.90	-	-	mgN/l	Undiod Sol Org N	N _{ouise}	0.90	-	-	mgN/l
FSA-N	N _{re}	0.29	<6	<2	mgFSA-N/l	FSA-N	N _{re}	0.26	<6	<2	mgFSA-N/l
TKN-N	N _{re}	1.19	-	-	mgTKN-N/l	TKN-N	N _{re}	1.16	-	-	mgTKN-N/l
Nitrate	N _{re}	18.47	<15	<1.5	mgNO ₃ -N/l	Nitrate	N _{re}	18.77	<15	<1.5	mgNO ₃ -N/l
Undiod Sol Org P	P _{ouise}	0.60	-	-	mgP/l	Undiod Sol Org P	P _{ouise}	0.00	-	-	mgP/l
Ortho P as P	P _{oe}	12.38	<10	<2.5	mgOP-P/l	Ortho P as P	P _{oe}	13.12	<10	<2.5	mgOP-P/l
TP	P _{le}	12.98	-	-	mgP/l	TP	P _{le}	13.12	-	-	mgP/l

MLE Reactor @ 30 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Qi	8.9 Ml/d
Sludge Age	SRT	30.0 days
Reactor TSS concentration	Xr	3302 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	619	5501
BPO COD	Sbpi	479	4257
UPO COD	Supi	29	255
	fS'up		0.0464
VFA COD	Sbsi,a	0.0	0
FBSO COD	Sbsfi	75	667
BSO COD	Sbsi	75	667
USO COD	Susi	36.3	323
	fS'us		0.0587
BO COD	Sbi	554	4924
UO COD	Sui	65	578
TSS		241	2140
ISS		51.4	457
VSS		189	1683
UPO VSS		19.4	172
BPO VSS		170	1510
TKN	Nti	48.2	428
Org N	Noi	13.8	123
FSA	Nai	34.4	306
BSO	Nobsi	2.90	26
USO	Nousi	0.90	8
BPO	Nobpi	8.70	77
UPO	Noupi	1.30	12
Total P	Pti	15.50	138
OP	Pai	12.80	114
Org P	Poi	2.70	24
BSO	Pobsi	0.70	6
USO	Pousi	0.60	5
BPO	Pobpi	0.78	7
UPO	Poupi	0.62	6

Constants		
COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{OHO}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,BSO}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,USO}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{N,UPO}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{P,UPO}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{C,UPO}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2141 /d
	μ _{Am20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.2829 /d
	b _{a20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0357 /d
	K _{s20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{HT}	0.6288 mgFSA/l

Activated Sludge Masses		
Ordinary Heterotrophic Organisms VSS	MX _{BH}	8956 kgVSS
Endogenous Residue VSS	MX _{EH}	11502 kgVSS
Unbiodegradeable Organic VSS	MX _{iv}	5171 kgVSS
Total VSS	MX _v	25629 kgVSS
ISS from influent		13709 kgISS
ISS of OHO's		1343 kgISS
ISS	MX _{Oi}	15052 kgISS
TSS	MX _t	40682 kgTSS

Reactor Volume	Vp	12320 m ³
Nominal hydraulic retention time	R _{th}	33.3 hr

TEMPERATURE	T	24 °C
Influent Flow Rate	Qi	8.9 Ml/d
Sludge Age	SRT	30.0 days
Reactor TSS concentration	XT	3176 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	618.9	5501
BPO COD	Sbpi	479	4257
UPO COD	Supi	29	255
	fS'up		0.04637
VFA COD	Sbsi,a	0	0
FBSO COD	Sbsfi	75	667
BSO COD	Sbsi	75	667
USO COD	Susi	36.3	323
	fS'us		0.05865
BO COD	Sbi	554	4924
UO COD	Sui	65	578
TSS		240.7272727	2140
ISS		51.4	457
VSS		189.3181818	1683
UPO VSS		19.39	172
BPO VSS		170	1510
TKN	Nti	48.2	428
Org N	Noi	13.8	123
FSA	Nai	34.4	306
BSO	Nobsi	2.90	25.8
USO	Nousi	0.90	8.0
BPO	Nobpi	8.70	77
UPO	Noupi	1.30	12
Total P	Pti	15.5	138
OP	Pai	12.8	114
Org P	Poi	2.7	24.0
BSO	Pobsi	0.7	6.2
USO	Pousi		
BPO	Pobpi	0.78	7
UPO	Poupi	0.62	5.52

Constants		
COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{OHO}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,BSO}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,USO}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{N,UPO}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{P,UPO}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{C,UPO}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2691 /d
	μ _{Am20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.7157 /d
	b _{a20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0448 /d
	K _{s20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{HT}	1.5904 mgFSA/l

Activated Sludge Masses		
Ordinary Heterotrophic Organisms VSS	MX _{BH}	7327 kgVSS
Endogenous Residue VSS	MX _{EH}	11828 kgVSS
Unbiodegradeable Organic VSS	MX _{iv}	5171 kgVSS
Total VSS	MX _v	24326 kgVSS
ISS from influent		13709 kgISS
ISS of OHO's		1099 kgISS
ISS	MX _{Oi}	14808 kgISS
TSS	MX _t	39134 kgTSS

Reactor Volume	Vp	12320 m ³
Nominal hydraulic retention time	R _{th}	33.3 hr

MLE Reactor @ 30 Days SRT

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	727 mgVSS/l
Endogenous Residue VSS	X_{EH}	934 mgVSS/l
Unbiodegradable Organic VSS	X_i	420 mgVSS/l
Total VSS	X_T	2080 mgVSS/l
Influent Biodegradable ISS	$X_{(i)}$	1222 mgISS/l
TSS	X_t	3302 mgTSS/l

Active fraction of VSS	f_{av}	0.349 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.220 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.630 kgVSS/kgTSS

Waste Flow Rate	Q_w	411 m ³ /d
TSS wasted per day		1356 kgTSS/d
VSS wasted per day		854 kgVSS/d

Flux of N in waste VSS	FN_i	85 kgN/d
Equiv concn in influent	N_i	9.61 mgN/l influent
Effluent Sol Unbiodeg Org N	N_{oxide}	0.90 mgN/l

Factor of safety reducing $\mu_{max,T}$	Sf	1.25
total unaerated mass fraction	f_{xt}	0.148
Minimum sludge age for nitrification	SRT_{min}	4.87 days
SRT _{in} with Safety factor	$SRT_{in}(Sf)$	6.09 Nitrifies!

<u>If no nitrification</u>		
Effluent NO ₃	N_{de}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	38.6 mgTKN-N/l
Effluent FSA-N	$N_{de} = N_{di}$	37.7 mgFSA-N/l

<u>If complete nitrification</u>		
Effluent NO ₃	N_{de}	37.7 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	0.9 mgTKN-N/l
Effluent FSA-N	N_{de}	0.0 mgFSA-N/l

<u>Nitrification Results</u>		
Effluent NO ₃ if no denitrification	$N_{de} = N_t$	37.44 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	1.15 mgTKN-N/l
(calculated N_{de})	(N_{de})	0.252 mgFSA-N/l
Effluent FSA-N	N_{de}	0.252 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	482.2 kgVSS

Denitrification	$K_{(D2)}$	0.72 mgFSA/l
Half Saturation Coefficient	Θ	1.2
	K_{ST}	0.3472 mgFSA/l
Denitrification	$K_{(D2)}$	0.101 mgFSA/l
Half Saturation Coefficient	Θ	1.08
	K_{ST}	0.0742 mgFSA/l

s-recycle ratio	s	1.00 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.695
Anoxic sludge mass fraction	f_{x1}	0.148 set = f_{xm} for balanced MLE
Min anoxic sludge mass fraction	f_{x1min}	0.025

Influent RBCOD fraction (Sbs/Sbi)	$f_{Sb's}$	0.135

Denitrification potential BSO (K1)	$D_{(BSO)}$	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	$D_{(BPO)}$	11.10 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	19.84 mgNO ₃ -N/l influent

	A	0.6993
	B	19.3403
	C	1.553
Optimal a-recycle ratio	a_{opt}	0.08
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00 set = a_{opt} for balanced MLE
recycle limited		

Effluent Nitrate if recycle limited		18.72 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		17.94 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{de}	18.72 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{de} + N_{te}$	19.87 mgN/l
N removal		58.8%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Carbonaceous Oxygen flux	FO_c	3914 kgO/d
Nitrogenous Oxygen flux	FO_N	1521 kgO/d
Oxygen dmdnd recover by denitrification	FO_D	476 kgO/d
Total Oxygen Demand ($FO_c + FO_N - FO_D$)	FO_T	4959 kgO/d
Oxygen utilisation rate	O_T	19.7 mgO/l.h

Alkalinity consumed by nitrification		267 mg CaCO ₃
Alkalinity recovered by denitrification		67 mg CaCO ₃
Total Alkalinity consumption		200 mg CaCO ₃

COD mass balance		
COD in (influent)		5501.3 kgCOD/d
COD out		5501.5 kgCOD/d
$Q_s S_{te} + Q_w S_{te}$		322.7 kgCOD/d
$Q_w X_{f_{cv}}$		1265.2 kgCOD/d
$V_r O_c$		3913.6 kgO/d

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	595 mgVSS/l
Endogenous Residue VSS	X_{EH}	960 mgVSS/l
Unbiodegradable Organic VSS	X_i	420 mgVSS/l
Total VSS	X_T	1975 mgVSS/l
Influent Biodegradable ISS	$X_{(i)}$	1202 mgISS/l
TSS	X_t	3176 mgTSS/l

Active fraction of VSS	f_{av}	0.301 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.187 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.622 kgVSS/kgTSS

Waste Flow Rate	Q_w	411 m ³ /d
TSS wasted per day		1304 kgTSS/d
VSS wasted per day		811 kgVSS/d

Flux of N in waste VSS	FN_i	81 kgN/d
Equiv concn in influent	N_i	9.12 mgN/l influent
Effluent Sol Unbiodeg Org N	N_{oxide}	0.90 mgN/l

Factor of safety reducing $\mu_{max,T}$	Sf	1.25
total unaerated mass fraction	f_{xt}	0.148
Minimum sludge age for nitrification	SRT_{min}	1.77 days
SRT _{in} with Safety factor	$SRT_{in}(Sf)$	2.21 Nitrifies!

<u>If no nitrification</u>		
Effluent NO ₃	N_{de}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	39.1 mgTKN-N/l
Effluent FSA-N	$N_{de} = N_{di}$	38.2 mgFSA-N/l

<u>If complete nitrification</u>		
Effluent NO ₃	N_{de}	38.2 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	0.9 mgTKN-N/l
Effluent FSA-N	N_{de}	0.0 mgFSA-N/l

<u>Nitrification Results</u>		
Effluent NO ₃ if no denitrification	$N_{de} = N_t$	37.94 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	1.13 mgTKN-N/l
(calculated N_{de})	(N_{de})	0.234 mgFSA-N/l
Effluent FSA-N	N_{de}	0.234 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	431.4 kgVSS

Denitrification	$K_{(D2)}$	0.72 mgFSA/l
Half Saturation Coefficient	Θ	1.2
	K_{ST}	1.4930 mgFSA/l
Denitrification	$K_{(D2)}$	0.101 mgFSA/l
Half Saturation Coefficient	Θ	1.08
	K_{ST}	0.1374 mgFSA/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.863
Anoxic sludge mass fraction	f_{x1}	0.148
Min anoxic sludge mass fraction	f_{x1min}	0.007

Influent RBCOD fraction (Sbs/Sbi)	$f_{Sb's}$	0.135

Denitrification potential BSO (K1)	$D_{(BSO)}$	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	$D_{(BPO)}$	16.80 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	25.55 mgNO ₃ -N/l influent

	A	0.6993
	B	14.1403
	C	12.460
Optimal a-recycle ratio	a_{opt}	0.85
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00
recycle limited		

Effluent Nitrate if recycle limited		18.97 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		12.74 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{de}	18.97 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{de} + N_{te}$	20.11 mgN/l
N removal		58.3%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Carbonaceous Oxygen flux	FO_c	3978 kgO/d
Nitrogenous Oxygen flux	FO_N	1541 kgO/d
Oxygen dmdnd recover by denitrification	FO_D	482 kgO/d
Total Oxygen Demand ($FO_c + FO_N - FO_D$)	FO_T	5037 kgO/d
Oxygen utilisation rate	O_T	20.0 mgO/l.h

Alkalinity consumed by nitrification		271 mg CaCO ₃
Alkalinity recovered by denitrification		68 mg CaCO ₃
Total Alkalinity consumption		203 mg CaCO ₃

COD mass balance		
COD in (influent)		5501.3 kgCOD/d
COD out		5501.5 kgCOD/d
$Q_s S_{te} + Q_w S_{te}$		322.7 kgCOD/d
$Q_w X_{f_{cv}}$		1200.9 kgCOD/d
$V_r O_c$		3977.9 kgO/d

MLE Reactor @ 30 Days SRT

N mass balance		
N in (influent)	428.4	kgTKN-N/d
N out	428.4	kgTKN-N/d
Q _n N _{in} + Q _n N ₂	10.2	kgTKN-N/d
QN _i	85.4	kgTKN-N/d
QN ₂	332.8	kgNO3-N/d

TOD balance		
TOD in (influent)	7459.32	kgTOD/d
TOD out	7459.50	kgTOD/d
TOD _{effluent}	352.41	kgTOD/d
TOD _{waste}	1672.72	kgTOD/d
TOD _{N2 gas}	475.86	kgTOD/d
FO _i	4958.51	kgTOD/d

Flux of P in waste VSS	FP _i	21	kgP/d
Equiv conc in influent	P _i	2.40	mgP/l
Effluent Sol Unbiod Org P	P _{ouss}	0.60	mgP/l
Effluent TP	P ₁₀	13.10	mgP/l
Effluent Ortho-P as P	P ₀₀	12.50	mgOP-P/l

N mass balance		
N in (influent)	428.4	kgTKN-N/d
N out	428.4	kgTKN-N/d
Q _n N _{in} + Q _n N ₂	10.1	kgTKN-N/d
QN _i	81.1	kgTKN-N/d
QN ₂	337.3	kgNO3-N/d

TOD balance		
TOD in (influent)	7459.32	kgTOD/d
TOD out	7459.50	kgTOD/d
TOD _{effluent}	351.70	kgTOD/d
TOD _{waste}	1588.49	kgTOD/d
TOD _{N2 gas}	482.31	kgTOD/d
FO _i	5037.00	kgTOD/d

Flux of P in waste VSS	FP _i	20	kgP/d
Equiv conc in influent	P _i	2.28	mgP/l
Effluent Sol Unbiod Org P	P _{ouss}	0.00	mgP/l
Effluent TP	P ₁₀	13.22	mgP/l
Effluent Ortho-P as P	P ₀₀	13.22	mgOP-P/l

Effluent Concentrations			General	Special	Unit	Effluent Concentrations			General	Special	Unit
Unbiod Sol COD	S _{u00}	36.30	<75	<30	mgCOD/l	Unbiod Sol COD	S _{u00}	36.30	<75	<30	mgCOD/l
Undiod Sol Org N	N _{ouss}	0.90	-	-	mgN/l	Undiod Sol Org N	N _{ouss}	0.90	-	-	mgN/l
FSA-N	N ₂₀	0.25	<6	<2	mgFSA-N/l	FSA-N	N ₂₀	0.23	<6	<2	mgFSA-N/l
TKN-N	N ₁₀	1.15	-	-	mgTKN-N/l	TKN-N	N ₁₀	1.13	-	-	mgTKN-N/l
Nitrate	N ₀₀	18.72	<15	<1.5	mgNO ₃ -N/l	Nitrate	N ₀₀	18.97	<15	<1.5	mgNO ₃ -N/l
Undiod Sol Org P	P _{ouss}	0.60	-	-	mgP/l	Undiod Sol Org P	P _{ouss}	0.00	-	-	mgP/l
Ortho P as P	P ₀₀	12.50	<10	<2.5	mgOP-P/l	Ortho P as P	P ₀₀	13.22	<10	<2.5	mgOP-P/l
TP	P ₁₀	13.10	-	-	mgP/l	TP	P ₁₀	13.22	-	-	mgP/l

UCT Reactor @ 10 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	11.11 Ml/d
Sludge Age	SRT	10.0 days
Reactor TSS concentration	X _r	2092.77 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti	619
BPO COD	Sbpi	479
UPO COD	Supi	29
	fS'up	0.046
VFA COD	Sbsi,a	0
FBSO COD	Sbsfi	75
BSO COD	Sbsi	75
USO COD	Susi	36.3
	fS'us	0.059
BO COD	Sbi	554
UO COD	Sui	65
		722
TSS		241
ISS		51.4
VSS		189
UPO VSS		19.4
BPO VSS		170
		1888
TKN	Nti	48.2
Org N	Noi	13.8
FSA	Nai	34.4
BSO	Nobsi	2.90
USO	Nousi	0.90
BPO	Nobpi	8.70
UPO	Noupi	1.30
		14
Total P	Pti	15.50
OP	Pai	12.80
Org P	Poi	2.70
BSO	Pobsi	0.70
USO	Pousi	0.60
BPO	Pobpi	0.78
UPO	Poupi	0.62
		7

Constants		
COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{CHO}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{CN,BSO}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{CN,USO}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{N,UPO}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{P,UPO}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{C,UPO}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{H2O}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2141 /d
	μ _{AH2O}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.2829 /d
	b _{A2O}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0357 /d
	K _{A2O}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{AT}	0.6288 mgFSA/l
	K _{A2O}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{AT}	0.3472
Denitrification	K _{A2O}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{AT}	0.0742
Denitrification	K _{A2O}	0.255
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K _{AT}	0.1874
Factor of safety reducing μ _{AmT}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _{min}	6.76 days
SRT _{min} (with safety factor)	SRT _{min}	8.45 Nitrifies!

Max unaerated sludge mass fraction	f _{xm}	0.40
Total unaerated sludge mass fraction	f _{xt}	0.35
Anoxic mass fraction primary anox 2	f _{x,prim anox 2}	0.27
Anaerobic mass fraction	f _{xanaer}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments		2
r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N _{or}	3.9 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{O2,r}	0.0 mgO/l
influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
influent DO concentration	O _i	0.0 mgO/l
s-recycle ratio	s	1.000 :1
s-recycle DO concentration	O _s	1.0 mgO/l
a-recycle DO concentration	O _a	2.0 mgO/l

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	11.11 Ml/d
Sludge Age	SRT	10.0 days
Reactor TSS concentration	X _r	1980 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti	619
BPO COD	Sbpi	479
UPO COD	Supi	29
	fS'up	0.046
VFA COD	Sbsi,a	0
FBSO COD	Sbsfi	75
BSO COD	Sbsi	75
USO COD	Susi	36
	fS'us	0.059
BO COD	Sbi	554
UO COD	Sui	65
		722
TSS		241
ISS		51
VSS		189
UPO VSS		19
BPO VSS		170
		1888
TKN	Nti	48
Org N	Noi	14
FSA	Nai	34
BSO	Nobsi	2.90
USO	Nousi	0.90
BPO	Nobpi	8.70
UPO	Noupi	1.30
		14
Total P	Pti	15.50
OP	Pai	12.80
Org P	Poi	2.70
BSO	Pobsi	0.70
USO	Pousi	0.60
BPO	Pobpi	0.78
UPO	Poupi	0.62
		7

Constants		
COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{CHO}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{CN,BSO}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{CN,USO}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{N,UPO}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{P,UPO}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{C,UPO}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{H2O}	0.24 /d
	θ	1.029
Endogenous respiration rate OHO	b _{HT}	0.2691 /d
	μ _{AH2O}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.7157 /d
	b _{A2O}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0448 /d
	K _{A2O}	1.0
Nitrification	θ	1.123
Half Saturation Coefficient	K _{AT}	1.5904
	K _{A2O}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{AT}	1.4930
Denitrification	K _{A2O}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{AT}	0.1374
Denitrification	K _{A2O}	0.255
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K _{AT}	0.3469
Factor of safety reducing μ _{AmT}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _{min}	2.38 days
SRT _{min} (with safety factor)	SRT _{min}	2.98 Nitrifies!

Max unaerated sludge mass fraction	f _{xm}	0.75
Total unaerated sludge mass fraction	f _{xt}	0.35
Anoxic mass fraction primary anox 2	f _{x,prim anox 2}	0.27
Anaerobic mass fraction	f _{xanaer}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments		2
r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N _{or}	3.9 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{O2,r}	0.0 mgO/l
influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
influent DO concentration	O _i	0.0 mgO/l
s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O _s	1.0 mgO/l
a-recycle DO concentration	O _a	2.0 mgO/l

UCT Reactor @ 10 Days SRT

Influent RBCOD fraction (Sbsi/Sbi)	f_{bsi}	0.135
Influent TKN	N_{ij}	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_i	152 kgN/d
Equiv conc in influent	N_i	13.72 mgN/l
Effluent Sol Unbiol Org N	N_{oude}	0.90 mgN/l
Effluent ammonia	N_{ae}	1.78 mgFSA-N/l
TKN in effluent	N_{te}	2.68 mgTKN-N/l
Nitrification capacity	N_c	31.79 mgN/l influent

Denitrification potential BSO (K1)	D_{pBSO}	1.5 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	38.11 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	39.57 mgNO ₂ -N/l influent

	A	0.6993
	B	-6.0320
	C	46.654
Optimal a-recycle ratio	a_{opt}	13.55
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00 set = a_{opt} for balanced UCT recycle limited

Effluent Nitrate if recycle limited		3.97 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-3.23 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{ne}	3.97 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₃)	$N_{te} + N_{td}$	6.66 mgN/l
N removal		86.2%

Alkalinity consumed by nitrification		227 mg CaCO ₃
Alkalinity recovered by denitrification		99 mg CaCO ₃
Total Alkalinity consumption		128 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	S_{biLA}	0 mgCOD/l
FBSO COD	S_{bui}	75 mgCOD/l
BSO COD	S_{bi}	75 mgCOD/l
BO COD	S_{bi}	554 mgCOD/l

S_{F1} reduction due to O ₂ & NO ₃		33.54 mgCOD/l
Reduced FBSO concentration	$S_{F1,DRIV}$	41.46 mgCOD/l

	$k_{c,T20}$	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	$k_{c,T}$	0.0535 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	S_{buiN}	MX_{bui}/Q_i	S_{buiN}	
Trial 1	0.00	734		6.42
Trial 2	6.42	753		6.28
Trial 3	6.28	752		6.29
Trial 4	6.29	752		6.29

Flux BO COD obtained by OHO's	95%	5833 kgCOD/d
Flux BO COD obtained by PAO's	5%	321 kgCOD/d
Check total BO COD		6154 kgCOD/d

correct
6154

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_e	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{GD0}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{GT}	0.0357 /d

Activated Sludge Masses

OHO VSS		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	8358 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	3578 kgVSS

PAO VSS		
Polyphosphate Acc Organisms VSS	MX_{PAO}	1065 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	95 kgVSS

Unbiodegradable Organic VSS	MX_{iu}	2153 kgVSS
Total VSS	MX_y	15249 kgVSS

ISS from influent		5712 kgISS
ISS of OHO's		1254 kgISS
ISS of PAO's		1402 kgISS
ISS	MX_{IO}	8367 kgISS
TSS	MX_i	23617 kgTSS
VSS/TSS ratio		0.646 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.380 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	3.40 mgP/l
biomass P-content	ΔP_{OHO}	3.43 mgP/l
Potential P-removal		6.83 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	3.40 mgP/l
biomass P-content	ΔP_{OHO}	3.43 mgP/l
Total Actual P-removal		6.83 mgP/l

TP effluent

Note: Add P content of TSS in effluent

P_{te} 8.67 mgP/l

Influent RBCOD fraction (Sbsi/Sbi)	f_{bsi}	0.135
Influent TKN	N_{ij}	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_i	142 kgN/d
Equiv conc in influent	N_i	12.79 mgN/l
Effluent Sol Unbiol Org N	N_{oude}	0.90 mgN/l
Effluent ammonia	N_{ae}	0.72 mgFSA-N/l
TKN in effluent	N_{te}	1.62 mgTKN-N/l
Nitrification capacity	N_c	33.78 mgN/l influent

Denitrification potential BSO (K1)	D_{pBSO}	1.4 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	59.94 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	61.32 mgNO ₂ -N/l influent

	A	0.6993
	B	-25.7836
	C	88.149
Optimal a-recycle ratio	a_{opt}	40.02
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00 recycle limited

Effluent Nitrate if recycle limited		4.22 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-22.99 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{ne}	4.22 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₃)	$N_{te} + N_{td}$	5.84 mgN/l
N removal		87.9%

Alkalinity consumed by nitrification		241 mg CaCO ₃
Alkalinity recovered by denitrification		106 mg CaCO ₃
Total Alkalinity consumption		136 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	S_{biLA}	0 mgCOD/l
FBSO COD	S_{bui}	75 mgCOD/l
BSO COD	S_{bi}	75 mgCOD/l
BO COD	S_{bi}	554 mgCOD/l

S_{F1} reduction due to O ₂ & NO ₃		33.54 mgCOD/l
Reduced FBSO concentration	$S_{F1,DRIV}$	41.46 mgCOD/l

	$k_{c,T20}$	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	$k_{c,T}$	0.0673 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	S_{buiN}	MX_{bui}/Q_i	S_{buiN}	
Trial 1	0.00	625		6.04
Trial 2	6.04	640		5.92
Trial 3	5.92	639		5.92
Trial 4	5.92	639		5.92

Flux BO COD obtained by OHO's	95%	5825 kgCOD/d
Flux BO COD obtained by PAO's	5%	329 kgCOD/d
Check total BO COD		6154 kgCOD/d

correct

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_e	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{GD0}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{GT}	0.0448 /d

Activated Sludge Masses

OHO VSS		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	7103 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	3822 kgVSS

PAO VSS		
Polyphosphate Acc Organisms VSS	MX_{PAO}	1023 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	115 kgVSS

Unbiodegradable Organic VSS	MX_{iu}	2153 kgVSS
Total VSS	MX_y	14215 kgVSS

ISS from influent		5712 kgISS
ISS of OHO's		1065 kgISS
ISS of PAO's		1346 kgISS
ISS	MX_{IO}	8124 kgISS
TSS	MX_i	22339 kgTSS
VSS/TSS ratio		0.636 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.38 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	3.27 mgP/l
biomass P-content	ΔP_{OHO}	3.20 mgP/l
Potential P-removal		6.47 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	3.27 mgP/l
biomass P-content	ΔP_{OHO}	3.20 mgP/l
Total Actual P-removal		6.47 mgP/l

TP effluent

Note: Add P content of TSS in effluent

P_{te} 9.03 mgP/l

UCT Reactor @ 10 Days SRT

Carbonaceous Oxygen flux OHO's	FO _{OHO}	4066 kgO/d
Carbonaceous Oxygen flux PAO's	FO _{PAO}	149 kgO/d
Carbonaceous Oxygen flux	FO _c	4215 kgO/d
Nitrogenous Oxygen flux	FO _n	1614 kgO/d
Oxygen dmmnd recover by denitrification	FO _D	884 kgO/d
Total Oxygen Demand (FO _c + FO _n + FO _D)	FO _T	4945 kgO/d
Oxygen utilisation rate	O _T	28.1 mgO/l/h

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Check	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	1915	6383	15319	23617
Concentration TSS (kgTSS/m ³)	1.05	2.09	2.09	1.936
Volume (m ³)	1830	3050	7320	12200
Volume fraction	15%	25%	60%	100%
Concentration VSS (kgVSS/m ³)	0.68	1.35	1.35	1.25
UPO VSS Concentration (kgUPOVSS/m ³)	0.095	0.191	0.191	0.176

Mass TSS wasted per day 2361.7 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 1128.5 m³/d

COD mass balance	
COD in (influent)	6877 kgCOD/d
COD out	6877 kgCOD/d
Q _s S _{in} + Q _w S _{in}	403 kgCOD/d
Q _s X _{f,cs} or f _{cs} MX _v /Rs	2258 kgCOD/d
FO _c	4215 kgO/d

N Mass balance	
TKN in (influent)	536 kgN/d
TKN out	536 kgN/d
N _{in}	66 kgN/d
N _{waste}	160 kgN/d
N _{denitrified}	309 kgN/d

TOD balance	
TOD in (influent)	9324 kgTOD/d
TOD out	9324 kgTOD/d
TOD _{effluent}	485 kgTOD/d
TOD _{waste}	3010 kgTOD/d
TOD _{N2-gas}	884 kgTOD/d
FO _i	4945 kgTOD/d

Effluent Concentrations		General		Special	Unit
Unbiol Sol COD	S _{sol}	36.30	75	30	mgCOD/l
Unbiol Sol Org N	N _{sol}	0.90	-	-	mgN/l
FSA-N	N _{sa}	1.78	6	2	mgFSA-N/l
TKN-N	N _{te}	2.68	-	-	mgTKN-N/l
Nitrate	N _{oe}	3.97	15	1.5	mgNO ₃ -N/l
Unbiol Sol Org P	P _{sol}	0.60	-	-	mgP/l
Ortho P as P	P _{oe}	8.67	10	2.5	mgP/l
TP	P _{te}	9.27	-	-	mgP/l

Carbonaceous Oxygen flux OHO's	FO _{OHO}	4207 kgO/d
Carbonaceous Oxygen flux PAO's	FO _{PAO}	161 kgO/d
Carbonaceous Oxygen flux	FO _c	4368 kgO/d
Nitrogenous Oxygen flux	FO _n	1716 kgO/d
Oxygen dmmnd recover by denitrification	FO _D	939 kgO/d
Total Oxygen Demand (FO _c + FO _n + FO _D)	FO _T	5144 kgO/d
Oxygen utilisation rate	O _T	29.3 mgO/l/h

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	1811	6038	14490	22339
Concentration TSS (kgTSS/m ³)	0.99	1.98	1.98	1.831
Volume (m ³)	1830	3050	7320	12200
Concentration VSS (kgVSS/m ³)	0.63	1.26	1.26	1.17
UPO VSS Concentration (kgUPOVSS/m ³)	0.095	0.191	0.191	0.176

Mass TSS wasted per day 2233.9 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 1128.5 m³/d

COD mass balance	
COD in (influent)	6876.7 kgCOD/d
COD out	6876.7 kgCOD/d
Q _s S _{in} + Q _w S _{in}	403.3 kgCOD/d
Q _s X _{f,cs} or f _{cs} MX _v /Rs	2105.3 kgCOD/d
FO _c	4368.1 kgO/d

N Mass balance	
TKN in (influent)	535.56 kgN/d
TKN out	535.56 kgN/d
N _{in}	58.34 kgN/d
N _{waste}	148.7 kgN/d
N _{denitrified}	328.5 kgN/d

TOD balance	
TOD in (influent)	9324.16 kgTOD/d
TOD out	9324.16 kgTOD/d
TOD _{effluent}	436.33 kgTOD/d
TOD _{waste}	2804.25 kgTOD/d
TOD _{N2-gas}	939.41 kgTOD/d
FO _i	5144.17 kgTOD/d

Effluent Concentrations		General		Special	Unit
Unbiol Sol COD	S _{sol}	36.30	75	30	mgCOD/l
Unbiol Sol Org N	N _{sol}	0.90	-	-	mgN/l
FSA-N	N _{sa}	0.72	6	2	mgFSA-N/l
TKN-N	N _{te}	1.62	-	-	mgTKN-N/l
Nitrate	N _{oe}	4.22	15	1.5	mgNO ₃ -N/l
Unbiol Sol Org P	P _{sol}	0.60	-	-	mgP/l
Ortho P as P	P _{oe}	9.03	10	2.5	mgP/l
TP	P _{te}	9.63	-	-	mgP/l

UCT Reactor @ 15 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	11.11 Ml/d
Sludge Age	SRT	15.0 days
Reactor TSS concentration	X _r	2829.69 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	619	6877
BPO COD	Sbpi	479	5321
UPO COD	Supi	29	319
	fS'up		0.046
VFA COD	Sbsi,a	0.0	0
FBSO COD	Sbsfi	75	833
BSO COD	Sbsi	75	833
USO COD	Susi	36.3	403
	fS'us		0.059
BO COD	Sbi	554	6154
UO COD	Sul	65	722
TSS		241	2675
ISS		51.4	571
VSS		189	2104
UPO VSS		19.4	215
BPO VSS		170	1888
TKN	Nti	48.2	536
Org N	Noi	13.8	153
FSA	Nai	34.4	382
BSO	Nobsi	2.90	32
USO	Nousi	0.90	10
BPO	Nobpi	8.70	97
UPO	Noupi	1.30	14
Total P	Pti	15.50	172
OP	Pai	12.80	142
Org P	Poi	2.70	30
BSO	Pobsi	0.70	8
USO	Pousi	0.60	7
BPO	Pobpi	0.78	9
UPO	Poupi	0.62	7

Constants			
COD/VSS ratio	f _{cv}	1.481	mgCOD/mgVSS
Yield coefficient of OHO's	Y _{ih}	0.67	mgCOD/mgCOD
Yield coefficient of OHO's	Y _{ihv}	0.45	mgVSS/mgCOD
Endogenous residue fraction	f _h	0.2	
ISS content of OHO's	f _{IOHO}	0.15	
Yield coefficient of ANO's	Y _A	0.10	mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bsso}	1.42	mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493	mgCOD/mg
N Content of UPO and biomass VSS	f _{N,uipo}	0.1	mgN/mgVSS
P Content of UPO and biomass VSS	f _{P,uipo}	0.025	mgP/mgVSS
C Content of UPO and biomass VSS	f _{C,uipo}	0.518	mgC/mgVSS

Temperature dependant coefficients		T	16 °C
	b _{h20}	0.24	/d
	θ	1.029	
Endogenous respiration rate heterotrophs	b _{HT}	0.2141	/d
	μ _{hmax20}	0.45	/d
	θ	1.123	
nitrifiers max spec. growth rate	μ _{amT}	0.2829	/d
	b _{a20}	0.0400	/d
	θ	1.029	
Endogenous respiration rate autotrophs	b _{AT}	0.0357	/d
	K _{a20}	1.0	mgFSA/l
Nitrification	θ	1.123	
Half Saturation Coefficient	K _{HT}	0.6288	mgFSA/l
	K _{h20}	0.72	
Denitrification	θ	1.2	
Half Saturation Coefficient	K _{HT}	0.3472	
Denitrification	K _{h20}	0.101	
for ND system	θ	1.08	
Half Saturation Coefficient	K _{HT}	0.0742	
Denitrification	K [*] _{h20}	0.255	
primary anoxic of NDBPER system	θ	1.08	
Half Saturation Coefficient	K [*] _{HT}	0.1874	

Factor of safety reducing μ _{amT}	Sf	1.25
total unaerated mass fraction	f _{st}	0.351
Minimum sludge age for nitrification	SRT _m	6.76 days
SRT _m (with safety factor)	SRT _m	8.45 Nitrifies!

Max unaerated sludge mass fraction	f _{un}	0.55	
Total unaerated sludge mass fraction	f _{st}	0.35	Ok!
Anoxic mass fraction primary anox 2	f _{prim anox 2}	0.27	
Anaerobic mass fraction	f _{anaer}	0.08	
Aerobic mass fraction	f _{aer}	0.65	

Nr of equal size compartments

r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N _{nr}	4.3 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{O2,r}	0.0 mgO/l

influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)

Influent TKN	N _{ti}	48.2 mgTKN-N/l
Flux of N in waste VSS	FN _v	134 kgN/d
Equiv conc in influent	N _i	12.10 mgN/l
Effluent Sol Unbioid Org N	N _{uise}	0.90 mgN/l
Effluent ammonia	N _{ae}	0.79 mgFSA-N/l
TKN in effluent	N _{te}	1.69 mgTKN-N/l
Nitrification capacity	N _c	34.41 mgN/l influent

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	11.11 Ml/d
Sludge Age	SRT	15.0 days
Reactor TSS concentration	X _r	2683 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	619	6877
BPO COD	Sbpi	479	5321
UPO COD	Supi	29	319
	fS'up		0.046
VFA COD	Sbsi,a	0	0
FBSO COD	Sbsfi	75	833
BSO COD	Sbsi	75	833
USO COD	Susi	36	403
	fS'us		0.059
BO COD	Sbi	554	6154
UO COD	Sul	65	722
TSS		241	2675
ISS		51	571
VSS		189	2104
UPO VSS		19	215
BPO VSS		170	1888
TKN	Nti	48	536
Org N	Noi	14	153
FSA	Nai	34	382
BSO	Nobsi	2.90	32
USO	Nousi	0.90	10
BPO	Nobpi	8.70	97
UPO	Noupi	1.30	14
Total P	Pti	15.50	172
OP	Pai	12.80	142
Org P	Poi	2.70	30
BSO	Pobsi	0.70	8
USO	Pousi	0.60	7
BPO	Pobpi	0.78	9
UPO	Poupi	0.62	7

Constants			
COD/VSS ratio	f _{cv}	1.481	mgCOD/mgVSS
Yield coefficient of OHO's	Y _{ih}	0.67	mgCOD/mgCOD
Yield coefficient of OHO's	Y _{ihv}	0.45	mgVSS/mgCOD
Endogenous residue fraction	f _h	0.2	
ISS content of OHO's	f _{IOHO}	0.15	
Yield coefficient of ANO's	Y _A	0.1	mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bsso}	1.42	mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493	mgCOD/mg
N Content of UPO and biomass VSS	f _{N,uipo}	0.1	mgN/mgVSS
P Content of UPO and biomass VSS	f _{P,uipo}	0.025	mgP/mgVSS
C Content of UPO and biomass VSS	f _{C,uipo}	0.518	mgC/mgVSS

Temperature dependant coefficients		T	24 °C
	b _{h20}	0.24	/d
	θ	1.029	
Endogenous respiration rate OHO	b _{HT}	0.2691	/d
	μ _{hmax20}	0.45	/d
	θ	1.123	
nitrifiers max spec. growth rate	μ _{amT}	0.7157	/d
	b _{a20}	0.0400	/d
	θ	1.029	
Endogenous respiration rate autotrophs	b _{AT}	0.0448	/d
	K _{a20}	1.0	
Nitrification	θ	1.123	
Half Saturation Coefficient	K _{HT}	1.5904	
	K _{h20}	0.72	
Denitrification	θ	1.2	
Half Saturation Coefficient	K _{HT}	1.4930	
Denitrification	K _{h20}	0.101	
for ND system	θ	1.08	
Half Saturation Coefficient	K _{HT}	0.1374	
Denitrification	K [*] _{h20}	0.255	
primary anoxic of NDBPER system	θ	1.08	
Half Saturation Coefficient	K [*] _{HT}	0.3469	

Factor of safety reducing μ _{amT}	Sf	1.25
total unaerated mass fraction	f _{st}	0.351
Minimum sludge age for nitrification	SRT _m	2.38 days
SRT _m (with safety factor)	SRT _m	2.98 Nitrifies!

Max unaerated sludge mass fraction	f _{un}	0.81	
Total unaerated sludge mass fraction	f _{st}	0.35	
Anoxic mass fraction primary anox 2	f _{prim anox 2}	0.27	
Anaerobic mass fraction	f _{anaer}	0.08	
Aerobic mass fraction	f _{aer}	0.65	

Nr of equal size compartments

r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N _{nr}	4.3 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{O2,r}	0.0 mgO/l

influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)

Influent TKN	N _{ti}	48.2 mgTKN-N/l
Flux of N in waste VSS	FN _v	126 kgN/d
Equiv conc in influent	N _i	11.32 mgN/l
Effluent Sol Unbioid Org N	N _{uise}	0.90 mgN/l
Effluent ammonia	N _{ae}	0.50 mgFSA-N/l
TKN in effluent	N _{te}	1.40 mgTKN-N/l
Nitrification capacity	N _c	35.48 mgN/l influent

UCT Reactor @ 15 Days SRT

Denitrification potential BSO (K1)	D _{BSO}	1.2 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D _{BPO}	42.71 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D _{a1}	43.93 mgNO ₃ -N/l influent

	A	0.6993
	B	-7.7715
	C	52.751
Optimal a-recycle ratio	a _{opt}	15.87
Maximum practical a-recycle ratio	a _{max}	6
chosen a-recycle ratio	a	6.00 set = a _{opt} for balanced UCT
	recycle limited	

Effluent Nitrate if recycle limited		4.30 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		4.97 mgNO ₃ -N/l
Actual Effluent Nitrate	N _{ae}	4.30 mgNO ₃ -N/l influent

Effluent total N (TKN + NO ₃)	N _{ta} + N _{te}	5.99 mgN/l
N removal		87.6%

Alkalinity consumed by nitrification		246 mg CaCO ₃
Alkalinity recovered by denitrification		107 mg CaCO ₃
Total Alkalinity consumption		138 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	S _{bio,a}	0 mgCOD/l
FBSO COD	S _{bio,f}	75 mgCOD/l
BSO COD	S _{bio}	75 mgCOD/l
BO COD	S _{bi}	554 mgCOD/l

S _{ij} reduction due to O ₂ & NO ₃		36.55 mgCOD/l
Reduced FBSO concentration	S _{F,i,conv}	38.45 mgCOD/l

	k _{F,T20}	0.06 m ³ /gVSS.d
	Θ	1.029
Fermentation rate	k _{F,T}	0.0535 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	S _{bioIN}	MX _{bio} /Q _i	S _{bioIN}	
Trial 1	0.00	826		5.35
Trial 2	5.35	843		5.24
Trial 3	5.24	843		5.24
Trial 4	5.24	843		5.24

Flux BO COD obtained by OHO's	95%	5844 kgCOD/d
Flux BO COD obtained by PAO's	5%	311 kgCOD/d
Check total BO COD		6154 kgCOD/d

correct

Yield coefficient of PAO's	Y _G	0.47 mgCOD/mgCOD
Yield coefficient of PAO's	Y _{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _G	0.25
ISS content of PAO's	f _{PAO}	0.15

	b _{o20}	0.04 /d
	Θ	1.029
Endogenous respiration rate PAO's	b _{oT}	0.0357 /d

Activated Sludge Masses

OHO VSS		
Ordinary Heterotrophic Organisms VSS	MX _{OHO}	9367 kgVSS
Endogenous Residue VSS OHO	MX _{E,OHO}	6016 kgVSS

PAO VSS		
Polyphosphate Acc Organisms VSS	MX _{PAO}	1366 kgVSS
Endogenous Residue VSS PAO	MX _{E,PAO}	183 kgVSS

Unbiodegradable Organic VSS	MX _u	3230 kgVSS
Total VSS	MX _v	20161 kgVSS

ISS from influent		8568 kgISS
ISS of OHO's		1405 kgISS
ISS of PAO's		1798 kgISS
ISS	MX _{IO}	11772 kgISS
TSS	MX _t	31933 kgTSS
VSS/TSS ratio		0.631 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	f _{PB,PAO}	0.353 mgP/mgPAOVSS
		0.380 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	ΔP _{PAO,2}	2.91 mgP/l
biomass P-content	ΔP _{OHO}	3.02 mgP/l
Potential P-removal		5.93 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	f _{PB,PAO}	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	ΔP _{PAO,2}	2.91 mgP/l
biomass P-content	ΔP _{OHO}	3.02 mgP/l
Total Actual P-removal		5.93 mgP/l

TP effluent P_{te} 9.57 mgP/l

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO _{OHO}	4325 kgO/d
Carbonaceous Oxygen flux PAO's	FO _{PAO}	158 kgO/d
Carbonaceous Oxygen flux	FO _c	4483 kgO/d
Nitrogenous Oxygen flux	FO _N	1747 kgO/d
Oxygen dmnd recover by denitrification	FO _D	957 kgO/d
Total Oxygen Demand (FO _c + FO _N - FO _D)	FO _T	5273 kgO/d
Oxygen utilisation rate	O _r	30.0 mgO/l.h

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Check	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	2589	8631	20713	31933
Concentration TSS (kgTSS/m ³)	1.41	2.83	2.83	2.617
Volume (m ³)	1830	3050	7320	12200
Volume fraction	15%	25%	60%	100%
Concentration VSS (kgVSS/m ³)	0.89	1.79	1.79	1.65
UPO VSS Concentration (kgUPOVSS/m ³)	0.143	0.286	0.286	0.265

Denitrification potential BSO (K1)	D _{BSO}	1.2 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D _{BPO}	66.04 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D _{a1}	67.20 mgNO ₃ -N/l influent

	A	0.6993
	B	-29.9740
	C	98.225
Optimal a-recycle ratio	a _{opt}	45.92
Maximum practical a-recycle ratio	a _{max}	6
chosen a-recycle ratio	a	6.00
	recycle limited	

Effluent Nitrate if recycle limited		4.44 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		-27.18 mgNO ₃ -N/l
Actual Effluent Nitrate	N _{ae}	4.44 mgNO ₃ -N/l influent

Effluent total N (TKN + NO ₃)	N _{ta} + N _{te}	5.84 mgN/l
N removal		87.9%

Alkalinity consumed by nitrification		253 mg CaCO ₃
Alkalinity recovered by denitrification		111 mg CaCO ₃
Total Alkalinity consumption		142 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	S _{bio,a}	0 mgCOD/l
FBSO COD	S _{bio,f}	75 mgCOD/l
BSO COD	S _{bio}	75 mgCOD/l
BO COD	S _{bi}	554 mgCOD/l

S _{ij} reduction due to O ₂ & NO ₃		36.55 mgCOD/l
Reduced FBSO concentration	S _{F,i,conv}	38.45 mgCOD/l

	k _{F,T20}	0.06 m ³ /gVSS.d
	Θ	1.029
Fermentation rate	k _{F,T}	0.0673 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	S _{bioIN}	MX _{bio} /Q _i	S _{bioIN}	
Trial 1	0.00	691		5.10
Trial 2	5.10	705		5.00
Trial 3	5.00	704		5.00
Trial 4	5.00	704		5.00

Flux BO COD obtained by OHO's	95%	5838 kgCOD/d
Flux BO COD obtained by PAO's	5%	316 kgCOD/d
Check total BO COD		6154 kgCOD/d

correct

Yield coefficient of PAO's	Y _G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y _{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _G	0.25
ISS content of PAO's	f _{PAO}	0.15

	b _{o20}	0.04 /d
	Θ	1.029
Endogenous respiration rate PAO's	b _{oT}	0.0448 /d

Activated Sludge Masses

OHO VSS		
Ordinary Heterotrophic Organisms VSS	MX _{OHO}	7825 kgVSS
Endogenous Residue VSS OHO	MX _{E,OHO}	6317 kgVSS

PAO VSS		
Polyphosphate Acc Organisms VSS	MX _{PAO}	1275 kgVSS
Endogenous Residue VSS PAO	MX _{E,PAO}	214 kgVSS

Unbiodegradable Organic VSS	MX _u	3230 kgVSS
Total VSS	MX _v	18862 kgVSS

ISS from influent		8568 kgISS
ISS of OHO's		1174 kgISS
ISS of PAO's		1679 kgISS
ISS	MX _{IO}	11421 kgISS
TSS	MX _t	30283 kgTSS
VSS/TSS ratio		0.623 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	f _{PB,PAO}	0.355 mgP/mgPAOVSS
		0.38 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	ΔP _{PAO,2}	2.72 mgP/l
biomass P-content	ΔP _{OHO}	2.83 mgP/l
Potential P-removal		5.55 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	f _{PB,PAO}	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	ΔP _{PAO,2}	2.72 mgP/l
biomass P-content	ΔP _{OHO}	2.83 mgP/l
Total Actual P-removal		5.55 mgP/l

TP effluent P_{te} 9.95 mgP/l

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO _{OHO}	4442 kgO/d
Carbonaceous Oxygen flux PAO's	FO _{PAO}	169 kgO/d
Carbonaceous Oxygen flux	FO _c	4611 kgO/d
Nitrogenous Oxygen flux	FO _N	1802 kgO/d
Oxygen dmnd recover by denitrification	FO _D	987 kgO/d
Total Oxygen Demand (FO _c + FO _N - FO _D)	FO _T	5426 kgO/d
Oxygen utilisation rate	O _r	30.9 mgO/l.h

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	2455	8185	19643	30283
Concentration TSS (kgTSS/m ³)	1.34	2.68	2.68	2.482
Volume (m ³)	1830	3050	7320	12200
	2455			
Concentration VSS (kgVSS/m ³)	0.84	1.67	1.67	1.55
UPO VSS Concentration (kgUPOVSS/m ³)	0.143	0.286	0.286	0.265

UCT Reactor @ 15 Days SRT

Mass TSS wasted per day 2128.9 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 752.3 m³/d

COD mass balance	
COD in (influent)	6876.7 kgCOD/d
COD out	6876.7 kgCOD/d
$Q_a S_{10} + Q_w S_{10}$	403.3 kgCOD/d
$Q_w X_{f,10}$ or $t_{10} MX_{f,10}/R_s$	1990.6 kgCOD/d
FO_L	4482.7 kgO/d

N Mass balance	
TKN in (influent)	535.56 kgN/d
TKN out	535.56 kgN/d
N_{10}	62.09 kgN/d
N_{waste}	138.9 kgN/d
$N_{denitrified}$	334.5 kgN/d

TOD balance	
TOD in (influent)	9324.16 kgTOD/d
TOD out	9324.16 kgTOD/d
$TOD_{effluent}$	456.15 kgTOD/d
TOD_{waste}	2637.99 kgTOD/d
TOD_{N2-gas}	956.80 kgTOD/d
FO_L	5273.21 kgTOD/d

Effluent Concentrations		General		Special	Unit
Unbiol Sol COD	S_{100}	36.30	75	30	mgCOD/l
Unbiol Sol Org N	N_{1000}	0.90	-	-	mgN/l
FSA-N	N_{100}	0.79	6	2	mgFSA-N/l
TKN-N	N_{10}	1.69	-	-	mgTKN-N/l
Nitrate	N_{10}	4.30	15	1.5	mgNO ₃ -N/l
Unbiol Sol Org P	P_{1000}	0.60	-	-	mgP/l
Ortho P as P	P_{100}	9.57	10	2.5	mgP/l
TP	P_{10}	10.17	-	-	mgP/l

Mass TSS wasted per day 2018.9 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 752.3 m³/d

COD mass balance	
COD in (influent)	6876.7 kgCOD/d
COD out	6876.7 kgCOD/d
$Q_a S_{10} + Q_w S_{10}$	403.3 kgCOD/d
$Q_w X_{f,10}$ or $t_{10} MX_{f,10}/R_s$	1862.3 kgCOD/d
FO_L	4611.0 kgO/d

N Mass balance	
TKN in (influent)	535.56 kgN/d
TKN out	535.56 kgN/d
N_{10}	60.47 kgN/d
N_{waste}	130.1 kgN/d
$N_{denitrified}$	344.9 kgN/d

TOD balance	
TOD in (influent)	9324.16 kgTOD/d
TOD out	9324.16 kgTOD/d
$TOD_{effluent}$	442.43 kgTOD/d
TOD_{waste}	2469.07 kgTOD/d
TOD_{N2-gas}	986.54 kgTOD/d
FO_L	5426.11 kgTOD/d

Effluent Concentrations		General		Special	Unit
Unbiol Sol COD	S_{100}	36.30	75	30	mgCOD/l
Unbiol Sol Org N	N_{1000}	0.90	-	-	mgN/l
FSA-N	N_{100}	0.50	6	2	mgFSA-N/l
TKN-N	N_{10}	1.40	-	-	mgTKN-N/l
Nitrate	N_{10}	4.44	15	1.5	mgNO ₃ -N/l
Unbiol Sol Org P	P_{1000}	0.60	-	-	mgP/l
Ortho P as P	P_{100}	9.95	10	2.5	mgP/l
TP	P_{10}	10.55	-	-	mgP/l

UCT Reactor @ 20 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	11.11 Ml/d
Sludge Age	SRT	20.0 days
Reactor TSS concentration	X _r	3521.81 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	619	6877
BPO COD	Sbpi	479	5321
UPO COD	Supi	29	319
	f _{S'up}		0.046
VFA COD	Sbsi,a	0.0	0
FBSO COD	Sbsfi	75	833
BSO COD	Sbsi	75	833
USO COD	Susi	36.3	403
	f _{S'us}		0.059
BO COD	Sbi	554	6154
UO COD	Sui	65	722
TSS		241	2675
ISS		51.4	571
VSS		189	2104
UPO VSS		19.4	215
BPO VSS		170	1888
TKN	Nti	48.2	536
Org N	Noi	13.8	153
FSA	Nai	34.4	382
BSO	Nobsi	2.90	32
USO	Nousi	0.90	10
BPO	Nobpi	8.70	97
UPO	Noupi	1.30	14
Total P	Pti	15.50	172
OP	Pai	12.80	142
Org P	Poi	2.70	30
BSO	Pobsi	0.70	8
USO	Pousi	0.60	7
BPO	Pobpi	0.78	9
UPO	Poupi	0.62	7

Constants		
COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{OHO}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cv,FBSO}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cv,USO}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{N,UPO}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{P,UPO}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{C,UPO}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{H20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2141 /d
	μ _{AH20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{AHnT}	0.2829 /d
	b _{A20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0357 /d
	K _{s20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{sT}	0.6288 mgFSA/l
	K _{s20}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{sT}	0.3472
Denitrification	K _{s20}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{sT}	0.0742
Denitrification	K _{s20}	0.255
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K _{s2T}	0.1874
Factor of safety reducing μ _{AHnT}	Sf	1.25
total unaerated mass fraction	fx _t	0.351
Minimum sludge age for nitrification	SRT _{min}	6.76 days
SRT _{min} (with safety factor)	SRT _{min}	8.45 Nitrifies!

Max unaerated sludge mass fraction	f _{un}	0.62	
Total unaerated sludge mass fraction	f _u	0.35	Ok!
Anoxic mass fraction primary anox 2	f _{s,prim anox 2}	0.27	
Anaerobic mass fraction	f _{anaer}	0.08	
Aerobic mass fraction	f _{aer}	0.65	

Nr of equal size compartments		2
r-recyle ratio	r	1.0 :1
r-recyle NO ₃ concentration	N _{ox}	4.4 mgNO ₃ -N/l
r-recyle O ₂ concentration	S _{O2,s}	0.0 mgO/l
	S _{NO3,s}	0.0 mgNO ₃ -N/l
influent NO ₃ concentration	O _i	0.0 mgO/l
influent DO concentration		
s-recyle ratio	s	1.000 :1
s-recyle DO concentration	O _s	1.0 mgO/l
a-recyle DO concentration	O _a	2.0 mgO/l
Influent RBCOD fraction (Sbsi/Sbi)	f _{Sb/s}	0.135

4.45

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	11.11 Ml/d
Sludge Age	SRT	20.0 days
Reactor TSS concentration	X _r	3352 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	619	6877
BPO COD	Sbpi	479	5321
UPO COD	Supi	29	319
	f _{S'up}		0.046
VFA COD	Sbsi,a	0	0
FBSO COD	Sbsfi	75	833
BSO COD	Sbsi	75	833
USO COD	Susi	36	403
	f _{S'us}		0.059
BO COD	Sbi	554	6154
UO COD	Sui	65	722
TSS		241	2675
ISS		51	571
VSS		189	2104
UPO VSS		19	215
BPO VSS		170	1888
TKN	Nti	48	536
Org N	Noi	14	153
FSA	Nai	34	382
BSO	Nobsi	2.90	32
USO	Nousi	0.90	10
BPO	Nobpi	8.70	97
UPO	Noupi	1.30	14
Total P	Pti	15.50	172
OP	Pai	12.80	142
Org P	Poi	2.70	30
BSO	Pobsi	0.70	8
USO	Pousi	0.60	7
BPO	Pobpi	0.78	9
UPO	Poupi	0.62	7

Constants		
COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{OHO}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cv,FBSO}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cv,USO}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{N,UPO}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{P,UPO}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{C,UPO}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{H20}	0.24 /d
	θ	1.029
Endogenous respiration rate OHO	b _{HT}	0.2691 /d
	μ _{AHn20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{AHnT}	0.7157 /d
	b _{A20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0448 /d
	K _{s20}	1.0
Nitrification	θ	1.123
Half Saturation Coefficient	K _{sT}	1.5904
	K _{s20}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{sT}	1.4930
Denitrification	K _{s20}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{sT}	0.1374
Denitrification	K _{s20}	0.255
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K _{s2T}	0.3469
Factor of safety reducing μ _{AHnT}	Sf	1.25
total unaerated mass fraction	fx _t	0.351
Minimum sludge age for nitrification	SRT _{min}	2.38 days
SRT _{min} (with safety factor)	SRT _{min}	2.98 Nitrifies!

Max unaerated sludge mass fraction	f _{un}	0.83
Total unaerated sludge mass fraction	f _u	0.35
Anoxic mass fraction primary anox 2	f _{s,prim anox 2}	0.27
Anaerobic mass fraction	f _{anaer}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments		2
r-recyle ratio	r	1.0 :1
r-recyle NO ₃ concentration	N _{ox}	4.4 mgNO ₃ -N/l
r-recyle O ₂ concentration	S _{O2,s}	0.0 mgO/l
	S _{NO3,s}	0.0 mgNO ₃ -N/l
influent NO ₃ concentration	O _i	0.0 mgO/l
influent DO concentration		
s-recyle ratio	s	1.0 :1
s-recyle DO concentration	O _s	1.0 mgO/l
a-recyle DO concentration	O _a	2.0 mgO/l
Influent RBCOD fraction (Sbsi/Sbi)	f _{Sb/s}	0.135

UCT Reactor @ 20 Days SRT

Influent TKN	N_{ti}	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_i	124 kgN/d
Equiv conc in influent	N_i	11.12 mgN/l
Effluent Sol Unbiobd Org N	N_{dude}	0.90 mgN/l
Effluent ammonia	N_{de}	0.55 mgFSA-N/l
TKN in effluent	N_{te}	1.45 mgTKN-N/l
Nitrification capacity	N_c	35.63 mgN/l influent

Denitrification potential BSO (K1)	D_{BBSO}	1.1 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BBPO}	45.43 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	46.55 mgNO ₂ -N/l influent

	A	0.6993
	B	-9.1644
	C	56.759
Optimal a-recycle ratio	a_{opt}	17.69
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00 set = a_{opt} for balanced UCT recycle limited

Effluent Nitrate if recycle limited		4.45 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-6.37 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{ne}	4.45 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₃)	$N_{te} + N_{de}$	5.90 mgN/l
N removal		87.7%

Alkalinity consumed by nitrification		254 mg CaCO ₃
Alkalinity recovered by denitrification		111 mg CaCO ₃
Total Alkalinity consumption		143 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{bi,a}$	0 mgCOD/l
FBSO COD	S_{bdf}	75 mgCOD/l
BSO COD	S_{bdi}	75 mgCOD/l
BO COD	S_{bi}	554 mgCOD/l

S_{rj} reduction due to O ₂ & NO ₃		37.84 mgCOD/l
Reduced FBSO concentration	$S_{rj,LOHV}$	37.16 mgCOD/l

	$k_{c,T20}$	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	$k_{f,T}$	0.0535 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	S_{biRn}	MX_{bi}/Q_i	S_{biRn}	
Trial 1	0.00	881		4.86
Trial 2	4.86	897		4.77
Trial 3	4.77	897		4.77
Trial 4	4.77	897		4.77

Flux BO COD obtained by OHO's	95%	5848 kgCOD/d
Flux BO COD obtained by PAO's	5%	307 kgCOD/d
Check total BO COD		6154 kgCOD/d

correct
6154

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_d	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{c20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{GT}	0.0357 /d

Activated Sludge Masses

OHO VSS		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	9965 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	8533 kgVSS

PAO VSS		
Polyphosphate Acc Organisms VSS	MX_{PAO}	1611 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	287 kgVSS

Unbiodegradable Organic VSS	MX_{iv}	4306 kgVSS
Total VSS	MX_v	24703 kgVSS

ISS from influent		11424 kgISS
ISS of OHO's		1495 kgISS
ISS of PAO's		2122 kgISS
ISS	$MX_{(O)}$	15041 kgISS
TSS	MX_t	39744 kgTSS
VSS/TSS ratio		0.622 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{pp,PAO}$	0.355 mgP/mgPAOVSS
		0.380 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.57 mgP/l
biomass P-content	ΔP_{OHO}	2.78 mgP/l
Potential P-removal		5.35 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{pp,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.57 mgP/l
biomass P-content	ΔP_{OHO}	2.78 mgP/l
Total Actual P-removal		5.35 mgP/l

TP effluent P_{te} 10.15 mgP/l

Note: Add P content of TSS in effluent

Influent TKN	N_{ti}	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_i	116 kgN/d
Equiv conc in influent	N_i	10.45 mgN/l
Effluent Sol Unbiobd Org N	N_{dude}	0.90 mgN/l
Effluent ammonia	N_{de}	0.41 mgFSA-N/l
TKN in effluent	N_{te}	1.31 mgTKN-N/l
Nitrification capacity	N_c	36.44 mgN/l influent

Denitrification potential BSO (K1)	D_{BBSO}	1.1 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BBPO}	69.55 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	70.62 mgNO ₂ -N/l influent

	A	0.6993
	B	-32.4288
	C	104.096
Optimal a-recycle ratio	a_{opt}	49.39
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00 recycle limited

Effluent Nitrate if recycle limited		4.56 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-29.63 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{ne}	4.56 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₃)	$N_{te} + N_{de}$	5.86 mgN/l
N removal		87.8%

Alkalinity consumed by nitrification		260 mg CaCO ₃
Alkalinity recovered by denitrification		114 mg CaCO ₃
Total Alkalinity consumption		146 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{bi,a}$	0 mgCOD/l
FBSO COD	S_{bdf}	75 mgCOD/l
BSO COD	S_{bdi}	75 mgCOD/l
BO COD	S_{bi}	554 mgCOD/l

S_{rj} reduction due to O ₂ & NO ₃		37.84 mgCOD/l
Reduced FBSO concentration	$S_{rj,LOHV}$	37.16 mgCOD/l

	$k_{c,T20}$	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	$k_{f,T}$	0.0673 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	S_{biRn}	MX_{bi}/Q_i	S_{biRn}	
Trial 1	0.00	729		4.67
Trial 2	4.67	742		4.59
Trial 3	4.59	742		4.59
Trial 4	4.59	742		4.59

Flux BO COD obtained by OHO's	95%	5844 kgCOD/d
Flux BO COD obtained by PAO's	5%	311 kgCOD/d
Check total BO COD		6154 kgCOD/d

correct

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_d	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{c20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{GT}	0.0448 /d

Activated Sludge Masses

OHO VSS		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	8241 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	8870 kgVSS

PAO VSS		
Polyphosphate Acc Organisms VSS	MX_{PAO}	1475 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	331 kgVSS

Unbiodegradable Organic VSS	MX_{iv}	4306 kgVSS
Total VSS	MX_v	23223 kgVSS

ISS from influent		11424 kgISS
ISS of OHO's		1236 kgISS
ISS of PAO's		1942 kgISS
ISS	$MX_{(O)}$	14602 kgISS
TSS	MX_t	37825 kgTSS
VSS/TSS ratio		0.614 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{pp,PAO}$	0.355 mgP/mgPAOVSS
		0.38 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.36 mgP/l
biomass P-content	ΔP_{OHO}	2.61 mgP/l
Potential P-removal		4.97 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{pp,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.36 mgP/l
biomass P-content	ΔP_{OHO}	2.61 mgP/l
Total Actual P-removal		4.97 mgP/l

TP effluent P_{te} 10.53 mgP/l

Note: Add P content of TSS in effluent

UCT Reactor @ 20 Days SRT

Carbonaceous Oxygen flux OHO's	FO _{OHO}	4478 kgO/d
Carbonaceous Oxygen flux PAO's	FO _{PAO}	166 kgO/d
Carbonaceous Oxygen flux	FO _c	4644 kgO/d
Nitrogenous Oxygen flux	FO _N	1809 kgO/d
Oxygen dmnd recover by denitrification	FO _D	991 kgO/d
Total Oxygen Demand (FO _c + FO _N - FO _D)	FO _T	5463 kgO/d
Oxygen utilisation rate	O _T	31.1 mgO/l/h

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Check	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	3222	10742	25780	39744
Concentration TSS (kgTSS/m ³)	1.76	3.52	3.52	3.258
Volume (m ³)	1830	3050	7320	12200
Volume fraction	15%	25%	60%	100%
Concentration VSS (kgVSS/m ³)	1.09	2.19	2.19	2.02
UPO VSS Concentration (kgUPOVSS/m ³)	0.191	0.382	0.382	0.353

Mass TSS wasted per day 1987.2 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 564.3 m³/d 610

COD mass balance	
COD in (influent)	6876.7 kgCOD/d
COD out	6876.7 kgCOD/d
Q _L S _{in} + Q _L S _{in}	403.3 kgCOD/d
Q _L X _{f,COD} or f _{COD} MX _d /Rs	1829.3 kgCOD/d
FO _c	4644.1 kgO/d

N Mass balance	
TKN in (influent)	535.56 kgN/d
TKN out	535.56 kgN/d
N _{in}	62.28 kgN/d
N _{waste}	126.8 kgN/d
N _{denitrified}	346.4 kgN/d

TOD balance	
TOD in (influent)	9324.16 kgTOD/d
TOD out	9324.16 kgTOD/d
TOD _{effluent}	452.77 kgTOD/d
TOD _{waste}	2417.95 kgTOD/d
TOD _{N2 gas}	990.80 kgTOD/d
FO _L	5462.64 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiolod Sol COD	S _{unbiolod}	36.30	75	30 mgCOD/l
Unbiolod Sol Org N	N _{unbiolod}	0.90	-	mgN/l
FSA-N	N _{ae}	0.55	6	2 mgFSA-N/l
TKN-N	N _{in}	1.45	-	mgTKN-N/l
Nitrate	N _{in}	4.45	15	1.5 mgNO ₃ -N/l
Unbiolod Sol Org P	P _{unbiolod}	0.60	-	mgP/l
Ortho P as P	P _{in}	10.15	10	2.5 mgP/l
TP	P _{in}	10.75	-	mgP/l

Carbonaceous Oxygen flux OHO's	FO _{OHO}	4576 kgO/d
Carbonaceous Oxygen flux PAO's	FO _{PAO}	177 kgO/d
Carbonaceous Oxygen flux	FO _c	4754 kgO/d
Nitrogenous Oxygen flux	FO _N	1850 kgO/d
Oxygen dmnd recover by denitrification	FO _D	1013 kgO/d
Total Oxygen Demand (FO _c + FO _N - FO _D)	FO _T	5591 kgO/d
Oxygen utilisation rate	O _T	31.8 mgO/l/h

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	3067	10223	24535	37825
Concentration TSS (kgTSS/m ³)	1.68	3.35	3.35	3.100
Volume (m ³)	1830	3050	7320	12200
	3067			
Concentration VSS (kgVSS/m ³)	1.03	2.06	2.06	1.90
UPO VSS Concentration (kgUPOVSS/m ³)	0.191	0.382	0.382	0.353

Mass TSS wasted per day 1891.3 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 564.3 m³/d

COD mass balance	
COD in (influent)	6876.7 kgCOD/d
COD out	6876.7 kgCOD/d
Q _L S _{in} + Q _L S _{in}	403.3 kgCOD/d
Q _L X _{f,COD} or f _{COD} MX _d /Rs	1719.7 kgCOD/d
FO _c	4753.6 kgO/d

N Mass balance	
TKN in (influent)	535.56 kgN/d
TKN out	535.56 kgN/d
N _{in}	61.84 kgN/d
N _{waste}	119.4 kgN/d
N _{denitrified}	354.3 kgN/d

TOD balance	
TOD in (influent)	9324.16 kgTOD/d
TOD out	9324.16 kgTOD/d
TOD _{effluent}	445.91 kgTOD/d
TOD _{waste}	2274.21 kgTOD/d
TOD _{N2 gas}	1013.26 kgTOD/d
FO _L	5590.77 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiolod Sol COD	S _{unbiolod}	36.30	75	30 mgCOD/l
Unbiolod Sol Org N	N _{unbiolod}	0.90	-	mgN/l
FSA-N	N _{ae}	0.41	6	2 mgFSA-N/l
TKN-N	N _{in}	1.31	-	mgTKN-N/l
Nitrate	N _{in}	4.56	15	1.5 mgNO ₃ -N/l
Unbiolod Sol Org P	P _{unbiolod}	0.60	-	mgP/l
Ortho P as P	P _{in}	10.53	10	2.5 mgP/l
TP	P _{in}	11.13	-	mgP/l

UCT Reactor @ 25 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	11.11 Ml/d
Sludge Age	SRT	25.0 days
Reactor TSS concentration	X _r	4187.67 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti	619 6877
BPO COD	Sbpi	479 5321
UPO COD	Supi	29 319
	fS'up	0.046
VFA COD	Sbsi,a	0 0
FBSO COD	Sbsfi	75 833
BSO COD	Sbsi	75 833
USO COD	Susi	36.3 403
	fS'us	0.059
BO COD	Sbi	554 6154
UO COD	Sui	65 722
TSS		241 2675
ISS		51.4 571
VSS		189 2104
UPO VSS		19.4 215
BPO VSS		170 1888
TKN	Nti	48.2 536
Org N	Noi	13.8 153
FSA	Nai	34.4 382
BSO	Nobsi	2.90 32
USO	Nousi	0.90 10
BPO	Nobpi	8.70 97
UPO	Noupi	1.30 14
Total P	Pti	15.50 172
OP	Pai	12.80 142
Org P	Poi	2.70 30
BSO	Pobsi	0.70 8
USO	Pousi	0.60 7
BPO	Pobpi	0.78 9
UPO	Poupi	0.62 7

Constants		
COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{div}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{CHO}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{CN,BSO}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{CN,USO}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{N,UPO}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{P,UPO}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{C,UPO}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{H2O}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2141 /d
	μ _{AH2O}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.2829 /d
	b _{A2O}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0357 /d
	K _{s2O}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{sT}	0.6288 mgFSA/l
	K _{s2O}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{sT}	0.3472
Denitrification	K _{s2O}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{sT}	0.0742
Denitrification	K _{s2O}	0.255
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K _{sT}	0.1874
Factor of safety reducing μ _{AmT}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _{min}	6.76 days
SRT _{min} (with safety factor)	SRT _{min}	8.45 Nitrifies!

Max unaerated sludge mass fraction	f _{xm}	0.67
Total unaerated sludge mass fraction	f _{xt}	0.35
Anoxic mass fraction primary anox 2	f _{s,prim anox 2}	0.27
Anaerobic mass fraction	f _{s,anaer}	0.08
Aerobic mass fraction	f _{s,er}	0.65

Nr of equal size compartments		2
r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N _{or}	4.5 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{O2,r}	0.0 mgO/l

Influent NO ₃ concentration	S _{NO3+i}	0.0 mgNO ₃ -N/l
Influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	1.000 :1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)	f _{bsi}	0.135

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	11.11 Ml/d
Sludge Age	SRT	25.0 days
Reactor TSS concentration	X _r	4000 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti	619 6877
BPO COD	Sbpi	479 5321
UPO COD	Supi	29 319
	fS'up	0.046
VFA COD	Sbsi,a	0 0
FBSO COD	Sbsfi	75 833
BSO COD	Sbsi	75 833
USO COD	Susi	36 403
	fS'us	0.059
BO COD	Sbi	554 6154
UO COD	Sui	65 722
TSS		241 2675
ISS		51 571
VSS		189 2104
UPO VSS		19 215
BPO VSS		170 1888
TKN	Nti	48 536
Org N	Noi	14 153
FSA	Nai	34 382
BSO	Nobsi	2.90 32
USO	Nousi	0.90 10
BPO	Nobpi	8.70 97
UPO	Noupi	1.30 14
Total P	Pti	15.50 172
OP	Pai	12.80 142
Org P	Poi	2.70 30
BSO	Pobsi	0.70 8
USO	Pousi	0.60 7
BPO	Pobpi	0.78 9
UPO	Poupi	0.62 7

Constants		
COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{div}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{CHO}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{CN,BSO}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{CN,USO}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{N,UPO}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{P,UPO}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{C,UPO}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{H2O}	0.24 /d
	θ	1.029
Endogenous respiration rate OHO	b _{HT}	0.2691 /d
	μ _{AH2O}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.7157 /d
	b _{A2O}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0448 /d
	K _{s2O}	1.0
Nitrification	θ	1.123
Half Saturation Coefficient	K _{sT}	1.5904
	K _{s2O}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{sT}	1.4930
Denitrification	K _{s2O}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{sT}	0.1374
Denitrification	K _{s2O}	0.255
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K _{sT}	0.3469
Factor of safety reducing μ _{AmT}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _{min}	2.38 days
SRT _{min} (with safety factor)	SRT _{min}	2.98 Nitrifies!

Max unaerated sludge mass fraction	f _{xm}	0.85
Total unaerated sludge mass fraction	f _{xt}	0.35
Anoxic mass fraction primary anox 2	f _{s,prim anox 2}	0.27
Anaerobic mass fraction	f _{s,anaer}	0.08
Aerobic mass fraction	f _{s,er}	0.65

Nr of equal size compartments		2
r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N _{or}	4.5 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{O2,r}	0.0 mgO/l

Influent NO ₃ concentration	S _{NO3+i}	0.0 mgNO ₃ -N/l
Influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)	f _{bsi}	0.135

UCT Reactor @ 25 Days SRT

Influent TKN	N_i	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_i	116 kgN/d
Equiv conc in influent	N_i	10.46 mgN/l
Effluent Sol Unbiol Org N	N_{out}	0.90 mgN/l
Effluent ammonia	N_{NH}	0.44 mgFSA-N/l
TKN in effluent	N_{NH}	1.34 mgTKN-N/l
Nitrification capacity	N_c	36.40 mgN/l influent

Denitrification potential BSO (K1)	D_{BPO}	1.0 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BPO}	47.25 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	48.29 mgNO ₂ -N/l influent

	A	0.6993
	B	-10.1413
	C	59.482
Optimal a-recycle ratio	a_{opt}	18.98
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00 set = a_{opt} for balanced UCT recycle limited

Effluent Nitrate if recycle limited		4.55 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-7.34 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{NH}	4.55 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₃)	$N_{\text{NH}} + N_{\text{NH}}$	5.89 mgN/l
N removal		87.8%

Alkalinity consumed by nitrification		260 mg CaCO ₃
Alkalinity recovered by denitrification		114 mg CaCO ₃
Total Alkalinity consumption		146 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{\text{sol,a}}$	0 mgCOD/l
FBSD COD	$S_{\text{sol,f}}$	75 mgCOD/l
BSO COD	S_{sol}	75 mgCOD/l
BO COD	S_{sol}	554 mgCOD/l

S_{fj} reduction due to O ₂ & NO ₃		38.7 mgCOD/l
Reduced FBSD concentration	$S_{\text{fj,OHV}}$	36.3 mgCOD/l

	$k_{\text{c,120}}$	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	$k_{\text{c,T}}$	0.0535 m ³ /gVSS.d

PAO's get all VFA's + FBSD converted to VFA
OHO's get BPO and remaining FBSD

	$S_{\text{sol,OH}}$	MX_{sol}/Q_i	$S_{\text{sol,OH}}$	
Trial 1	0.00	917		4.56
Trial 2	4.56	933		4.48
Trial 3	4.48	933		4.48
Trial 4	4.48	933		4.48

Flux BO COD obtained by OHO's	95%	5851 kgCOD/d
Flux BO COD obtained by PAO's	5%	304 kgCOD/d
Check total BO COD		6154 kgCOD/d

correct
6154

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_d	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{G20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{GT}	0.0357 /d

Activated Sludge Masses

OHO VSS		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	10363 kgVSS
Endogenous Residue VSS OHO	$MX_{\text{E,OHO}}$	11092 kgVSS

PAO VSS		
Polyphosphate Acc Organisms VSS	MX_{PAO}	1806 kgVSS
Endogenous Residue VSS PAO	$MX_{\text{E,PAO}}$	403 kgVSS

Unbiodegradable Organic VSS	MX_{U}	5383 kgVSS
Total VSS	MX_{V}	29046 kgVSS

ISS from influent		14280 kgISS
ISS of OHO's		1554 kgISS
ISS of PAO's		2377 kgISS
ISS	MX_{ID}	18212 kgISS
TSS	MX_{I}	47258 kgTSS
VSS/TSS ratio		0.615 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{\text{PB,PAO}}$	0.355 mgP/mgPAOVSS
		0.380 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{\text{PAO,2}}$	2.31 mgP/l
biomass P-content	ΔP_{OHO}	2.61 mgP/l
Potential P-removal		4.92 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{\text{PB,PAO}}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{\text{PAO,2}}$	2.31 mgP/l
biomass P-content	ΔP_{OHO}	2.61 mgP/l
Total Actual P-removal		4.92 mgP/l

TP effluent P_{NH} 10.58 mgP/l

Note: Add P content of TSS in effluent

Influent TKN	N_i	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_i	110 kgN/d
Equiv conc in influent	N_i	9.88 mgN/l
Effluent Sol Unbiol Org N	N_{out}	0.90 mgN/l
Effluent ammonia	N_{NH}	0.36 mgFSA-N/l
TKN in effluent	N_{NH}	1.26 mgTKN-N/l
Nitrification capacity	N_c	37.07 mgN/l influent

Denitrification potential BSO (K1)	D_{BPO}	1.0 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BPO}	71.85 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	72.86 mgNO ₂ -N/l influent

	A	0.6993
	B	-34.0422
	C	107.949
Optimal a-recycle ratio	a_{opt}	51.67
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00 recycle limited

Effluent Nitrate if recycle limited		4.63 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-31.24 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{NH}	4.63 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₃)	$N_{\text{NH}} + N_{\text{NH}}$	5.89 mgN/l
N removal		87.8%

Alkalinity consumed by nitrification		265 mg CaCO ₃
Alkalinity recovered by denitrification		116 mg CaCO ₃
Total Alkalinity consumption		149 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{\text{sol,a}}$	0 mgCOD/l
FBSD COD	$S_{\text{sol,f}}$	75 mgCOD/l
BSO COD	S_{sol}	75 mgCOD/l
BO COD	S_{sol}	554 mgCOD/l

S_{fj} reduction due to O ₂ & NO ₃		38.7 mgCOD/l
Reduced FBSD concentration	$S_{\text{fj,OHV}}$	36.3 mgCOD/l

	$k_{\text{c,120}}$	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	$k_{\text{c,T}}$	0.0673 m ³ /gVSS.d

PAO's get all VFA's + FBSD converted to VFA
OHO's get BPO and remaining FBSD

	$S_{\text{sol,OH}}$	MX_{sol}/Q_i	$S_{\text{sol,OH}}$	
Trial 1	0.00	754		4.41
Trial 2	4.41	766		4.34
Trial 3	4.34	766		4.34
Trial 4	4.34	766		4.34

Flux BO COD obtained by OHO's	95%	5848 kgCOD/d
Flux BO COD obtained by PAO's	5%	307 kgCOD/d
Check total BO COD		6154 kgCOD/d

correct

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_d	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{G20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{GT}	0.0448 /d

Activated Sludge Masses

OHO VSS		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	8514 kgVSS
Endogenous Residue VSS OHO	$MX_{\text{E,OHO}}$	11454 kgVSS

PAO VSS		
Polyphosphate Acc Organisms VSS	MX_{PAO}	1628 kgVSS
Endogenous Residue VSS PAO	$MX_{\text{E,PAO}}$	456 kgVSS

Unbiodegradable Organic VSS	MX_{U}	5383 kgVSS
Total VSS	MX_{V}	27435 kgVSS

ISS from influent		14280 kgISS
ISS of OHO's		1277 kgISS
ISS of PAO's		2143 kgISS
ISS	MX_{ID}	17700 kgISS
TSS	MX_{I}	45135 kgTSS
VSS/TSS ratio		0.608 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{\text{PB,PAO}}$	0.355 mgP/mgPAOVSS
		0.38 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{\text{PAO,2}}$	2.08 mgP/l
biomass P-content	ΔP_{OHO}	2.47 mgP/l
Potential P-removal		4.55 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{\text{PB,PAO}}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{\text{PAO,2}}$	2.08 mgP/l
biomass P-content	ΔP_{OHO}	2.47 mgP/l
Total Actual P-removal		4.55 mgP/l

TP effluent P_{NH} 10.95 mgP/l

Note: Add P content of TSS in effluent

UCT Reactor @ 25 Days SRT

Carbonaceous Oxygen flux OHO's	FO _{OHO}	4580 kgO/d
Carbonaceous Oxygen flux PAO's	FO _{PAO}	173 kgO/d
Carbonaceous Oxygen flux	FO _c	4753 kgO/d
Nitrogenous Oxygen flux	FO _n	1848 kgO/d
Oxygen dimnd recover by denitrification	FO _D	1012 kgO/d
Total Oxygen Demand (FO _c + FO _n + FO _D)	FO _T	5589 kgO/d
Oxygen utilisation rate	O _T	31.8 mgO/l/h

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Check	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	3832	12772	30654	47258
Concentration TSS (kgTSS/m ³)	2.09	4.19	4.19	3.874
Volume (m ³)	1830	3050	7320	12200
Volume fraction	15%	25%	60%	100%
Concentration VSS (kgVSS/m ³)	1.29	2.57	2.57	2.38
UPO VSS Concentration (kgUPOVSS/m ³)	0.239	0.477	0.477	0.441

Mass TSS wasted per day 1890.3 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 451.4 m³/d

COD mass balance	
COD in (influent)	6876.7 kgCOD/d
COD out	6876.7 kgCOD/d
Q _s S _{in} + Q _w S _w	403.3 kgCOD/d
Q _w X _{f,ss} or f _{cv} ·MX _d /Rs	1720.7 kgCOD/d
FO _c	4752.7 kgO/d

N Mass balance	
TKN in (influent)	535.56 kgN/d
TKN out	535.56 kgN/d
N _{to}	62.80 kgN/d
N _{waste}	118.8 kgN/d
N _{denitrified}	353.9 kgN/d

TOD balance	
TOD in (influent)	9324.16 kgTOD/d
TOD out	9324.16 kgTOD/d
TOD _{effluent}	452.28 kgTOD/d
TOD _{waste}	2270.79 kgTOD/d
TOD _{N2 gas}	1012.19 kgTOD/d
FO _L	5588.90 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiolod Sol COD	S _{out}	36.30	75	30 mgCOD/l
Unbiolod Sol Org N	N _{out}	0.90	-	mgN/l
FSA-N	N _{ae}	0.44	6	2 mgFSA-N/l
TKN-N	N _{to}	1.34	-	mgTKN-N/l
Nitrate	N _{noe}	4.55	15	1.5 mgNO ₃ -N/l
Unbiolod Sol Org P	P _{out}	0.60	-	mgP/l
Ortho P as P	P _{oe}	10.58	10	2.5 mgP/l
TP	P _{te}	11.18	-	mgP/l

Carbonaceous Oxygen flux OHO's	FO _{OHO}	4665 kgO/d
Carbonaceous Oxygen flux PAO's	FO _{PAO}	183 kgO/d
Carbonaceous Oxygen flux	FO _c	4848 kgO/d
Nitrogenous Oxygen flux	FO _n	1882 kgO/d
Oxygen dimnd recover by denitrification	FO _D	1031 kgO/d
Total Oxygen Demand (FO _c + FO _n + FO _D)	FO _T	5700 kgO/d
Oxygen utilisation rate	O _T	32.4 mgO/l/h

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	3660	12199	29277	45135
Concentration TSS (kgTSS/m ³)	2.00	4.00	4.00	3.700
Volume (m ³)	1830	3050	7320	12200
	3660			
Concentration VSS (kgVSS/m ³)	1.22	2.43	2.43	2.25
UPO VSS Concentration (kgUPOVSS/m ³)	0.239	0.477	0.477	0.441

Mass TSS wasted per day 1805.4 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 451.4 m³/d

COD mass balance	
COD in (influent)	6876.7 kgCOD/d
COD out	6876.7 kgCOD/d
Q _s S _{in} + Q _w S _w	403.3 kgCOD/d
Q _w X _{f,ss} or f _{cv} ·MX _d /Rs	1625.2 kgCOD/d
FO _c	4848.1 kgO/d

N Mass balance	
TKN in (influent)	535.56 kgN/d
TKN out	535.56 kgN/d
N _{to}	62.78 kgN/d
N _{waste}	112.4 kgN/d
N _{denitrified}	360.4 kgN/d

TOD balance	
TOD in (influent)	9324.16 kgTOD/d
TOD out	9324.16 kgTOD/d
TOD _{effluent}	448.12 kgTOD/d
TOD _{waste}	2145.73 kgTOD/d
TOD _{N2 gas}	1030.69 kgTOD/d
FO _L	5699.62 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiolod Sol COD	S _{out}	36.30	75	30 mgCOD/l
Unbiolod Sol Org N	N _{out}	0.90	-	mgN/l
FSA-N	N _{ae}	0.36	6	2 mgFSA-N/l
TKN-N	N _{to}	1.26	-	mgTKN-N/l
Nitrate	N _{noe}	4.63	15	1.5 mgNO ₃ -N/l
Unbiolod Sol Org P	P _{out}	0.60	-	mgP/l
Ortho P as P	P _{oe}	10.95	10	2.5 mgP/l
TP	P _{te}	11.55	-	mgP/l

UCT Reactor @ 30 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	11.11 Ml/d
Sludge Age	SRT	30.0 days
Reactor TSS concentration	X _r	4833.64 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti	619
BPO COD	Sbpi	479
UPO COD	Supi	29
	fS'up	0.046
VFA COD	Sbsi,a	0.0
FBSO COD	Sbsfi	75
BSO COD	Sbsi	75
USO COD	Susi	36.3
	fS'us	0.059
BO COD	Sbi	554
UO COD	Sui	65
		722
TSS		241
ISS		51.4
VSS		189
UPO VSS		19.4
BPO VSS		170
		1888
TKN	Nti	48.2
Org N	Noi	13.8
FSA	Nai	34.4
BSO	Nobsi	2.90
USO	Nousi	0.90
BPO	Nobpi	8.70
UPO	Noupi	1.30
		14
Total P	Pti	15.50
OP	Pai	12.80
Org P	Poi	2.70
BSO	Pobsi	0.70
USO	Pousi	0.60
BPO	Pobpi	0.78
UPO	Poupi	0.62
		7

Constants		
COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{div}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{CHO}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{CN,BSO}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{CN,USO}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{N,UPO}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{P,UPO}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{C,UPO}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{H2O}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2141 /d
	μ _{AH2O}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.2829 /d
	b _{A2O}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0357 /d
	K _{A2O}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{AT}	0.6288 mgFSA/l
	K _{A2O}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{IT}	0.3472
Denitrification	K _{A2O}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{IT}	0.0742
Denitrification	K _{A2O}	0.255
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K _{IT}	0.1874
Factor of safety reducing μ _{AmT}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _{min}	6.76 days
SRT _{min} (with safety factor)	SRT _{min}	8.45 Nitrifies!

Max unaerated sludge mass fraction	f _{xm}	0.70
Total unaerated sludge mass fraction	f _{xt}	0.35
Anoxic mass fraction primary anox 2	f _{s,prim anox 2}	0.27
Anaerobic mass fraction	f _{s,anaer}	0.08
Aerobic mass fraction	f _{s,er}	0.65

Nr of equal size compartments		2
r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N _{or}	4.6 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{O2,r}	0.0 mgO/l

Influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
Influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	1.000 :1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)	f _{SO/s}	0.135

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	11.11 Ml/d
Sludge Age	SRT	30.0 days
Reactor TSS concentration	X _r	4631 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti	619
BPO COD	Sbpi	479
UPO COD	Supi	29
	fS'up	0.046
VFA COD	Sbsi,a	0
FBSO COD	Sbsfi	75
BSO COD	Sbsi	75
USO COD	Susi	36
	fS'us	0.059
BO COD	Sbi	554
UO COD	Sui	65
		722
TSS		241
ISS		51
VSS		189
UPO VSS		19
BPO VSS		170
		1888
TKN	Nti	48
Org N	Noi	14
FSA	Nai	34
BSO	Nobsi	2.90
USO	Nousi	0.90
BPO	Nobpi	8.70
UPO	Noupi	1.30
		14
Total P	Pti	15.50
OP	Pai	12.80
Org P	Poi	2.70
BSO	Pobsi	0.70
USO	Pousi	0.60
BPO	Pobpi	0.78
UPO	Poupi	0.62
		7

Constants		
COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{div}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{CHO}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{CN,BSO}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{CN,USO}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{N,UPO}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{P,UPO}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{C,UPO}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{H2O}	0.24 /d
	θ	1.029
Endogenous respiration rate OHO	b _{HT}	0.2691 /d
	μ _{AH2O}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.7157 /d
	b _{A2O}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0448 /d
	K _{A2O}	1.0
Nitrification	θ	1.123
Half Saturation Coefficient	K _{AT}	1.5904
	K _{A2O}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{IT}	1.4930
Denitrification	K _{A2O}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{IT}	0.1374
Denitrification	K _{A2O}	0.255
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K _{IT}	0.3469
Factor of safety reducing μ _{AmT}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _{min}	2.38 days
SRT _{min} (with safety factor)	SRT _{min}	2.98 Nitrifies!

Max unaerated sludge mass fraction	f _{xm}	0.86
Total unaerated sludge mass fraction	f _{xt}	0.35
Anoxic mass fraction primary anox 2	f _{s,prim anox 2}	0.27
Anaerobic mass fraction	f _{s,anaer}	0.08
Aerobic mass fraction	f _{s,er}	0.65

Nr of equal size compartments		2
r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N _{or}	4.6 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{O2,r}	0.0 mgO/l

Influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
Influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)	f _{SO/s}	0.135

UCT Reactor @ 30 Days SRT

Influent TKN	N_i	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_i	111 kgN/d
Equiv conc in influent	N_i	9.98 mgN/l
Effluent Sol Unbiol Org N	N_{out}	0.90 mgN/l
Effluent ammonia	N_{ae}	0.38 mgFSA-N/l
TKN in effluent	N_{te}	1.28 mgTKN-N/l
Nitrification capacity	N_c	36.94 mgN/l influent

Denitrification potential BSO (K1)	D_{pBSO}	1.0 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	48.57 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	49.56 mgNO ₂ -N/l influent

	A	0.6993
	B	-10.8636
	C	61.469
Optimal a-recycle ratio	a_{opt}	19.94
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00 set = a_{opt} for balanced UCT recycle limited

Effluent Nitrate if recycle limited		4.62 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-8.07 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{ne}	4.62 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₃)	$N_{\text{te}} + N_{\text{to}}$	5.90 mgN/l
N removal		87.8%

Alkalinity consumed by nitrification		264 mg CaCO ₃
Alkalinity recovered by denitrification		115 mg CaCO ₃
Total Alkalinity consumption		148 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{\text{sol,a}}$	0 mgCOD/l
FBSD COD	$S_{\text{sol,f}}$	75 mgCOD/l
BSO COD	S_{sol}	75 mgCOD/l
BO COD	S_{bi}	554 mgCOD/l

S_{fj} reduction due to O ₂ & NO ₃		39.71498628 mgCOD/l
Reduced FBSD concentration	$S_{\text{fj,OHV}}$	35.28501372 mgCOD/l

	$k_{\text{c},\text{T20}}$	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	$k_{\text{f},\text{T}}$	0.0535 m ³ /gVSS.d

PAO's get all VFA's + FBSD converted to VFA
OHO's get BPO and remaining FBSD

	S_{solfH}	MX_{solf}/Q_i	S_{solH}	
Trial 1	0.00	943		4.31
Trial 2	4.31	959		4.24
Trial 3	4.24	959		4.24
Trial 4	4.24	959		4.24

Flux BO COD obtained by OHO's	95%	5857 kgCOD/d
Flux BO COD obtained by PAO's	5%	298 kgCOD/d
Check total BO COD		6154 kgCOD/d

correct
6154

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_d	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{G20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{GT}	0.0357 /d

Activated Sludge Masses

OHO VSS		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	10653 kgVSS
Endogenous Residue VSS OHO	$MX_{\text{E,OHO}}$	13682 kgVSS

PAO VSS		
Polyphosphate Acc Organisms VSS	MX_{PAO}	1942 kgVSS
Endogenous Residue VSS PAO	$MX_{\text{E,PAO}}$	520 kgVSS

Unbiodegradable Organic VSS	MX_{U}	6460 kgVSS
Total VSS	MX_{V}	33256 kgVSS

ISS from influent		17136 kgISS
ISS of OHO's		1598 kgISS
ISS of PAO's		2557 kgISS
ISS	MX_{IDi}	21291 kgISS
TSS	MX_{I}	54548 kgTSS
VSS/TSS ratio		0.610 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{\text{pB,PAO}}$	0.350 mgP/mgPAOVSS
		0.380 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{\text{PAO},2}$	2.07 mgP/l
biomass P-content	ΔP_{OHO}	2.49 mgP/l
Potential P-removal		4.56 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{\text{pB,PAO}}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{\text{PAO},2}$	2.07 mgP/l
biomass P-content	ΔP_{OHO}	2.49 mgP/l
Total Actual P-removal		4.56 mgP/l

TP effluent P_{te} 10.94 mgP/l

Note: Add P content of TSS in effluent

Influent TKN	N_i	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_i	105 kgN/d
Equiv conc in influent	N_i	9.46 mgN/l
Effluent Sol Unbiol Org N	N_{out}	0.90 mgN/l
Effluent ammonia	N_{ae}	0.32 mgFSA-N/l
TKN in effluent	N_{te}	1.22 mgTKN-N/l
Nitrification capacity	N_c	37.51 mgN/l influent

Denitrification potential BSO (K1)	D_{pBSO}	1.0 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	73.51 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	74.47 mgNO ₂ -N/l influent

	A	0.6993
	B	-35.2087
	C	110.729
Optimal a-recycle ratio	a_{opt}	53.32
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00 recycle limited

Effluent Nitrate if recycle limited		4.69 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-32.41 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{ne}	4.69 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₃)	$N_{\text{te}} + N_{\text{to}}$	5.91 mgN/l
N removal		87.7%

Alkalinity consumed by nitrification		268 mg CaCO ₃
Alkalinity recovered by denitrification		117 mg CaCO ₃
Total Alkalinity consumption		151 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{\text{sol,a}}$	0 mgCOD/l
FBSD COD	$S_{\text{sol,f}}$	75 mgCOD/l
BSO COD	S_{sol}	75 mgCOD/l
BO COD	S_{bi}	554 mgCOD/l

S_{fj} reduction due to O ₂ & NO ₃		39.71498628 mgCOD/l
Reduced FBSD concentration	$S_{\text{fj,OHV}}$	35.28501372 mgCOD/l

	$k_{\text{c},\text{T20}}$	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	$k_{\text{f},\text{T}}$	0.0673 m ³ /gVSS.d

PAO's get all VFA's + FBSD converted to VFA
OHO's get BPO and remaining FBSD

	S_{solfH}	MX_{solf}/Q_i	S_{solH}	
Trial 1	0.00	772		4.19
Trial 2	4.19	784		4.12
Trial 3	4.12	784		4.12
Trial 4	4.12	784		4.12

Flux BO COD obtained by OHO's	95%	5854 kgCOD/d
Flux BO COD obtained by PAO's	5%	300 kgCOD/d
Check total BO COD		6154 kgCOD/d

correct

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_d	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{G20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{GT}	0.0448 /d

Activated Sludge Masses

OHO VSS		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	8711 kgVSS
Endogenous Residue VSS OHO	$MX_{\text{E,OHO}}$	14064 kgVSS

PAO VSS		
Polyphosphate Acc Organisms VSS	MX_{PAO}	1730 kgVSS
Endogenous Residue VSS PAO	$MX_{\text{E,PAO}}$	582 kgVSS

Unbiodegradable Organic VSS	MX_{U}	6460 kgVSS
Total VSS	MX_{V}	31545 kgVSS

ISS from influent		17136 kgISS
ISS of OHO's		1307 kgISS
ISS of PAO's		2277 kgISS
ISS	MX_{IDi}	20720 kgISS
TSS	MX_{I}	52265 kgTSS
VSS/TSS ratio		0.604 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{\text{pB,PAO}}$	0.355 mgP/mgPAOVSS
		0.38 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{\text{PAO},2}$	1.84 mgP/l
biomass P-content	ΔP_{OHO}	2.37 mgP/l
Potential P-removal		4.21 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{\text{pB,PAO}}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{\text{PAO},2}$	1.84 mgP/l
biomass P-content	ΔP_{OHO}	2.37 mgP/l
Total Actual P-removal		4.21 mgP/l

TP effluent P_{te} 11.29 mgP/l

Note: Add P content of TSS in effluent

UCT Reactor @ 30 Days SRT

Carbonaceous Oxygen flux OHO's	FO _{OHO}	4655 kgO/d
Carbonaceous Oxygen flux PAO's	FO _{PAO}	176 kgO/d
Carbonaceous Oxygen flux	FO _c	4832 kgO/d
Nitrogenous Oxygen flux	FO _n	1876 kgO/d
Oxygen dimnd recover by denitrification	FO _D	1027 kgO/d
Total Oxygen Demand (FO _c + FO _n + FO _D)	FO _T	5680 kgO/d
Oxygen utilisation rate	O _T	32.3 mgO/l/h

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Check	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	4423	14743	35382	54548
Concentration TSS (kgTSS/m ³)	2.42	4.83	4.83	4.471
Volume (m ³)	1830	3050	7320	12200
Volume fraction	15%	25%	60%	100%
Concentration VSS (kgVSS/m ³)	1.47	2.95	2.95	2.73
UPO VSS Concentration (kgUPOVSS/m ³)	0.286	0.572	0.572	0.529

Mass TSS wasted per day 1818.3 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 376.2 m³/d

COD mass balance	
COD in (influent)	6876.7 kgCOD/d
COD out	6876.7 kgCOD/d
Q _s S _{in} + Q _w S _w	403.3 kgCOD/d
Q _w X _{f,ss} or f _{cv} ·MX _d /Rs	1641.8 kgCOD/d
FO _c	4831.6 kgO/d

N Mass balance	
TKN in (influent)	535.56 kgN/d
TKN out	535.56 kgN/d
N _{eff}	63.30 kgN/d
N _{waste}	113.1 kgN/d
N _{denitrified}	359.2 kgN/d

TOD balance	
TOD in (influent)	9324.16 kgTOD/d
TOD out	9324.16 kgTOD/d
TOD _{effluent}	452.42 kgTOD/d
TOD _{waste}	2164.22 kgTOD/d
TOD _{N2 gas}	1027.25 kgTOD/d
FO _L	5680.27 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiolod Sol COD	S _{out}	36.30	75	30 mgCOD/l
Unbiolod Sol Org N	N _{out}	0.90	-	mgN/l
FSA-N	N _{ae}	0.38	6	2 mgFSA-N/l
TKN-N	N _{te}	1.28	-	mgTKN-N/l
Nitrate	N _{oe}	4.62	15	1.5 mgNO ₃ -N/l
Unbiolod Sol Org P	P _{out}	0.60	-	mgP/l
Ortho P as P	P _{oe}	10.94	10	2.5 mgP/l
TP	P _{te}	11.54	-	mgP/l

Carbonaceous Oxygen flux OHO's	FO _{OHO}	4730 kgO/d
Carbonaceous Oxygen flux PAO's	FO _{PAO}	186 kgO/d
Carbonaceous Oxygen flux	FO _c	4916 kgO/d
Nitrogenous Oxygen flux	FO _n	1905 kgO/d
Oxygen dimnd recover by denitrification	FO _D	1043 kgO/d
Total Oxygen Demand (FO _c + FO _n + FO _D)	FO _T	5778 kgO/d
Oxygen utilisation rate	O _T	32.9 mgO/l/h

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	4238	14126	33902	52265
Concentration TSS (kgTSS/m ³)	2.32	4.63	4.63	4.284
Volume (m ³)	1830	3050	7320	12200
	4238			
Concentration VSS (kgVSS/m ³)	1.40	2.80	2.80	2.59
UPO VSS Concentration (kgUPOVSS/m ³)	0.286	0.572	0.572	0.529

Mass TSS wasted per day 1742.2 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 376.2 m³/d

COD mass balance	
COD in (influent)	6876.7 kgCOD/d
COD out	6876.7 kgCOD/d
Q _s S _{in} + Q _w S _w	403.3 kgCOD/d
Q _w X _{f,ss} or f _{cv} ·MX _d /Rs	1557.3 kgCOD/d
FO _c	4916.0 kgO/d

N Mass balance	
TKN in (influent)	535.56 kgN/d
TKN out	535.56 kgN/d
N _{eff}	63.46 kgN/d
N _{waste}	107.4 kgN/d
N _{denitrified}	364.7 kgN/d

TOD balance	
TOD in (influent)	9324.16 kgTOD/d
TOD out	9324.16 kgTOD/d
TOD _{effluent}	449.63 kgTOD/d
TOD _{waste}	2053.59 kgTOD/d
TOD _{N2 gas}	1043.11 kgTOD/d
FO _L	5777.83 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiolod Sol COD	S _{out}	36.30	75	30 mgCOD/l
Unbiolod Sol Org N	N _{out}	0.90	-	mgN/l
FSA-N	N _{ae}	0.32	6	2 mgFSA-N/l
TKN-N	N _{te}	1.22	-	mgTKN-N/l
Nitrate	N _{oe}	4.69	15	1.5 mgNO ₃ -N/l
Unbiolod Sol Org P	P _{out}	0.60	-	mgP/l
Ortho P as P	P _{oe}	11.29	10	2.5 mgP/l
TP	P _{te}	11.89	-	mgP/l

Annexure A2 – Detailed Reactor Model for Influent Flow of 25 ML/d

MLE Reactor @ 10 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	11.1 Ml/d
Sludge Age	SRT	10.0 days
Reactor TSS concentration	X _r	1768 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	619	6877
BPO COD	Sbpi	479	5321
UPO COD	Supi	29	319
	fS'up		0.0464
VFA COD	Sbsi,a	0.0	0
FBSO COD	Sbsfi	75	833
BSO COD	Sbsi	75	833
USO COD	Susi	36.3	403
	fS'us		0.0587
BO COD	Sbi	554	6154
UO COD	Sui	65	722
TSS		241	2675
ISS		51.4	571
VSS		189	2104
UPO VSS		19.4	215
BPO VSS		170	1888
TKN	Nti	48.2	536
Org N	Noi	13.8	153
FSA	Nai	34.4	382
BSO	Nobsi	2.90	32
USO	Nousi	0.90	10
BPO	Nobpi	8.70	97
UPO	Noupi	1.30	14
Total P	Pti	15.50	172
OP	Pai	12.80	142
Org P	Poi	2.70	30
BSO	Pobsi	0.70	8
USO	Pousi	0.60	7
BPO	Pobpi	0.78	9
UPO	Poupi	0.62	7

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{COHO}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bsso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{N,UPO}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{P,UPO}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{C,UPO}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{H20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{H,T}	0.2141 /d
	μ _{A,m20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{A,mT}	0.2829 /d
	b _{A20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{A,T}	0.0357 /d
	K _{H20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{H,T}	0.6288 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{oh}	8818 kgVSS
Endogenous Residue VSS	MX _{eh}	3775 kgVSS
Unbiodegradeable Organic VSS	MX _{ov}	2155 kgVSS
Total VSS	MX _v	14748 kgVSS
ISS from influent		5712 kgISS
ISS of OHO's		1323 kgISS
ISS	MX _{coi}	7035 kgISS
TSS	MX _t	21783 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{h,n}	26.6 hr

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	11.1 Ml/d
Sludge Age	SRT	10.0 days
Reactor TSS concentration	X _T	1667 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	618.9	6877
BPO COD	Sbpi	479	5321
UPO COD	Supi	29	319
	fS'up		0.04637
VFA COD	Sbsi,a	0	0
FBSO COD	Sbsfi	75	833
BSO COD	Sbsi	75	833
USO COD	Susi	36.3	403
	fS'us		0.05865
BO COD	Sbi	554	6154
UO COD	Sui	65	722
TSS		240.7272727	2675
ISS		51.4	571
VSS		189.3181818	2104
UPO VSS		19.39	215
BPO VSS		170	1888
TKN	Nti	48.2	536
Org N	Noi	13.8	153
FSA	Nai	34.4	382
BSO	Nobsi	2.90	32.2
USO	Nousi	0.90	10.0
BPO	Nobpi	8.70	97
UPO	Noupi	1.30	14
Total P	Pti	15.5	172
OP	Pai	12.8	142
Org P	Poi	2.7	30.0
BSO	Pobsi	0.7	7.8
USO	Pousi		
BPO	Pobpi	0.78	9
UPO	Poupi	0.62	6.89

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{COHO}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bsso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{N,UPO}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{P,UPO}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{C,UPO}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{H20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{H,T}	0.2691 /d
	μ _{A,m20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{A,mT}	0.7157 /d
	b _{A20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{A,T}	0.0448 /d
	K _{H20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{H,T}	1.5904 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{oh}	7504 kgVSS
Endogenous Residue VSS	MX _{eh}	4038 kgVSS
Unbiodegradeable Organic VSS	MX _{ov}	2155 kgVSS
Total VSS	MX _v	13697 kgVSS
ISS from influent		5712 kgISS
ISS of OHO's		1126 kgISS
ISS	MX _{coi}	6838 kgISS
TSS	MX _t	20534 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{h,n}	26.6 hr

MLE Reactor @ 10 Days SRT

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	716 mgVSS/l
Endogenous Residue VSS	X_{CH}	306 mgVSS/l
Unbiodegradable Organic VSS	X_i	175 mgVSS/l
Total VSS	X_v	1197 mgVSS/l
Influent Biodegradable ISS	X_{IOI}	571 mgISS/l
TSS	X_t	1768 mgTSS/l

Active fraction of VSS	f_{av}	0.598 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.405 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.677 kgVSS/kgTSS

Waste Flow Rate	Q_w	1232 m ³ /d
TSS wasted per day		2178 kgTSS/d
VSS wasted per day		1475 kgVSS/d

Flux of N in waste VSS	FN_i	147 kgN/d
Equiv conc in influent	N_i	13.27 mgN/l influent
Effluent Sol Unbiol Org N	N_{outE}	0.90 mgN/l

Factor of safety reducing μ_{denT}	Sf	1.25
total unaerated mass fraction	f_{xt}	0.148
Minimum sludge age for nitrification	SRT_m	4.87 days
SRT_m with Safety factor	$SRT_m (Sf)$	6.09 Nitrifies!

If no nitrification		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{ne}	34.9 mgTKN-N/l
Effluent FSA-N	$N_{ne} = N_{an}$	34.0 mgFSA-N/l

If complete nitrification		
Effluent NO ₃	N_{ne}	34.0 mgNO ₃ -N/l
Effluent TKN-N	N_{ne}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ne}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	33.22 mgNO ₃ -N/l
Effluent TKN-N	N_{ne}	1.71 mgTKN-N/l
(calculated N_{ne})	(N_{ne})	0.810 mgFSA-N/l
Effluent FSA-N	N_{ne}	0.810 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	272.0 kgVSS

Denitrification	$K_{d(D)}$	0.72 mgFSA/l
Half Saturation Coefficient	θ	1.2
	K_{1T}	0.3472 mgFSA/l
	$K_{d(D)}$	0.101 mgFSA/l
Denitrification	θ	1.08
Half Saturation Coefficient	K_{2T}	0.0742 mgFSA/l

s-recycle ratio	s	1.00 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.401
Anoxic sludge mass fraction	f_{x1}	0.148 set = f_{xm} for balanced MLE
Min anoxic sludge mass fraction	f_{x1min}	0.032

Influent RBCOD fraction (Sbs/Sbi)	$f_{Sb/s}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	8.74 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	17.49 mgNO ₃ -N/l influent

	A	0.6993
	B	17.4756
	C	1.062
Optimal a-recycle ratio	a_{opt}	0.06
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00 set = a_{opt} for balanced MLE
	recycle limited	

Effluent Nitrate if recycle limited		16.61 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		16.08 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	16.61 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{de}$	18.32 mgN/l
N removal		62.0%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	609 mgVSS/l
Endogenous Residue VSS	X_{CH}	328 mgVSS/l
Unbiodegradable Organic VSS	X_i	175 mgVSS/l
Total VSS	X_v	1112 mgVSS/l
Influent Biodegradable ISS	X_{IOI}	555 mgISS/l
TSS	X_t	1667 mgTSS/l

Active fraction of VSS	f_{av}	0.548 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.365 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.667 kgVSS/kgTSS

Waste Flow Rate	Q_w	1232 m ³ /d
TSS wasted per day		2053 kgTSS/d
VSS wasted per day		1370 kgVSS/d

Flux of N in waste VSS	FN_i	137 kgN/d
Equiv conc in influent	N_i	12.33 mgN/l influent
Effluent Sol Unbiol Org N	N_{outE}	0.90 mgN/l

Factor of safety reducing μ_{denT}	Sf	1.25
total unaerated mass fraction	f_{xt}	0.148
Minimum sludge age for nitrification	SRT_m	1.77 days
SRT_m with Safety factor	$SRT_m (Sf)$	2.21 Nitrifies!

If no nitrification		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{ne}	35.9 mgTKN-N/l
Effluent FSA-N	$N_{ne} = N_{an}$	35.0 mgFSA-N/l

If complete nitrification		
Effluent NO ₃	N_{ne}	35.0 mgNO ₃ -N/l
Effluent TKN-N	N_{ne}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ne}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	34.48 mgNO ₃ -N/l
Effluent TKN-N	N_{ne}	1.40 mgTKN-N/l
(calculated N_{ne})	(N_{ne})	0.496 mgFSA-N/l
Effluent FSA-N	N_{ne}	0.496 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	264.5 kgVSS

Denitrification	$K_{d(D)}$	0.72 mgFSA/l
Half Saturation Coefficient	θ	1.2
	K_{1T}	1.4930 mgFSA/l
	$K_{d(D)}$	0.101 mgFSA/l
Denitrification	θ	1.08
Half Saturation Coefficient	K_{2T}	0.1374 mgFSA/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.747
Anoxic sludge mass fraction	f_{x1}	0.148
Min anoxic sludge mass fraction	f_{x1min}	0.009

Influent RBCOD fraction (Sbs/Sbi)	$f_{Sb/s}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	13.77 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	22.52 mgNO ₃ -N/l influent

	A	0.6993
	B	13.7091
	C	9.856
Optimal a-recycle ratio	a_{opt}	0.69
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00
	recycle limited	

Effluent Nitrate if recycle limited		17.24 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		12.31 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	17.24 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{de}$	18.63 mgN/l
N removal		61.3%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

MLE Reactor @ 10 Days SRT

Carbonaceous Oxygen flux	FO_c	4289 kgO/d
Nitrogenous Oxygen flux	FO_N	1687 kgO/d
Oxygen dmdnd recover by denitrification	FO_D	528 kgO/d
Total Oxygen Demand ($FO_c + FO_N - FO_D$)	FO_T	5448 kgO/d
Oxygen utilisation rate	O_r	21.6 mgO/l.h

Alkalinity consumed by nitrification	237 mg $CaCO_3$
Alkalinity recovered by denitrification	59 mg $CaCO_3$
Total Alkalinity consumption	178 mg $CaCO_3$

COD mass balance	
COD in (influent)	6876.7 kgCOD/d
COD out	6876.9 kgCOD/d
$Q_{25}S_{10} + Q_wS_{10}$	403.3 kgCOD/d
$Q_wX_r f_{cv}$	2184.2 kgCOD/d
V_pO_c	4289.3 kgO/d

N mass balance	
N in (influent)	535.6 kgTKN-N/d
N out	535.6 kgTKN-N/d
$Q_{25}N_{10} + Q_wN_{10}$	19.0 kgTKN-N/d
Q_rN_s	147.5 kgTKN-N/d
Q_rN_{oe}	369.1 kgNO3-N/d

TOD balance	
TOD in (influent)	9324.16 kgTOD/d
TOD out	9324.37 kgTOD/d
$TOD_{effluent}$	435.83 kgTOD/d
TOD_{waste}	2912.55 kgTOD/d
TOD_{N2-gas}	527.77 kgTOD/d
FO_T	5448.22 kgTOD/d

Flux of P in waste VSS	FP_s	37 kgP/d
Equiv concn in influent	P_i	3.32 mgP/l
Effluent Sol Unbiod Org P	P_{ouise}	0.60 mgP/l
Effluent TP	P_{10}	12.18 mgP/l
Effluent Ortho-P as P	P_{oe}	11.58 mgOP-P/l

Carbonaceous Oxygen flux	FO_c	4445 kgO/d	185.2107
Nitrogenous Oxygen flux	FO_N	1751 kgO/d	72.94465
Oxygen dmdnd recover by denitrification	FO_D	548 kgO/d	
Total Oxygen Demand ($FO_c + FO_N - FO_D$)	FO_T	5648 kgO/d	235.3302
Oxygen utilisation rate	O_r	22.4 mgO/l.h	

Alkalinity consumed by nitrification	246 mg $CaCO_3$
Alkalinity recovered by denitrification	62 mg $CaCO_3$
Total Alkalinity consumption	185 mg $CaCO_3$

COD mass balance	
COD in (influent)	6876.7 kgCOD/d
COD out	6876.9 kgCOD/d
$Q_{25}S_{10} + Q_wS_{10}$	403.3 kgCOD/d
$Q_wX_r f_{cv}$	2028.5 kgCOD/d
V_pO_c	4445.1 kgO/d

N mass balance	
N in (influent)	535.6 kgTKN-N/d
N out	535.6 kgTKN-N/d
$Q_{25}N_{10} + Q_wN_{10}$	15.5 kgTKN-N/d
Q_rN_s	137.0 kgTKN-N/d
Q_rN_{oe}	383.1 kgNO3-N/d

TOD balance	
TOD in (influent)	9324.16 kgTOD/d
TOD out	9324.37 kgTOD/d
$TOD_{effluent}$	421.63 kgTOD/d
TOD_{waste}	2707.02 kgTOD/d
TOD_{N2-gas}	547.80 kgTOD/d
FO_T	5647.92 kgTOD/d

Flux of P in waste VSS	FP_s	34 kgP/d
Equiv concn in influent	P_i	3.08 mgP/l
Effluent Sol Unbiod Org P	P_{ouise}	0.00 mgP/l
Effluent TP	P_{10}	12.42 mgP/l
Effluent Ortho-P as P	P_{oe}	12.42 mgOP-P/l

Effluent Concentrations				General	Special	Unit	Effluent Concentrations				General	Special	Unit
Unbiod Sol COD	S_{10}	36.30	<75	<30	mgCOD/l		Unbiod Sol COD	S_{10}	36.30	<75	<30	mgCOD/l	
Undiod Sol Org N	N_{ouise}	0.90	-	-	mgN/l		Undiod Sol Org N	N_{ouise}	0.90	-	-	mgN/l	
FSA-N	N_{10}	0.81	<6	<2	mgFSA-N/l		FSA-N	N_{10}	0.50	<6	<2	mgFSA-N/l	
TKN-N	N_{10}	1.71	-	-	mgTKN-N/l		TKN-N	N_{10}	1.40	-	-	mgTKN-N/l	
Nitrate	N_{10}	16.61	<15	<1.5	mgNO ₃ -N/l		Nitrate	N_{10}	17.24	<15	<1.5	mgNO ₃ -N/l	
Undiod Sol Org P	P_{ouise}	0.60	-	-	mgP/l		Undiod Sol Org P	P_{ouise}	0.00	-	-	mgP/l	
Ortho P as P	P_{oe}	11.58	<10	<2.5	mgOP-P/l		Ortho P as P	P_{oe}	12.42	<10	<2.5	mgOP-P/l	
TP	P_{10}	12.18	-	-	mgP/l		TP	P_{10}	12.42	-	-	mgP/l	

MLE Reactor @ 15 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	11.1 Ml/d
Sludge Age	SRT	15.0 days
Reactor TSS concentration	X _r	2393 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	619	6877
BPO COD	Sbpi	479	5321
UPO COD	Supi	29	319
	fS'up		0.0464
VFA COD	Sbsi,a	0.0	0
FBSO COD	Sbsfi	75	833
BSO COD	Sbsi	75	833
USO COD	Susi	36.3	403
	fS'us		0.0587
BO COD	Sbi	554	6154
UO COD	Sui	65	722
TSS		241	2675
ISS		51.4	571
VSS		189	2104
UPO VSS		19.4	215
BPO VSS		170	1888
TKN	Nti	48.2	536
Org N	Noi	13.8	153
FSA	Nai	34.4	382
BSO	Nobsi	2.90	32
USO	Nousi	0.90	10
BPO	Nobpi	8.70	97
UPO	Noupi	1.30	14
Total P	Pti	15.50	172
OP	Pai	12.80	142
Org P	Poi	2.70	30
BSO	Pobsi	0.70	8
USO	Pousi	0.60	7
BPO	Pobpi	0.78	9
UPO	Poupi	0.62	7

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _h	0.2
ISS content of OHO's	f _{i(OH)}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bsso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,uipo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,uipo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,uipo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{H20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{H,T}	0.2141 /d
	μ _{A,m20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{A,mT}	0.2829 /d
	b _{A20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{A,T}	0.0357 /d
	K _{H20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{H,T}	0.6288 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{oh}	9865 kgVSS
Endogenous Residue VSS	MX _{eh}	6335 kgVSS
Unbiodegradeable Organic VSS	MX _{ov}	3232 kgVSS
Total VSS	MX _v	19433 kgVSS
ISS from influent		8568 kgISS
ISS of OHO's		1480 kgISS
ISS	MX _(O)	10048 kgISS
TSS	MX _t	29481 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{h,n}	26.6 hr

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	11.1 Ml/d
Sludge Age	SRT	15.0 days
Reactor TSS concentration	X _T	2268 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	618.9	6877
BPO COD	Sbpi	479	5321
UPO COD	Supi	29	319
	fS'up		0.04637
VFA COD	Sbsi,a	0	0
FBSO COD	Sbsfi	75	833
BSO COD	Sbsi	75	833
USO COD	Susi	36.3	403
	fS'us		0.05865
BO COD	Sbi	554	6154
UO COD	Sui	65	722
TSS		240.7272727	2675
ISS		51.4	571
VSS		189.3181818	2104
UPO VSS		19.39	215
BPO VSS		170	1888
TKN	Nti	48.2	536
Org N	Noi	13.8	153
FSA	Nai	34.4	382
BSO	Nobsi	2.90	32.2
USO	Nousi	0.90	10.0
BPO	Nobpi	8.70	97
UPO	Noupi	1.30	14
Total P	Pti	15.5	172
OP	Pai	12.8	142
Org P	Poi	2.7	30.0
BSO	Pobsi	0.7	7.8
USO	Pousi		
BPO	Pobpi	0.78	9
UPO	Poupi	0.62	6.89

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _h	0.2
ISS content of OHO's	f _{i(OH)}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bsso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,uipo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,uipo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,uipo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{H20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{H,T}	0.2691 /d
	μ _{A,m20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{A,mT}	0.7157 /d
	b _{A20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{A,T}	0.0448 /d
	K _{H20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{H,T}	1.5904 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{oh}	8249 kgVSS
Endogenous Residue VSS	MX _{eh}	6659 kgVSS
Unbiodegradeable Organic VSS	MX _{ov}	3232 kgVSS
Total VSS	MX _v	18140 kgVSS
ISS from influent		8568 kgISS
ISS of OHO's		1237 kgISS
ISS	MX _(O)	9806 kgISS
TSS	MX _t	27945 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{h,n}	26.6 hr

MLE Reactor @ 15 Days SRT

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	801 mgVSS/l
Endogenous Residue VSS	X_{CH}	514 mgVSS/l
Unbiodegradeable Organic VSS	X_I	262 mgVSS/l
Total VSS	X_v	1577 mgVSS/l
Influent Biodegradeable ISS	X_{IOI}	816 mgISS/l
TSS	X_t	2393 mgTSS/l

Active fraction of VSS	f_{av}	0.508 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.335 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.659 kgVSS/kgTSS

Waste Flow Rate	Q_w	821 m ³ /d
TSS wasted per day		1965 kgTSS/d
VSS wasted per day		1296 kgVSS/d

Flux of N in waste VSS	FN_s	130 kgN/d
Equiv conc in influent	N_i	11.66 mgN/l influent
Effluent Sol Unbiol Org N	N_{outE}	0.90 mgN/l

Factor of safety reducing $\mu_{k_{dnt}}$	Sf	1.25
total unaerated mass fraction	f_{xt}	0.148
Minimum sludge age for nitrification	SRT_m	4.87 days
SRT_m with Safety factor	$SRT_m (Sf)$	6.09 Nitrifies!

<u>If no nitrification</u>		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{ne}	36.5 mgTKN-N/l
Effluent FSA-N	$N_{ne} = N_{an}$	35.6 mgFSA-N/l

<u>If complete nitrification</u>		
Effluent NO ₃	N_{ne}	35.6 mgNO ₃ -N/l
Effluent TKN-N	N_{ne}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ne}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	35.18 mgNO ₃ -N/l
Effluent TKN-N	N_{ne}	1.36 mgTKN-N/l
(calculated N_{ne})	(N_{ne})	0.464 mgFSA-N/l
Effluent FSA-N	N_{ne}	0.464 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	381.9 kgVSS

Denitrification	$K_{d(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	θ	1.2
	K_{1T}	0.3472 mgFSA/l
Denitrification	$K_{d(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	θ	1.08
	K_{2T}	0.0742 mgFSA/l

s-recycle ratio	s	1.00 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.548
Anoxic sludge mass fraction	f_{x1}	0.148 set = f_{xm} for balanced MLE
Min anoxic sludge mass fraction	f_{x1min}	0.028
Influent RBCOD fraction (Sbs/Sbi)	$f_{Sb/s}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	9.78 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	18.53 mgNO ₃ -N/l influent

	A	0.6993
	B	18.3974
	C	1.179
Optimal a-recycle ratio	a_{opt}	0.06
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00 set = a_{opt} for balanced MLE
recycle limited		

Effluent Nitrate if recycle limited		17.59 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		17.00 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	17.59 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{ne}$	18.95 mgN/l
N removal		60.7%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	670 mgVSS/l
Endogenous Residue VSS	X_{CH}	540 mgVSS/l
Unbiodegradeable Organic VSS	X_I	262 mgVSS/l
Total VSS	X_v	1472 mgVSS/l
Influent Biodegradeable ISS	X_{IOI}	796 mgISS/l
TSS	X_t	2268 mgTSS/l

Active fraction of VSS	f_{av}	0.455 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.295 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.649 kgVSS/kgTSS

Waste Flow Rate	Q_w	821 m ³ /d
TSS wasted per day		1863 kgTSS/d
VSS wasted per day		1209 kgVSS/d

Flux of N in waste VSS	FN_s	121 kgN/d
Equiv conc in influent	N_i	10.88 mgN/l influent
Effluent Sol Unbiol Org N	N_{outE}	0.90 mgN/l

Factor of safety reducing $\mu_{k_{dnt}}$	Sf	1.25
total unaerated mass fraction	f_{xt}	0.148
Minimum sludge age for nitrification	SRT_m	1.77 days
SRT_m with Safety factor	$SRT_m (Sf)$	2.21 Nitrifies!

<u>If no nitrification</u>		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{ne}	37.3 mgTKN-N/l
Effluent FSA-N	$N_{ne} = N_{an}$	36.4 mgFSA-N/l

<u>If complete nitrification</u>		
Effluent NO ₃	N_{ne}	36.4 mgNO ₃ -N/l
Effluent TKN-N	N_{ne}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ne}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	36.06 mgNO ₃ -N/l
Effluent TKN-N	N_{ne}	1.26 mgTKN-N/l
(calculated N_{ne})	(N_{ne})	0.356 mgFSA-N/l
Effluent FSA-N	N_{ne}	0.356 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	359.3 kgVSS

Denitrification	$K_{d(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	θ	1.2
	K_{1T}	1.4930 mgFSA/l
Denitrification	$K_{d(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	θ	1.08
	K_{2T}	0.1374 mgFSA/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.805
Anoxic sludge mass fraction	f_{x1}	0.148
Min anoxic sludge mass fraction	f_{x1min}	0.008
Influent RBCOD fraction (Sbs/Sbi)	$f_{Sb/s}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	15.14 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	23.88 mgNO ₃ -N/l influent

	A	0.6993
	B	13.9251
	C	11.007
Optimal a-recycle ratio	a_{opt}	0.76
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00
recycle limited		

Effluent Nitrate if recycle limited		18.03 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		12.53 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	18.03 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{ne}$	19.29 mgN/l
N removal		60.0%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

MLE Reactor @ 15 Days SRT

Carbonaceous Oxygen flux	FO _c	4555 kgO/d
Nitrogenous Oxygen flux	FO _N	1786 kgO/d
Oxygen dmnd recover by denitrification	FO _D	559 kgO/d
Total Oxygen Demand (FO _c + FO _N - FO _D)	FO _T	5782 kgO/d
Oxygen utilisation rate	O _r	23.0 mgO/l.h

Alkalinity consumed by nitrification	251 mg CaCO ₃
Alkalinity recovered by denitrification	63 mg CaCO ₃
Total Alkalinity consumption	188 mg CaCO ₃

COD mass balance	
COD in (influent)	6876.7 kgCOD/d
COD out	6876.9 kgCOD/d
Q ₂₅ S ₁₀ + Q ₂₀ S ₁₀	403.3 kgCOD/d
Q ₂₀ X _f f _{iv}	1918.7 kgCOD/d
V ₀ O _c	4554.9 kgO/d

N mass balance	
N in (influent)	535.6 kgTKN-N/d
N out	535.6 kgTKN-N/d
Q ₂₅ N ₁₀ + Q ₂₀ N ₁₀	15.2 kgTKN-N/d
Q ₂₅ N ₅	129.6 kgTKN-N/d
Q ₂₅ N ₁₀	390.8 kgNO ₃ -N/d

TOD balance	
TOD in (influent)	9324.16 kgTOD/d
TOD out	9324.37 kgTOD/d
TOD _{effluent}	437.67 kgTOD/d
TOD _{waste}	2545.63 kgTOD/d
TOD _{N2-gas}	558.91 kgTOD/d
FO _T	5782.15 kgTOD/d

Flux of P in waste VSS	FP _s	32 kgP/d
Equiv conc in influent	P _i	2.91 mgP/l
Effluent Sol Unbiod Org P	P _{ouise}	0.60 mgP/l
Effluent TP	P ₁₀	12.59 mgP/l
Effluent Ortho-P as P	P _{oe}	11.99 mgOP-P/l

Carbonaceous Oxygen flux	FO _c	4683 kgO/d	195.1069
Nitrogenous Oxygen flux	FO _N	1831 kgO/d	76.29382
Oxygen dmnd recover by denitrification	FO _D	573 kgO/d	
Total Oxygen Demand (FO _c + FO _N - FO _D)	FO _T	5941 kgO/d	247.5276
Oxygen utilisation rate	O _r	23.6 mgO/l.h	

Alkalinity consumed by nitrification	257 mg CaCO ₃
Alkalinity recovered by denitrification	64 mg CaCO ₃
Total Alkalinity consumption	193 mg CaCO ₃

COD mass balance	
COD in (influent)	6876.7 kgCOD/d
COD out	6876.9 kgCOD/d
Q ₂₅ S ₁₀ + Q ₂₀ S ₁₀	403.3 kgCOD/d
Q ₂₀ X _f f _{iv}	1791.0 kgCOD/d
V ₀ O _c	4682.6 kgO/d

N mass balance	
N in (influent)	535.6 kgTKN-N/d
N out	535.6 kgTKN-N/d
Q ₂₅ N ₁₀ + Q ₂₀ N ₁₀	14.0 kgTKN-N/d
Q ₂₅ N ₅	120.9 kgTKN-N/d
Q ₂₅ N ₁₀	400.7 kgNO ₃ -N/d

TOD balance	
TOD in (influent)	9324.16 kgTOD/d
TOD out	9324.37 kgTOD/d
TOD _{effluent}	432.59 kgTOD/d
TOD _{waste}	2378.17 kgTOD/d
TOD _{N2-gas}	572.95 kgTOD/d
FO _T	5940.66 kgTOD/d

Flux of P in waste VSS	FP _s	30 kgP/d
Equiv conc in influent	P _i	2.72 mgP/l
Effluent Sol Unbiod Org P	P _{ouise}	0.00 mgP/l
Effluent TP	P ₁₀	12.78 mgP/l
Effluent Ortho-P as P	P _{oe}	12.78 mgOP-P/l

Effluent Concentrations				General	Special	Unit	Effluent Concentrations				General	Special	Unit
Unbiod Sol COD	S _{use}	36.30	<75	<30	mgCOD/l		Unbiod Sol COD	S _{use}	36.30	<75	<30	mgCOD/l	
Undiod Sol Org N	N _{ouise}	0.90	-	-	mgN/l		Undiod Sol Org N	N _{ouise}	0.90	-	-	mgN/l	
FSA-N	N _{se}	0.46	<6	<2	mgFSA-N/l		FSA-N	N _{se}	0.36	<6	<2	mgFSA-N/l	
TKN-N	N ₁₀	1.36	-	-	mgTKN-N/l		TKN-N	N ₁₀	1.26	-	-	mgTKN-N/l	
Nitrate	N ₁₀	17.59	<15	<1.5	mgNO ₃ -N/l		Nitrate	N ₁₀	18.03	<15	<1.5	mgNO ₃ -N/l	
Undiod Sol Org P	P _{ouise}	0.60	-	-	mgP/l		Undiod Sol Org P	P _{ouise}	0.00	-	-	mgP/l	
Ortho P as P	P _{oe}	11.99	<10	<2.5	mgOP-P/l		Ortho P as P	P _{oe}	12.78	<10	<2.5	mgOP-P/l	
TP	P ₁₀	12.59	-	-	mgP/l		TP	P ₁₀	12.78	-	-	mgP/l	

MLE Reactor @ 20 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	11.1 Ml/d
Sludge Age	SRT	20.0 days
Reactor TSS concentration	X _r	2985 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti	619 6877
BPO COD	Sbpi	479 5321
UPO COD	Supi	29 319
	fS'up	0.0464
VFA COD	Sbsi,a	0.0 0
FBSD COD	Sbsfi	75 833
BSO COD	Sbsi	75 833
USO COD	Susi	36.3 403
	fS'us	0.0587
BO COD	Sbi	554 6154
UO COD	Sui	65 722
TSS		241 2675
ISS		51.4 571
VSS		189 2104
UPO VSS		19.4 215
BPO VSS		170 1888
TKN	Nti	48.2 536
Org N	Noi	13.8 153
FSA	Nai	34.4 382
BSO	Nobsi	2.90 32
USO	Nousi	0.90 10
BPO	Nobpi	8.70 97
UPO	Noupi	1.30 14
Total P	Pti	15.50 172
OP	Pal	12.80 142
Org P	Poi	2.70 30
BSO	Pobsi	0.70 8
USO	Pousi	0.60 7
BPO	Pobpi	0.78 9
UPO	Poupi	0.62 7

Constants		
COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{OHO}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSD	f _{cm,bsd}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,upo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,upo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,upo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{H20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2141 /d
	μ _{Am20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.2829 /d
	b _{A20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0357 /d
	K _{s20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{NT}	0.6288 mgFSA/l

Activated Sludge Masses		
Ordinary Heterotrophic Organisms VSS	MX _{BH}	10488 kgVSS
Endogenous Residue VSS	MX _{EH}	8980 kgVSS
Unbiodegradable Organic VSS	MX _u	4309 kgVSS
Total VSS	MX _v	23778 kgVSS
ISS from influent		11424 kgISS
ISS of OHO's		1573 kgISS
ISS	MX _{OI}	12997 kgISS
TSS	MX _t	36775 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{nh}	26.6 hr

Activated Sludge Concentrations		
Ordinary Heterotrophic Organisms VSS	X _{BH}	851 mgVSS/l
Endogenous Residue VSS	X _{EH}	729 mgVSS/l
Unbiodegradable Organic VSS	X _i	350 mgVSS/l
Total VSS	X _v	1930 mgVSS/l
Influent Biodegradable ISS	X _{OI}	1055 mgISS/l
TSS	X _t	2985 mgTSS/l

Active fraction of VSS	f _{av}	0.441 kgVSS/kgVSS
Active fraction of TSS	f _{at}	0.285 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.647 kgVSS/kgTSS

Waste Flow Rate	Q _w	616 m ³ /d
TSS wasted per day		1839 kgTSS/d
VSS wasted per day		1189 kgVSS/d

Flux of N in waste VSS	FN _v	119 kgN/d
Equiv conc in influent	N _i	10.70 mgN/l influent
Effluent Sol Unbioid Org N	N _{oude}	0.90 mgN/l

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	11.1 Ml/d
Sludge Age	SRT	20.0 days
Reactor TSS concentration	X _T	2846 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti	618.9 6877
BPO COD	Sbpi	479 5321
UPO COD	Supi	29 319
	fS'up	0.04637
VFA COD	Sbsi,a	0 0
FBSD COD	Sbsfi	75 833
BSO COD	Sbsi	75 833
USO COD	Susi	36.3 403
	fS'us	0.05865
BO COD	Sbi	554 6154
UO COD	Sui	65 722
TSS		240.7272727 2675
ISS		51.4 571
VSS		189.3181818 2104
UPO VSS		19.39 215
BPO VSS		170 1888
TKN	Nti	48.2 536
Org N	Noi	13.8 153
FSA	Nai	34.4 382
BSO	Nobsi	2.90 32.2
USO	Nousi	0.90 10.0
BPO	Nobpi	8.70 97
UPO	Noupi	1.30 14
Total P	Pti	15.5 172
OP	Pal	12.8 142
Org P	Poi	2.7 30.0
BSO	Pobsi	0.7 7.8
USO	Pousi	
BPO	Pobpi	0.78 9
UPO	Poupi	0.62 6.89

Constants		
COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{OHO}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSD	f _{cm,bsd}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,upo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,upo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,upo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{H20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2691 /d
	μ _{Am20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.7157 /d
	b _{A20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0448 /d
	K _{s20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{NT}	1.5904 mgFSA/l

Activated Sludge Masses		
Ordinary Heterotrophic Organisms VSS	MX _{BH}	8680 kgVSS
Endogenous Residue VSS	MX _{EH}	9342 kgVSS
Unbiodegradable Organic VSS	MX _u	4309 kgVSS
Total VSS	MX _v	22331 kgVSS
ISS from influent		11424 kgISS
ISS of OHO's		1302 kgISS
ISS	MX _{OI}	12726 kgISS
TSS	MX _t	35057 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{nh}	26.6 hr

Activated Sludge Concentrations		
Ordinary Heterotrophic Organisms VSS	X _{BH}	705 mgVSS/l
Endogenous Residue VSS	X _{EH}	758 mgVSS/l
Unbiodegradable Organic VSS	X _i	350 mgVSS/l
Total VSS	X _v	1813 mgVSS/l
Influent Biodegradable ISS	X _{OI}	1033 mgISS/l
TSS	X _t	2846 mgTSS/l

Active fraction of VSS	f _{av}	0.389 kgVSS/kgVSS
Active fraction of TSS	f _{at}	0.248 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.637 kgVSS/kgTSS

Waste Flow Rate	Q _w	616 m ³ /d
TSS wasted per day		1753 kgTSS/d
VSS wasted per day		1117 kgVSS/d

Flux of N in waste VSS	FN _v	112 kgN/d
Equiv conc in influent	N _i	10.05 mgN/l influent
Effluent Sol Unbioid Org N	N _{oude}	0.90 mgN/l

MLE Reactor @ 20 Days SRT

Factor of safety reducing μ_{aerT}	Sf	1.25
total unaerated mass fraction	fxt	0.148
Minimum sludge age for nitrification	SRT _m	4.87 days
SRT _m with Safety factor	SRT _m (Sf)	6.09 Nitrifies!

<u>If no nitrification</u>		
Effluent NO ₃	N _{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	37.5 mgTKN-N/l
Effluent FSA-N	N _{ae} = N _{an}	36.6 mgFSA-N/l

<u>If complete nitrification</u>		
Effluent NO ₃	N _{ne}	36.6 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	0.9 mgTKN-N/l
Effluent FSA-N	N _{ae}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	N _{ne} = N _e	36.25 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	1.25 mgTKN-N/l
(calculated N _{ae})	(N _{ae})	0.347 mgFSA-N/l
Effluent FSA-N	N _{ae}	0.347 mgFSA-N/l
Nitrifier sludge mass	MX _{SA}	470.1 kgVSS

Denitrification	K ₁₍₂₀₎	0.72 mgFSA/l
Half Saturation Coefficient	Θ	1.2
Denitrification	K _{1T}	0.3472 mgFSA/l
Half Saturation Coefficient	K ₂₍₂₀₎	0.101 mgFSA/l
Denitrification	Θ	1.08
Half Saturation Coefficient	K _{2T}	0.0742 mgFSA/l

s-recycle ratio	s	1.00 :1
s-recycle DO concentration	O _s	1.0 mgO/l
a-recycle DO concentration	O _a	2.0 mgO/l

Max unaerated sludge mass fraction	f _{sm}	0.621
Anoxic sludge mass fraction	f _{a1}	0.148 set = f _{sm} for balanced MLE
Min anoxic sludge mass fraction	f _{a1min}	0.027
Influent RBCOD fraction (Sbsi/Sbi)	f _{50/s}	0.135

Denitrification potential BSO (K1)	D _{pBSO}	8.75 mgNO ₃ -N/l Influent
Denitrification potential BPO (K2)	D _{pBPO}	10.40 mgNO ₃ -N/l Influent
Denitr potential primary anoxic tank	D _{p1}	19.14 mgNO ₃ -N/l Influent

	A	0.6993
	B	18.8571
	C	1.336
Optimal a-recycle ratio	a _{opt}	0.07
Maximum practical a-recycle ratio	a _{max}	6
chosen a-recycle ratio	a	0.00
	set = a _{opt} for balanced MLE	
	recycle limited	

Effluent Nitrate if recycle limited	18.13 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited	17.46 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne} 18.13 mgNO₃-N/l

Effluent total N (TKN + NO ₃)	N _{te} + N _{te}	19.37 mgN/l
N removal		59.8%

Volume of Primary Anoxic Tank	V _{anox}	1828 m³
Volume of Aerobic Tank	V _{aer}	10492 m³

Carbonaceous Oxygen flux	FO _c	4713 kgO/d
Nitrogenous Oxygen flux	FO _N	1841 kgO/d
Oxygen dmdnd recover by denitrification	FO _D	576 kgO/d
Total Oxygen Demand (FO _c + FO _N - FO _D)	FO _T	5978 kgO/d
Oxygen utilisation rate	O _T	23.7 mgO/Lh

Alkalinity consumed by nitrification	259 mg CaCO ₃
Alkalinity recovered by denitrification	65 mg CaCO ₃
Total Alkalinity consumption	194 mg CaCO ₃

COD mass balance		
COD in (influent)	6877 kgCOD/d	
COD out	6877 kgCOD/d	
Q _a S _{ae} + Q _w S _{1e}	403 kgCOD/d	
Q _w X _f f _{cv}	1761 kgCOD/d	
V _a O _c	4713 kgO/d	

N mass balance		
N in (influent)	535.6 kgTKN-N/d	
N out	535.6 kgTKN-N/d	
Q _a N _{te} + Q _w N _{1e}	13.9 kgTKN-N/d	
Q _a N _e	118.9 kgTKN-N/d	
Q _a N _{ne}	402.8 kgNO ₃ -N/d	

TOD balance		
TOD in (influent)	9325 kgTOD/d	
TOD out	9324 kgTOD/d	
TOD _{effluent}	441 kgTOD/d	
TOD _{waste}	2330 kgTOD/d	
TOD _{N2-gas}	576 kgTOD/d	
FO _c	5978 kgTOD/d	

Flux of P in waste VSS	FP _s	30 kgP/d
Equiv conc in influent	P _s	2.67 mgP/l
Effluent Sol Unbiodeg Org P	P _{ouste}	0.60 mgP/l
Effluent TP	P _{te}	12.83 mgP/l
Effluent Ortho-P as P	P _{oe}	12.23 mgOP-P/l

Factor of safety reducing μ_{aerT}	Sf	1.25
total unaerated mass fraction	fxt	0.148
Minimum sludge age for nitrification	SRT _m	1.77 days
SRT _m with Safety factor	SRT _m (Sf)	2.21 Nitrifies!

<u>If no nitrification</u>		
Effluent NO ₃	N _{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	38.2 mgTKN-N/l
Effluent FSA-N	N _{ae} = N _{an}	37.3 mgFSA-N/l

<u>If complete nitrification</u>		
Effluent NO ₃	N _{ne}	37.3 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	0.9 mgTKN-N/l
Effluent FSA-N	N _{ae}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	N _{ne} = N _e	36.96 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	1.19 mgTKN-N/l
(calculated N _{ae})	(N _{ae})	0.293 mgFSA-N/l
Effluent FSA-N	N _{ae}	0.293 mgFSA-N/l
Nitrifier sludge mass	MX _{SA}	433.0 kgVSS

Denitrification	K ₁₍₂₀₎	0.72 mgFSA/l
Half Saturation Coefficient	Θ	1.2
Denitrification	K _{1T}	1.4930 mgFSA/l
Half Saturation Coefficient	K ₂₍₂₀₎	0.101 mgFSA/l
Denitrification	Θ	1.08
Half Saturation Coefficient	K _{2T}	0.1374 mgFSA/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O _s	1.0 mgO/l
a-recycle DO concentration	O _a	2.0 mgO/l

Max unaerated sludge mass fraction	f _{sm}	0.834
Anoxic sludge mass fraction	f _{a1}	0.148
Min anoxic sludge mass fraction	f _{a1min}	0.007
Influent RBCOD fraction (Sbsi/Sbi)	f _{50/s}	0.135

Denitrification potential BSO (K1)	D _{pBSO}	8.75 mgNO ₃ -N/l Influent
Denitrification potential BPO (K2)	D _{pBPO}	15.93 mgNO ₃ -N/l Influent
Denitr potential primary anoxic tank	D _{p1}	24.67 mgNO ₃ -N/l Influent

	A	0.6993
	B	14.0322
	C	11.691
Optimal a-recycle ratio	a _{opt}	0.80
Maximum practical a-recycle ratio	a _{max}	6
chosen a-recycle ratio	a	0.00
	recycle limited	

Effluent Nitrate if recycle limited	18.48 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited	12.63 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne} 18.48 mgNO₃-N/l

Effluent total N (TKN + NO ₃)	N _{te} + N _{te}	19.67 mgN/l
N removal		59.2%

Volume of Primary Anoxic Tank	V _{anox}	1828 m³
Volume of Aerobic Tank	V _{aer}	10492 m³

Carbonaceous Oxygen flux	FO _c	4820 kgO/d
Nitrogenous Oxygen flux	FO _N	1877 kgO/d
Oxygen dmdnd recover by denitrification	FO _D	587 kgO/d
Total Oxygen Demand (FO _c + FO _N - FO _D)	FO _T	6109 kgO/d
Oxygen utilisation rate	O _T	24.3 mgO/Lh

Alkalinity consumed by nitrification	264 mg CaCO ₃
Alkalinity recovered by denitrification	66 mg CaCO ₃
Total Alkalinity consumption	198 mg CaCO ₃

COD mass balance		
COD in (influent)	6877 kgCOD/d	
COD out	6877 kgCOD/d	
Q _a S _{ae} + Q _w S _{1e}	403.3 kgCOD/d	
Q _w X _f f _{cv}	1653.6 kgCOD/d	
V _a O _c	4819.9 kgO/d	

N mass balance		
N in (influent)	535.6 kgTKN-N/d	
N out	535.6 kgTKN-N/d	
Q _a N _{te} + Q _w N _{1e}	13.3 kgTKN-N/d	
Q _a N _e	111.7 kgTKN-N/d	
Q _a N _{ne}	410.6 kgNO ₃ -N/d	

TOD balance		
TOD in (influent)	9325 kgTOD/d	
TOD out	9324 kgTOD/d	
TOD _{effluent}	438 kgTOD/d	
TOD _{waste}	2190 kgTOD/d	
TOD _{N2-gas}	587 kgTOD/d	
FO _c	6109 kgTOD/d	

Flux of P in waste VSS	FP _s	28 kgP/d
Equiv conc in influent	P _s	2.51 mgP/l
Effluent Sol Unbiodeg Org P	P _{ouste}	0.00 mgP/l
Effluent TP	P _{te}	12.99 mgP/l
Effluent Ortho-P as P	P _{oe}	12.99 mgOP-P/l

Effluent Concentrations		General	Special	Unit	Effluent Concentrations		General	Special	Unit
Unbiodeg Sol COD	S _{use}	36.30	<75	mgCOD/l	Unbiodeg Sol COD	S _{use}	36.30	<75	mgCOD/l

MLE Reactor @ 20 Days SRT

Undiod Sol Org N	N _{ouse}	0.90	-	-	mgN/l	Undiod Sol Org N	N _{ouse}	0.90	-	-	mgN/l
FSA-N	N _{ae}	0.35	<6	<2	mgFSA-N/l	FSA-N	N _{ae}	0.29	<6	<2	mgFSA-N/l
TKN-N	N _{te}	1.25	-	-	mgTKN-N/l	TKN-N	N _{te}	1.19	-	-	mgTKN-N/l
Nitrate	N _{ne}	18.13	<15	<1.5	mgNO ₃ -N/l	Nitrate	N _{ne}	18.48	<15	<1.5	mgNO ₃ -N/l
Undiod Sol Org P	P _{ouse}	0.60	-	-	mgP/l	Undiod Sol Org P	P _{ouse}	0.00	-	-	mgP/l
Ortho P as P	P _{oe}	12.23	<10	<2.5	mgOP-P/l	Ortho P as P	P _{oe}	12.99	<10	<2.5	mgOP-P/l
TP	P _{te}	12.83	-	-	mgP/l	TP	P _{te}	12.99	-	-	mgP/l

MLE Reactor @ 25 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	11.1 Ml/d
Sludge Age	SRT	25.0 days
Reactor TSS concentration	X _r	3561 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	619	6877
BPO COD	Sbpi	479	5321
UPO COD	Supi	29	319
	fS'up		0.0464
VFA COD	Sbsi,a	0.0	0
FBSO COD	Sbsfi	75	833
BSO COD	Sbsi	75	833
USO COD	Susi	36.3	403
	fS'us		0.0587
BO COD	Sbi	554	6154
UO COD	Sui	65	722
TSS		241	2675
ISS		51.4	571
VSS		189	2104
UPO VSS		19.4	215
BPO VSS		170	1888
TKN	Nti	48.2	536
Org N	Noi	13.8	153
FSA	Nai	34.4	382
BSO	Nobsi	2.90	32
USO	Nousi	0.90	10
BPO	Nobpi	8.70	97
UPO	Noupi	1.30	14
Total P	Pti	15.50	172
OP	Pal	12.80	142
Org P	Poi	2.70	30
BSO	Pobsi	0.70	8
USO	Pousi	0.60	7
BPO	Pobpi	0.78	9
UPO	Poupi	0.62	7

Constants			
COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS	
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD	
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD	
Endogenous residue fraction	f _H	0.2	
ISS content of OHO's	f _{OHO}	0.15	
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA	
COD per mass fraction of FBSO	f _{cm,bsso}	1.42 mgCOD/mg	
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg	
N Content of UPO and biomass VSS	f _{N,uipo}	0.1 mgN/mgVSS	
P Content of UPO and biomass VSS	f _{P,uipo}	0.025 mgP/mgVSS	
C Content of UPO and biomass VSS	f _{C,uipo}	0.518 mgC/mgVSS	

Temperature dependant coefficients	T	16 °C
	b _{H20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2141 /d
	μ _{Am20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.2829 /d
	b _{A20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0357 /d
	K _{A20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{HT}	0.6288 mgFSA/l

Activated Sludge Masses			
Ordinary Heterotrophic Organisms VSS	MX _{EH}	10901 kgVSS	
Endogenous Residue VSS	MX _{EH}	11667 kgVSS	
Unbiodegradable Organic VSS	MX _u	5387 kgVSS	
Total VSS	MX _v	27955 kgVSS	
ISS from influent		14280 kgISS	
ISS of OHO's		1635 kgISS	
ISS	MX _{OH}	15915 kgISS	
TSS	MX _t	43870 kgTSS	

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{th}	26.6 hr

Activated Sludge Concentrations			
Ordinary Heterotrophic Organisms VSS	X _{BH}	885 mgVSS/l	
Endogenous Residue VSS	X _{EH}	947 mgVSS/l	
Unbiodegradable Organic VSS	X _i	437 mgVSS/l	
Total VSS	X _v	2269 mgVSS/l	
Influent Biodegradable ISS	X _{OH}	1292 mgISS/l	
TSS	X _t	3561 mgTSS/l	

Active fraction of VSS	f _{av}	0.390 kgVSS/kgVSS	
Active fraction of TSS	f _{at}	0.248 kgVSS/kgTSS	
VSS/TSS ratio	VSS/TSS	0.637 kgVSS/kgTSS	

Waste Flow Rate	Q _w	493 m ³ /d
TSS wasted per day		1755 kgTSS/d
VSS wasted per day		1118 kgVSS/d

Flux of N in waste VSS	FN _i	112 kgN/d
Equiv conc in influent	N _i	10.06 mgN/l influent
Effluent Sol Unbioid Org N	N _{u,ss}	0.90 mgN/l

Factor of safety reducing μ _{AmT}	Sf	1.25
total unaerated mass fraction	fxt	0.148

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	11.1 Ml/d
Sludge Age	SRT	25.0 days
Reactor TSS concentration	X _T	3411 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	618.9	6877
BPO COD	Sbpi	479	5321
UPO COD	Supi	29	319
	fS'up		0.04637
VFA COD	Sbsi,a	0	0
FBSO COD	Sbsfi	75	833
BSO COD	Sbsi	75	833
USO COD	Susi	36.3	403
	fS'us		0.05865
BO COD	Sbi	554	6154
UO COD	Sui	65	722
TSS		240.72727	2675
ISS		51.4	571
VSS		189.31818	2104
UPO VSS		19.39	215
BPO VSS		170	1888
TKN	Nti	48.2	536
Org N	Noi	13.8	153
FSA	Nai	34.4	382
BSO	Nobsi	2.90	32.2
USO	Nousi	0.90	10.0
BPO	Nobpi	8.70	97
UPO	Noupi	1.30	14
Total P	Pti	15.5	172
OP	Pal	12.8	142
Org P	Poi	2.7	30.0
BSO	Pobsi	0.7	7.8
USO	Pousi		
BPO	Pobpi	0.78	9
UPO	Poupi	0.62	6.89

Constants			
COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS	
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD	
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD	
Endogenous residue fraction	f _H	0.2	
ISS content of OHO's	f _{OHO}	0.15	
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA	
COD per mass fraction of FBSO	f _{cm,bsso}	1.42 mgCOD/mg	
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg	
N Content of UPO and biomass VSS	f _{N,uipo}	0.1 mgN/mgVSS	
P Content of UPO and biomass VSS	f _{P,uipo}	0.025 mgP/mgVSS	
C Content of UPO and biomass VSS	f _{C,uipo}	0.518 mgC/mgVSS	

Temperature dependant coefficients	T	24 °C
	b _{H20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2691 /d
	μ _{Am20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.7157 /d
	b _{A20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0448 /d
	K _{A20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{HT}	1.5904 mgFSA/l

Activated Sludge Masses			
Ordinary Heterotrophic Organisms VSS	MX _{EH}	8961 kgVSS	
Endogenous Residue VSS	MX _{EH}	12055 kgVSS	
Unbiodegradable Organic VSS	MX _u	5387 kgVSS	
Total VSS	MX _v	26403 kgVSS	
ISS from influent		14280 kgISS	
ISS of OHO's		1344 kgISS	
ISS	MX _{OH}	15624 kgISS	
TSS	MX _t	42027 kgTSS	

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{th}	26.6 hr

Activated Sludge Concentrations			
Ordinary Heterotrophic Organisms VSS	X _{BH}	727 mgVSS/l	
Endogenous Residue VSS	X _{EH}	979 mgVSS/l	
Unbiodegradable Organic VSS	X _i	437 mgVSS/l	
Total VSS	X _v	2143 mgVSS/l	
Influent Biodegradable ISS	X _{OH}	1268 mgISS/l	
TSS	X _t	3411 mgTSS/l	

Active fraction of VSS	f _{av}	0.339 kgVSS/kgVSS	
Active fraction of TSS	f _{at}	0.213 kgVSS/kgTSS	
VSS/TSS ratio	VSS/TSS	0.628 kgVSS/kgTSS	

Waste Flow Rate	Q _w	493 m ³ /d
TSS wasted per day		1681 kgTSS/d
VSS wasted per day		1056 kgVSS/d

Flux of N in waste VSS	FN _i	106 kgN/d
Equiv conc in influent	N _i	9.50 mgN/l influent
Effluent Sol Unbioid Org N	N _{u,ss}	0.90 mgN/l

Factor of safety reducing μ _{AmT}	Sf	1.25
total unaerated mass fraction	fxt	0.148

MLE Reactor @ 25 Days SRT

Minimum sludge age for nitrification	SRT_{min}	4.87 days
SRT_{min} with Safety factor	$SRT_{min}(SF)$	6.09 Nitrifies!

<u>If no nitrification</u>		
Effluent NO_3	N_{ne}	0 mg NO_3 -N/l
Effluent TKN-N	N_{te}	38.1 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	37.2 mgFSA-N/l

<u>If complete nitrification</u>		
Effluent NO_3	N_{ne}	37.2 mg NO_3 -N/l
Effluent TKN-N	N_{te}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ae}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO_3 if no denitrification	$N_{ne} = N_e$	36.95 mg NO_3 -N/l
Effluent TKN-N	N_{te}	1.19 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.288 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.288 mgFSA-N/l
Nitrifier sludge mass	MX_{SA}	542.5 kgVSS

Denitrification	$K_{d(20)}$	0.72 mgFSA/l
	θ	1.2
Half Saturation Coefficient	K_{1T}	0.3472 mgFSA/l
Denitrification	$K_{d(20)}$	0.101 mgFSA/l
	θ	1.08
Half Saturation Coefficient	K_{2T}	0.0742 mgFSA/l

s-recycle ratio	s	1.00 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{um}	0.666
Anoxic sludge mass fraction	f_{a1}	0.148 set = f_{um} for balanced MLE
Min anoxic sludge mass fraction	f_{a1min}	0.026

Influent RBCOD fraction (Sbsi/Sbi)	$f_{Sbi/s}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mg NO_3 -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	10.81 mg NO_3 -N/l influent
Denitr potential primary anoxic tank	D_{p1}	19.55 mg NO_3 -N/l influent

Optimal a-recycle ratio	A	0.6993
	B	19.1432
	C	1.459
	a_{opt}	0.08
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00 set = a_{opt} for balanced MLE
recycle limited		

Effluent Nitrate if recycle limited		18.47 mg NO_3 -N/l
Effluent Nitrate if kinetics limited		17.74 mg NO_3 -N/l
Actual Effluent Nitrate	N_{ne}	18.47 mgNO_3-N/l

Effluent total N (TKN + NO_3)	$N_{te} + N_{ne}$	19.66 mgN/l
N removal		59.2%

Volume of Primary Anoxic Tank	V_{anox}	1828 m³
Volume of Aerobic Tank	V_{aer}	10492 m³

Carbonaceous Oxygen flux	FO_c	4818 kgO/d
Nitrogenous Oxygen flux	FO_N	1876 kgO/d
Oxygen dmnd recover by denitrification	FO_D	587 kgO/d
Total Oxygen Demand ($FO_c + FO_N - FO_D$)	FO_T	6107 kgO/d
Oxygen utilisation rate	O_T	24.3 mgO/l.h

Alkalinity consumed by nitrification		264 mg CaCO ₃
Alkalinity recovered by denitrification		66 mg CaCO ₃
Total Alkalinity consumption		198 mg CaCO ₃

COD mass balance		
COD in (influent)		6876.7 kgCOD/d
COD out		6876.9 kgCOD/d
$Q_w S_{te} + Q_w S_{ne}$		403.3 kgCOD/d
$Q_w X_v f_{cv}$		1656.0 kgCOD/d
$V_d O_2$		4817.5 kgO/d

Minimum sludge age for nitrification	SRT_{min}	1.77 days
SRT_{min} with Safety factor	$SRT_{min}(SF)$	2.21 Nitrifies!

<u>If no nitrification</u>		
Effluent NO_3	N_{ne}	0 mg NO_3 -N/l
Effluent TKN-N	N_{te}	38.7 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	37.8 mgFSA-N/l

<u>If complete nitrification</u>		
Effluent NO_3	N_{ne}	37.8 mg NO_3 -N/l
Effluent TKN-N	N_{te}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ae}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO_3 if no denitrification	$N_{ne} = N_e$	37.54 mg NO_3 -N/l
Effluent TKN-N	N_{te}	1.16 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.257 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.257 mgFSA-N/l
Nitrifier sludge mass	MX_{SA}	491.6 kgVSS

Denitrification	$K_{d(20)}$	0.72 mgFSA/l
	θ	1.2
Half Saturation Coefficient	K_{1T}	1.4930 mgFSA/l
Denitrification	$K_{d(20)}$	0.101 mgFSA/l
	θ	1.08
Half Saturation Coefficient	K_{2T}	0.1374 mgFSA/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{um}	0.852
Anoxic sludge mass fraction	f_{a1}	0.148
Min anoxic sludge mass fraction	f_{a1min}	0.007

Influent RBCOD fraction (Sbsi/Sbi)	$f_{Sbi/s}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mg NO_3 -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	16.44 mg NO_3 -N/l influent
Denitr potential primary anoxic tank	D_{p1}	25.19 mg NO_3 -N/l influent

Optimal a-recycle ratio	A	0.6993
	B	14.0969
	C	12.141
	a_{opt}	0.83
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00
recycle limited		

Effluent Nitrate if recycle limited		18.77 mg NO_3 -N/l
Effluent Nitrate if kinetics limited		12.70 mg NO_3 -N/l
Actual Effluent Nitrate	N_{ne}	18.77 mgNO_3-N/l

Effluent total N (TKN + NO_3)	$N_{te} + N_{ne}$	19.93 mgN/l
N removal		58.7%

Volume of Primary Anoxic Tank	V_{anox}	1828 m³
Volume of Aerobic Tank	V_{aer}	10492 m³

Carbonaceous Oxygen flux	FO_c	4909 kgO/d
Nitrogenous Oxygen flux	FO_N	1906 kgO/d
Oxygen dmnd recover by denitrification	FO_D	596 kgO/d
Total Oxygen Demand ($FO_c + FO_N - FO_D$)	FO_T	6219 kgO/d
Oxygen utilisation rate	O_T	24.7 mgO/l.h

Alkalinity consumed by nitrification		268 mg CaCO ₃
Alkalinity recovered by denitrification		67 mg CaCO ₃
Total Alkalinity consumption		201 mg CaCO ₃

COD mass balance		
COD in (influent)		6876.7 kgCOD/d
COD out		6876.9 kgCOD/d
$Q_w S_{te} + Q_w S_{ne}$		403.3 kgCOD/d
$Q_w X_v f_{cv}$		1564.1 kgCOD/d
$V_d O_2$		4909.5 kgO/d

MLE Reactor @ 25 Days SRT

N mass balance		
N in (influent)		535.6 kgTKN-N/d
N out		535.6 kgTKN-N/d
$Q_a N_{te} + Q_w N_{te}$		13.2 kgTKN-N/d
$Q_a N_i$		111.8 kgTKN-N/d
$Q_a N_{re}$		410.5 kgNO ₃ -N/d

TOD balance		
TOD in (influent)		9324.16 kgTOD/d
TOD out		9324.37 kgTOD/d
TOD _{effluent}		443.09 kgTOD/d
TOD _{waste}		2187.61 kgTOD/d
TOD _{N₂ gas}		587.07 kgTOD/d
FO ₁		6106.60 kgTOD/d

Flux of P in waste VSS	FP _s	28 kgP/d
Equiv conc in influent	P _s	2.52 mgP/l
Effluent Sol Unbiol Org P	P _{ouse}	0.60 mgP/l
Effluent TP	P _{te}	12.98 mgP/l
Effluent Ortho-P as P	P _{oe}	12.38 mgOP-P/l

N mass balance		
N in (influent)		535.6 kgTKN-N/d
N out		535.6 kgTKN-N/d
$Q_a N_{te} + Q_w N_{te}$		12.9 kgTKN-N/d
$Q_a N_i$		105.6 kgTKN-N/d
$Q_a N_{re}$		417.1 kgNO ₃ -N/d

TOD balance		
TOD in (influent)		9324.16 kgTOD/d
TOD out		9324.37 kgTOD/d
TOD _{effluent}		441.60 kgTOD/d
TOD _{waste}		2067.23 kgTOD/d
TOD _{N₂ gas}		596.43 kgTOD/d
FO ₁		6219.11 kgTOD/d

Flux of P in waste VSS	FP _s	26 kgP/d
Equiv conc in influent	P _s	2.38 mgP/l
Effluent Sol Unbiol Org P	P _{ouse}	0.00 mgP/l
Effluent TP	P _{te}	13.12 mgP/l
Effluent Ortho-P as P	P _{oe}	13.12 mgOP-P/l

Effluent Concentrations			General	Special	Unit	Effluent Concentrations			General	Special	Unit
Unbiol Sol COD	S _{use}	36.30	<75	<30	mgCOD	Unbiol Sol COD	S _{use}	36.30	<75	<30	mgCOD/l
Undiol Sol Org N	N _{ouse}	0.90	-	-	mgN/l	Undiol Sol Org N	N _{ouse}	0.90	-	-	mgN/l
FSA-N	N _{ae}	0.29	<6	<2	mgFSA-N	FSA-N	N _{ae}	0.26	<6	<2	mgFSA-N/l
TKN-N	N _{te}	1.19	-	-	mgTKN-N	TKN-N	N _{te}	1.16	-	-	mgTKN-N/l
Nitrate	N _{re}	18.47	<15	<1.5	mgNO ₃ -N	Nitrate	N _{re}	18.77	<15	<1.5	mgNO ₃ -N/l
Undiol Sol Org P	P _{ouse}	0.60	-	-	mgP/l	Undiol Sol Org P	P _{ouse}	0.00	-	-	mgP/l
Ortho P as P	P _{oe}	12.38	<10	<2.5	mgOP-P	Ortho P as P	P _{oe}	13.12	<10	<2.5	mgOP-P/l
TP	P _{te}	12.98	-	-	mgP/l	TP	P _{te}	13.12	-	-	mgP/l

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	11.1 Ml/d
Sludge Age	SRT	30.0 days
Reactor TSS concentration	X _r	4128 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	619	6877
BPO COD	Sbpl	479	5321
UPO COD	Supl	29	319
			0.04654
VFA COD	ISup	Sbsi,a	0.0
FBSD COD		Sbsfi	75
BSO COD		Sbsi	75
USO COD		Susi	36.3
			0.0587
BO COD	ISus	Sbi	554
UO COD		Sul	65
			722
TSS			241
ISS			51.4
VSS			189
UPO VSS			19.4
BPO VSS			170
			1888
TKN		Nti	48.2
Org N		Nol	13.8
FSA		Nai	34.4
BSO		Nobsi	2.90
USO		Nousi	0.90
BPO		Nobpi	8.70
UPO		Noupi	1.30
			14
Total P	Pti	15.50	172
OP	Pal	12.80	142
Org P	Poi	2.70	30
BSO	Pobsi	0.70	8
USO	Pousi	0.60	7
BPO	Pobpi	0.78	9
UPO	Poupi	0.62	7

Constants		
COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _{lv}	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{lv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{lv}	0.2
ISS content of OHO's	f _{lv,ISS}	0.15
Yield coefficient of ANO's	Y _{lv}	0.10 mgVSS/mgFSA
COD per mass fraction of FBSD	f _{lv,fbso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{lv,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{lv,u}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{lv,p}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{lv,c}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{h20}	0.2141 /d
	θ _{h20}	0.45 /d
nitrifiers max spec. growth rate	θ _{h20}	1.123
	θ _{h20}	0.2829 /d
	b _{h20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{h20}	0.0357 /d
	K _{s20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{s20}	0.6288 mgFSA/l

Activated Sludge Masses		
Ordinary Heterotrophic Organisms VSS	MX _{hH}	11194 kgVSS
Endogenous Residue VSS	MX _{hH}	14378 kgVSS
Unbiodegradable Organic VSS	MX _u	6464 kgVSS
Total VSS	MX _v	32036 kgVSS
ISS from influent		17136 kgISS
ISS of OHO's		1679 kgISS
ISS	MX _{ci}	18816 kgISS
TSS	MX _t	50852 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{h20}	26.6 hr

Activated Sludge Concentrations		
Ordinary Heterotrophic Organisms VSS	X _{hH}	909 mgVSS/l
Endogenous Residue VSS	X _{hH}	1167 mgVSS/l
Unbiodegradable Organic VSS	X _i	525 mgVSS/l
Total VSS	X _v	2600 mgVSS/l
Influent Biodegradable ISS	X _{ci}	1527 mgISS/l
TSS	X _t	4128 mgTSS/l

Active fraction of VSS	f _{av}	0.349 kgVSS/kgVSS
Active fraction of TSS	f _{at}	0.220 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.630 kgVSS/kgTSS

Waste Flow Rate	Q _w	411 m ³ /d
TSS wasted per day		1695 kgTSS/d
VSS wasted per day		1068 kgVSS/d

Flux of N in waste VSS	FN _w	107 kgN/d
Equiv conc in influent	N _i	9.61 mgN/l influent
Effluent Sol Unbioid Org N	N _{u,ss}	0.90 mgN/l

Factor of safety reducing μ _{max}	Sf	1.25
total un aerated mass fraction	f _{st}	0.148
Minimum sludge age for nitrification	SRT _m	4.87 days
SRT _m with Safety factor	SRT _{m(SF)}	6.09 Nitrifles!

If no nitrification		
Effluent NO ₃	N _{ss}	0 mgNO ₃ -N/l
Effluent TKN-N	N _{ss}	38.6 mgTKN-N/l
Effluent FSA-N	N _{ss} = N _{ss}	37.7 mgFSA-N/l

If complete nitrification		
Effluent NO ₃	N _{ss}	37.7 mgNO ₃ -N/l
Effluent TKN-N	N _{ss}	0.9 mgTKN-N/l
Effluent FSA-N	N _{ss}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	N _{ss} = N _i	37.44 mgNO ₃ -N/l
Effluent TKN-N	N _{ss}	1.15 mgTKN-N/l
(calculated N _{ss})	(N _{ss})	0.252 mgFSA-N/l
Effluent FSA-N	N _{ss}	0.252 mgFSA-N/l
Nitrifier sludge mass	MX _{ss}	602.7 kgVSS

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	11.1 Ml/d
Sludge Age	SRT	30.0 days
Reactor TSS concentration	XT	3971 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	618.9	6877
BPO COD	Sbpl	479	5321
UPO COD	Supl	29	319
			0.04637
VFA COD	ISup	Sbsi,a	0
FBSD COD		Sbsfi	75
BSO COD		Sbsi	75
USO COD		Susi	36.3
			0.05865
BO COD	ISus	Sbi	554
UO COD		Sul	65
			722
TSS			240.7272727
ISS			51.4
VSS			189.3181818
UPO VSS			19.39
BPO VSS			170
			1888
TKN		Nti	48.2
Org N		Nol	13.8
FSA		Nai	34.4
BSO		Nobsi	2.90
USO		Nousi	0.90
BPO		Nobpi	8.70
UPO		Noupi	1.30
			14
Total P	Pti	15.5	172
OP	Pal	12.8	142
Org P	Poi	2.7	30.0
BSO	Pobsi	0.7	7.8
USO	Pousi	0.78	9
BPO	Pobpi	0.78	9
UPO	Poupi	0.62	6.89

Constants		
COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _{lv}	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{lv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{lv}	0.2
ISS content of OHO's	f _{lv,ISS}	0.15
Yield coefficient of ANO's	Y _{lv}	0.1 mgVSS/mgFSA
COD per mass fraction of FBSD	f _{lv,fbso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{lv,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{lv,u}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{lv,p}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{lv,c}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{h20}	0.2691 /d
	θ _{h20}	0.45 /d
nitrifiers max spec. growth rate	θ _{h20}	1.123
	θ _{h20}	0.7157 /d
	b _{h20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{h20}	0.0448 /d
	K _{s20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{s20}	1.5904 mgFSA/l

Activated Sludge Masses		
Ordinary Heterotrophic Organisms VSS	MX _{hH}	9158 kgVSS
Endogenous Residue VSS	MX _{hH}	14785 kgVSS
Unbiodegradable Organic VSS	MX _u	6464 kgVSS
Total VSS	MX _v	30407 kgVSS
ISS from influent		17136 kgISS
ISS of OHO's		1374 kgISS
ISS	MX _{ci}	18510 kgISS
TSS	MX _t	48918 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{h20}	26.6 hr

Activated Sludge Concentrations		
Ordinary Heterotrophic Organisms VSS	X _{hH}	743 mgVSS/l
Endogenous Residue VSS	X _{hH}	1200 mgVSS/l
Unbiodegradable Organic VSS	X _i	525 mgVSS/l
Total VSS	X _v	2468 mgVSS/l
Influent Biodegradable ISS	X _{ci}	1502 mgISS/l
TSS	X _t	3971 mgTSS/l

Active fraction of VSS	f _{av}	0.301 kgVSS/kgVSS
Active fraction of TSS	f _{at}	0.187 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.622 kgVSS/kgTSS

Waste Flow Rate	Q _w	411 m ³ /d
TSS wasted per day		1631 kgTSS/d
VSS wasted per day		1014 kgVSS/d

Flux of N in waste VSS	FN _w	101 kgN/d
Equiv conc in influent	N _i	9.12 mgN/l influent
Effluent Sol Unbioid Org N	N _{u,ss}	0.90 mgN/l

Factor of safety reducing μ _{max}	Sf	1.25
total un aerated mass fraction	f _{st}	0.148
Minimum sludge age for nitrification	SRT _m	1.77 days
SRT _m with Safety factor	SRT _{m(SF)}	2.21 Nitrifles!

If no nitrification		
Effluent NO ₃	N _{ss}	0 mgNO ₃ -N/l
Effluent TKN-N	N _{ss}	39.1 mgTKN-N/l
Effluent FSA-N	N _{ss} = N _{ss}	38.2 mgFSA-N/l

If complete nitrification		
Effluent NO ₃	N _{ss}	38.2 mgNO ₃ -N/l
Effluent TKN-N	N _{ss}	0.9 mgTKN-N/l
Effluent FSA-N	N _{ss}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	N _{ss} = N _i	37.94 mgNO ₃ -N/l
Effluent TKN-N	N _{ss}	1.13 mgTKN-N/l
(calculated N _{ss})	(N _{ss})	0.234 mgFSA-N/l
Effluent FSA-N	N _{ss}	0.234 mgFSA-N/l
Nitrifier sludge mass	MX _{ss}	539.3 kgVSS

MLE Reactor @ 30 Days SRT

	$K_{d(20)}$	0.72 mgFSA/l
Denitrification	θ	1.2
Half Saturation Coefficient	K_{11}	0.3472 mgFSA/l
	$K_{d(20)}$	0.101 mgFSA/l
Denitrification	θ	1.08
Half Saturation Coefficient	K_{12}	0.0742 mgFSA/l

	$K_{d(20)}$	0.72 mgFSA/l
Denitrification	θ	1.2
Half Saturation Coefficient	K_{11}	1.4930 mgFSA/l
	$K_{d(20)}$	0.101 mgFSA/l
Denitrification	θ	1.08
Half Saturation Coefficient	K_{12}	0.1374 mgFSA/l

MLE Reactor @ 30 Days SRT

s-recycle ratio	s	1.00	:1
s-recycle DO concentration	O ₂	1.0	mgO ₂ /l
a-recycle DO concentration	O ₂	2.0	mgO ₂ /l
Max unaerated sludge mass fraction	f _{sm}	0.695	
Anoxic sludge mass fraction	f _{ai}	0.148	set = f _{sm} for balanced MLE
Min anoxic sludge mass fraction	f _{smn}	0.025	
Influent RBCOD fraction (Sbsl/Sbi)	f _{Sbsl}	0.135	
Dentrification potential BSO (K1)	D _{BSO}	8.75	mgNO ₂ -N/l influent
Dentrification potential BPO (K2)	D _{BPO}	11.10	mgNO ₂ -N/l influent
Dentr potential primary anoxic tank	D _{ai}	19.84	mgNO ₂ -N/l influent
A	A	0.6993	
B	B	19.3403	
C	C	1.553	
Optimal a-recycle ratio	a _{opt}	0.08	
Maximum practical a-recycle ratio	a _{max}	6	
chosen a-recycle ratio	a	0.00	set = a _{opt} for balanced MLE
recycle limited			
Effluent Nitrate if recycle limited		18.72	mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		17.94	mgNO ₂ -N/l
Actual Effluent Nitrate	N _{ae}	18.72	mgNO ₂ -N/l
Effluent total N (TKN + NO ₂)	N _{ae} + N _{ae}	19.87	mgN/l
N removal		58.8%	
Volume of Primary Anoxic Tank	V _{max}	1828	m ³
Volume of Aerobic Tank	V _{ae}	10492	m ³
Carbonaceous Oxygen flux	FO _c	4892	kgO ₂ /d
Nitrogenous Oxygen flux	FO _n	1901	kgO ₂ /d
Oxygen dmnd recover by denitrification	FO _b	595	kgO ₂ /d
Total Oxygen Demand (FO _c + FO _n - FO _b)	FO _t	6198	kgO ₂ /d
Oxygen utilisation rate	O ₂	24.6	mgO ₂ /l.h
Alkalinity consumed by nitrification		267	mg CaCO ₃
Alkalinity recovered by denitrification		67	mg CaCO ₃
Total Alkalinity consumption		200	mg CaCO ₃
COD mass balance			
COD in (influent)		6876.7	kgCOD/d
COD out		6876.9	kgCOD/d
Q _a S _{ae} + Q _s S _{ae}		403.3	kgCOD/d
Q _a X _f f _{ae}		1581.5	kgCOD/d
V _a O ₂		4892.0	kgO ₂ /d
N mass balance			
N in (influent)		535.6	kgTKN-N/d
N out		535.6	kgTKN-N/d
Q _a N _{ae} + Q _s N _{ae}		12.8	kgTKN-N/d
Q _a N _{ae}		106.8	kgTKN-N/d
Q _a N _{ae}		416.0	kgNO3-N/d
TOD balance			
TOD in (influent)		9324.16	kgTOD/d
TOD out		9324.37	kgTOD/d
TOD _{influent}		444.78	kgTOD/d
TOD _{max}		2086.63	kgTOD/d
TOD _{net-gas}		594.83	kgTOD/d
FO _c		6198.14	kgTOD/d
Flux of P in waste VSS	FP _v	27	kgP/d
Equiv conc in influent	P _i	2.40	mgP/l
Effluent Sol Unbiol Org P	P _{unbiol}	0.60	mgP/l
Effluent TP	P _{ae}	13.10	mgP/l
Effluent Ortho-P as P	P _{ae}	12.50	mgOP-P/l

s-recycle ratio	s	1.0	:1
s-recycle DO concentration	O ₂	1.0	mgO ₂ /l
a-recycle DO concentration	O ₂	2.0	mgO ₂ /l
Max unaerated sludge mass fraction	f _{sm}	0.863	
Anoxic sludge mass fraction	f _{ai}	0.148	
Min anoxic sludge mass fraction	f _{smn}	0.007	
Influent RBCOD fraction (Sbsl/Sbi)	f _{Sbsl}	0.135	
Dentrification potential BSO (K1)	D _{BSO}	8.75	mgNO ₂ -N/l influent
Dentrification potential BPO (K2)	D _{BPO}	16.80	mgNO ₂ -N/l influent
Dentr potential primary anoxic tank	D _{ai}	25.55	mgNO ₂ -N/l influent
A	A	0.6993	
B	B	14.1403	
C	C	12.460	
Optimal a-recycle ratio	a _{opt}	0.85	
Maximum practical a-recycle ratio	a _{max}	6	
chosen a-recycle ratio	a	0.00	
recycle limited			
Effluent Nitrate if recycle limited		18.97	mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		12.74	mgNO ₂ -N/l
Actual Effluent Nitrate	N _{ae}	18.97	mgNO ₂ -N/l
Effluent total N (TKN + NO ₂)	N _{ae} + N _{ae}	20.11	mgN/l
N removal		58.3%	
Volume of Primary Anoxic Tank	V _{max}	1828	m ³
Volume of Aerobic Tank	V _{ae}	10492	m ³
Carbonaceous Oxygen flux	FO _c	4972	kgO ₂ /d
Nitrogenous Oxygen flux	FO _n	1927	kgO ₂ /d
Oxygen dmnd recover by denitrification	FO _b	603	kgO ₂ /d
Total Oxygen Demand (FO _c + FO _n - FO _b)	FO _t	6296	kgO ₂ /d
Oxygen utilisation rate	O ₂	25.0	mgO ₂ /l.h
Alkalinity consumed by nitrification		271	mg CaCO ₃
Alkalinity recovered by denitrification		68	mg CaCO ₃
Total Alkalinity consumption		203	mg CaCO ₃
COD mass balance			
COD in (influent)		6876.7	kgCOD/d
COD out		6876.9	kgCOD/d
Q _a S _{ae} + Q _s S _{ae}		403.3	kgCOD/d
Q _a X _f f _{ae}		1501.1	kgCOD/d
V _a O ₂		4972.4	kgO ₂ /d
N mass balance			
N in (influent)		535.6	kgTKN-N/d
N out		535.6	kgTKN-N/d
Q _a N _{ae} + Q _s N _{ae}		12.6	kgTKN-N/d
Q _a N _{ae}		101.4	kgTKN-N/d
Q _a N _{ae}		421.6	kgNO3-N/d
TOD balance			
TOD in (influent)		9324.16	kgTOD/d
TOD out		9324.37	kgTOD/d
TOD _{influent}		443.88	kgTOD/d
TOD _{max}		1981.36	kgTOD/d
TOD _{net-gas}		602.88	kgTOD/d
FO _c		6296.25	kgTOD/d
Flux of P in waste VSS	FP _v	25	kgP/d
Equiv conc in influent	P _i	2.28	mgP/l
Effluent Sol Unbiol Org P	P _{unbiol}	0.00	mgP/l
Effluent TP	P _{ae}	13.22	mgP/l
Effluent Ortho-P as P	P _{ae}	13.22	mgOP-P/l

Effluent Concentrations		General	Special	Unit	Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S _{unbiol}	36.30	<75	mgCOD/l	Unbiol Sol COD	S _{unbiol}	36.30	<30	mgCOD/l
Unbiol Sol Org N	N _{unbiol}	0.90	-	mgN/l	Unbiol Sol Org N	N _{unbiol}	0.90	-	mgN/l
PSA-N	N _{psa}	0.23	<6	mgPSA-N/l	PSA-N	N _{psa}	0.23	<2	mgPSA-N/l
TKN-N	N _{tkn}	1.15	-	mgTKN-N/l	TKN-N	N _{tkn}	1.13	-	mgTKN-N/l
Nitrate	N _{nit}	18.72	<15	mgNO ₂ -N/l	Nitrate	N _{nit}	18.97	<15	mgNO ₂ -N/l
Unbiol Sol Org P	P _{unbiol}	0.60	-	mgP/l	Unbiol Sol Org P	P _{unbiol}	0.00	-	mgP/l
Ortho P as P	P _{ae}	12.50	<10	mgOP-P/l	Ortho P as P	P _{ae}	13.22	<10	mgOP-P/l
TP	P _{ae}	13.10	-	mgP/l	TP	P _{ae}	13.22	-	mgP/l

UCT Reactor @ 10 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	13.89 M/d
Sludge Age	SRT	10.0 days
Reactor TSS concentration	X _r	2615.97 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sli	615	8596
BPO COD	Sbpl	479	6651
UPO COD	Supl	29	399
VFA COD	fs'up	0.0	0.046
FBSD COD	Sbsla	75	0
BSO COD	Sbsl	75	1042
USO COD	Susl	36.3	504
BO COD	fs'us	554	0.059
UO COD	Sul	65	7693
TSS		241	3343
SS		51.4	714
VSS		189	2629
UPO VSS		19.4	269
BPO VSS		170	2360
TKN	Nli	48.2	669
Org N	Nol	13.6	192
FSA	Nal	34.4	478
BSO	Nobsi	2.90	40
USO	Nousi	0.90	13
BPO	Nobpi	8.70	121
UPO	Noupi	1.30	18
Total P	Pl	15.50	215
OP	Pal	12.80	178
Org P	Poi	2.70	38
BSO	Pobsi	0.70	10
USO	Pousi	0.60	8
BPO	Pobpi	0.78	11
UPO	Poupi	0.62	9

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _{eh}	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{nv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{ed}	0.2
SS content of OHO's	f _{cohd}	0.15
Yield coefficient of ANO's	Y _a	0.10 mgVSS/mgFSA
COD per mass fraction of FBSD	f _{cofbso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cofuso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,upo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,upo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,upo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
Endogenous respiration rate heterotrophs	b _{h20}	0.24 /d
	θ	1.029
	b _{hT}	0.2141 /d
nitrifiers max spec. growth rate	μ _{am20}	0.45 /d
	θ	1.123
	μ _{amT}	0.2829 /d
Endogenous respiration rate autotrophs	b _{a20}	0.0400 /d
	θ	1.029
	b _{aT}	0.0357 /d
Nitrification	K _{s20}	1.0 mgFSA/l
Half Saturation Coefficient	K _{sT}	1.123
	θ	0.6288 mgFSA/l
Denitrification	K _{ap20}	0.72
Half Saturation Coefficient	θ	1.2
	K _{sT}	0.3472
Denitrification	K _{ap20}	0.101
Half Saturation Coefficient	θ	1.08
for ND system	K _{sT}	0.0742
Denitrification	K ⁻ _{ap20}	0.255
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K ⁻ _{sT}	0.1874

Factor of safety reducing μ _{amT}	Sf	1.25
total un aerated mass fraction	f _{ut}	0.351
Minimum sludge age for nitrification	SRT _m	6.76 days
SRT _m (with safety factor)	SRT _m	8.45 Nitrifies!

Max un aerated sludge mass fraction	f _{un}	0.40
Total un aerated sludge mass fraction	f _u	0.35
Anoxic mass fraction primary anox 2	f _{aprim anox 2}	0.27
Anaerobic mass fraction	f _{anaer}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments		3
r-recycle ratio	r	1.0 : 1
r-recycle NO ₂ concentration	N _{or}	3.9 mgNO ₂ -N/l
r-recycle O ₂ concentration	S _{OD,2}	0.0 mgO ₂ /l

influent NO ₂ concentration	S _{NO2a}	0.0 mgNO ₂ -N/l
influent O ₂ concentration	O _i	0.0 mgO ₂ /l

s-recycle ratio	s	1.000 : 1
s-recycle DO concentration	O _s	1.0 mgO ₂ /l

a-recycle DO concentration	O _a	2.0 mgO ₂ /l

Influent RBCOD fraction (Sbsi/Sbi)	f _{sbi,1}	0.135

influent TKN	N _{li}	48.2 mgTKN-N/l
Flux of N in waste VSS	FN _{li}	191 kgN/d
Equiv conc in influent	N _{li}	13.72 mgN/l
Effluent Sol Unbiol Org N	N _{unb}	0.90 mgN/l
Effluent ammonia	N _{am}	1.78 mgFSA-N/l
TKN in effluent	N _{de}	2.68 mgTKN-N/l
Nitrification capacity	N _{li}	31.79 mgN/l influent

Denitrification potential BSO (K1)	D _{hBDO}	1.5 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D _{hBPO}	38.11 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D _{h1}	39.57 mgNO ₂ -N/l influent

Optimal a-recycle ratio	A	0.6993
Maximum practical a-recycle ratio	B	-6.0320
chosen a-recycle ratio	C	46.654
	a _{opt}	13.55
	a _{max}	6
	a	6.05 set = a _{opt} for balanced UCT
	recycle limited	

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	13.89 M/d
Sludge Age	SRT	10.0 days
Reactor TSS concentration	X _r	2474 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sli	619	8596
BPO COD	Sbpl	479	6651
UPO COD	Supl	29	399
VFA COD	fs'up	0	0.046
FBSD COD	Sbsla	75	0
BSO COD	Sbsl	75	1042
USO COD	Susl	36	504
BO COD	fs'us	554	0.059
UO COD	Sul	65	7693
TSS		241	3343
SS		51	714
VSS		189	2629
UPO VSS		19	269
BPO VSS		170	2360
TKN	Nli	48	669
Org N	Nol	14	192
FSA	Nal	34	478
BSO	Nobsi	2.90	40
USO	Nousi	0.90	13
BPO	Nobpi	8.70	121
UPO	Noupi	1.30	18
Total P	Pl	15.50	215
OP	Pal	12.80	178
Org P	Poi	2.70	38
BSO	Pobsi	0.70	10
USO	Pousi	0.60	8
BPO	Pobpi	0.78	11
UPO	Poupi	0.62	9

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _{eh}	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{nv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{ed}	0.2
SS content of OHO's	f _{cohd}	0.15
Yield coefficient of ANO's	Y _a	0.1 mgVSS/mgFSA
COD per mass fraction of FBSD	f _{cofbso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cofuso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,upo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,upo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,upo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
Endogenous respiration rate heterotrophs	b _{h20}	0.24 /d
	θ	1.029
	b _{hT}	0.2691 /d
nitrifiers max spec. growth rate	μ _{am20}	0.45 /d
	θ	1.123
	μ _{amT}	0.7157 /d
Endogenous respiration rate autotrophs	b _{a20}	0.0400 /d
	θ	1.029
	b _{aT}	0.0448 /d
Nitrification	K _{s20}	1.0
Half Saturation Coefficient	K _{sT}	1.123
	θ	1.5904
Denitrification	K _{ap20}	0.72
Half Saturation Coefficient	θ	1.2
	K _{sT}	1.4930
Denitrification	K _{ap20}	0.101
Half Saturation Coefficient	θ	1.08
for ND system	K _{sT}	0.1374
Denitrification	K ⁻ _{ap20}	0.255
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K ⁻ _{sT}	0.3469

Factor of safety reducing μ _{amT}	Sf	1.25
total un aerated mass fraction	f _{ut}	0.351
Minimum sludge age for nitrification	SRT _m	2.38 days
SRT _m (with safety factor)	SRT _m	2.98 Nitrifies!

Max un aerated sludge mass fraction	f _{un}	0.75
Total un aerated sludge mass fraction	f _u	0.35
Anoxic mass fraction primary anox 2	f _{aprim anox 2}	0.27
Anaerobic mass fraction	f _{anaer}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments		2
r-recycle ratio	r	1.0 : 1
r-recycle NO ₂ concentration	N _{or}	3.9 mgNO ₂ -N/l
r-recycle O ₂ concentration	S _{OD,2}	0.0 mgO ₂ /l

influent NO ₂ concentration	S _{NO2a}	0.0 mgNO ₂ -N/l
influent O ₂ concentration	O _i	0.0 mgO ₂ /l

s-recycle ratio	s	1.0 : 1
s-recycle DO concentration	O _s	1.0 mgO ₂ /l

a-recycle DO concentration	O _a	2.0 mgO ₂ /l

Influent RBCOD fraction (Sbsi/Sbi)	f _{sbi,1}	0.135

influent TKN	N _{li}	48.2 mgTKN-N/l
Flux of N in waste VSS	FN _{li}	178 kgN/d
Equiv conc in influent	N _{li}	13.79 mgN/l
Effluent Sol Unbiol Org N	N _{unb}	0.90 mgN/l
Effluent ammonia	N _{am}	0.72 mgFSA-N/l
TKN in effluent	N _{de}	1.62 mgTKN-N/l
Nitrification capacity	N _{li}	33.78 mgN/l influent

Denitrification potential BSO (K1)	D _{hBDO}	1.4 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D _{hBPO}	59.94 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D _{h1}	61.32 mgNO ₂ -N/l influent

Optimal a-recycle ratio	A	0.6993
Maximum practical a-recycle ratio	B	-25.7836
chosen a-recycle ratio	C	88.149
	a _{opt}	40.02
	a _{max}	6
	a	6.00
	recycle limited	

UCT Reactor @ 10 Days SRT

Effluent Nitrate if recycle limited	3.97 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited	-3.23 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{out} 3.97 mgNO ₃ -N/l influent
Effluent total N (TKN + NO ₃)	N _{out} + N _{ox} 6.66 mgN/l
N removal	86.2%
Alkalinity consumed by nitrification	227 mg CaCO ₃
Alkalinity recovered by denitrification	99 mg CaCO ₃
Total Alkalinity consumption	128 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	S _{bio,a}	0 mgCOD/l
FBSO COD	S _{bio}	75 mgCOD/l
BSO COD	S _{bio}	75 mgCOD/l
BO COD	S _{bio}	554 mgCOD/l

S ₂ reduction due to O ₂ & NO ₃	33.54 mgCOD/l
Reduced FBSO concentration	S _{F,100%} 41.46 mgCOD/l

	k _{r,120}	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	k _{r,T}	0.0535 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	S _{bioH}	MX _{bioH} /Q _L	S _{bioH}	
Trial 1	0.00	734	6.42	
Trial 2	6.42	753	6.28	
Trial 3	6.28	752	6.29	
Trial 4	6.29	752	6.29	

Flux BO COD obtained by OHO's	95%	7292 kgCOD/d
Flux BO COD obtained by PAO's	5%	401 kgCOD/d
Check total BO COD		7693 kgCOD/d

Yield coefficient of PAO's	Y _G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y _{Gv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _G	0.25
ISS content of PAO's	f _{ISS}	0.15

	b _{0,20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b _{0,T}	0.0357 /d

Activated Sludge Masses

OHO VSS		
Ordinary Heterotrophic Organisms VSS	MX _{OHO}	10448 kgVSS
Endogenous Residue VSS OHO	MX _{e,OHO}	4473 kgVSS

PAO VSS		
Polyphosphate Acc Organisms VSS	MX _{PAO}	1331 kgVSS
Endogenous Residue VSS PAO	MX _{e,PAO}	119 kgVSS

Unbiodegradable Organic VSS	MX _u	2691 kgVSS
Total VSS	MX _T	19062 kgVSS

ISS from influent		7140 kgISS
ISS of OHO's		1567 kgISS
ISS of PAO's		1752 kgISS
ISS	MX _{ISS}	10459 kgISS
TSS	MX _T	29521 kgTSS
VSS/TSS ratio		0.646 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	f _{P0,PAO}	0.355 mgP/mgPAOVSS
		0.380 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	ΔP _{PAO,2}	3.40 mgP/l
biomass P-content	ΔP _{OHO}	3.43 mgP/l
Potential P-removal		6.83 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	f _{P0,PAO}	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	ΔP _{PAO,2}	3.40 mgP/l
biomass P-content	ΔP _{OHO}	3.43 mgP/l
Total Actual P-removal		6.83 mgP/l

TP effluent

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO _{OHO}	5082 kgO/d
Carbonaceous Oxygen flux PAO's	FO _{PAO}	187 kgO/d
Carbonaceous Oxygen flux	FO _c	5269 kgO/d
Nitrogenous Oxygen flux	FO _N	2018 kgO/d
Oxygen dmdnd recover by denitrification	FO _D	1105 kgO/d
Total Oxygen Demand (FO _c + FO _N - FO _D)	FO _T	6182 kgO/d
Oxygen utilisation rate	O _T	35.2 mgO/l.h

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Check	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	2394	7979	19149	29521
Concentration TSS (kgTSS/m ³)	1.31	2.62	2.62	2.420
Volume (m ³)	1830	3050	7320	12200
Volume fraction	15%	25%	60%	100%
Concentration VSS (kgVSS/m ³)	0.84	1.69	1.69	1.56
UPO VSS Concentration (kgUPOVSS/m ³)	0.119	0.239	0.239	0.221

Mass TSS wasted per day 2952.1 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 1128.5 m³/d

Effluent Nitrate if recycle limited	4.22 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited	-22.99 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{out} 4.22 mgNO ₃ -N/l influent

Effluent total N (TKN + NO ₃)	N _{out} + N _{ox} 5.84 mgN/l
N removal	87.9%

Alkalinity consumed by nitrification	241 mg CaCO ₃
Alkalinity recovered by denitrification	106 mg CaCO ₃
Total Alkalinity consumption	136 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	S _{bio,a}	0 mgCOD/l
FBSO COD	S _{bio}	75 mgCOD/l
BSO COD	S _{bio}	75 mgCOD/l
BO COD	S _{bio}	554 mgCOD/l

S ₂ reduction due to O ₂ & NO ₃	33.54 mgCOD/l
Reduced FBSO concentration	S _{F,100%} 41.46 mgCOD/l

	k _{r,120}	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	k _{r,T}	0.0673 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	S _{bioH}	MX _{bioH} /Q _L	S _{bioH}	
Trial 1	0.00	625	6.04	
Trial 2	6.04	640	5.92	
Trial 3	5.92	639	5.92	
Trial 4	5.92	639	5.92	

Flux BO COD obtained by OHO's	95%	7282 kgCOD/d
Flux BO COD obtained by PAO's	5%	411 kgCOD/d
Check total BO COD		7693 kgCOD/d

Yield coefficient of PAO's	Y _G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y _{Gv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _G	0.25
ISS content of PAO's	f _{ISS}	0.15

	b _{0,20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b _{0,T}	0.0448 /d

Activated Sludge Masses

OHO VSS		
Ordinary Heterotrophic Organisms VSS	MX _{OHO}	8878 kgVSS
Endogenous Residue VSS OHO	MX _{e,OHO}	4778 kgVSS

PAO VSS		
Polyphosphate Acc Organisms VSS	MX _{PAO}	1278 kgVSS
Endogenous Residue VSS PAO	MX _{e,PAO}	143 kgVSS

Unbiodegradable Organic VSS	MX _u	2691 kgVSS
Total VSS	MX _T	17769 kgVSS

ISS from influent		7140 kgISS
ISS of OHO's		1332 kgISS
ISS of PAO's		1683 kgISS
ISS	MX _{ISS}	10155 kgISS
TSS	MX _T	27924 kgTSS
VSS/TSS ratio		0.636 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	f _{P0,PAO}	0.355 mgP/mgPAOVSS
		0.38 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	ΔP _{PAO,2}	3.27 mgP/l
biomass P-content	ΔP _{OHO}	3.20 mgP/l
Potential P-removal		6.47 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	f _{P0,PAO}	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	ΔP _{PAO,2}	3.27 mgP/l
biomass P-content	ΔP _{OHO}	3.20 mgP/l
Total Actual P-removal		6.47 mgP/l

TP effluent

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO _{OHO}	5259 kgO/d
Carbonaceous Oxygen flux PAO's	FO _{PAO}	201 kgO/d
Carbonaceous Oxygen flux	FO _c	5460 kgO/d
Nitrogenous Oxygen flux	FO _N	2144 kgO/d
Oxygen dmdnd recover by denitrification	FO _D	1174 kgO/d
Total Oxygen Demand (FO _c + FO _N - FO _D)	FO _T	6430 kgO/d
Oxygen utilisation rate	O _T	36.6 mgO/l.h

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	2264	7547	18113	27924
Concentration TSS (kgTSS/m ³)	1.24	2.47	2.47	2.289
Volume (m ³)	1830	3050	7320	12200
Concentration VSS (kgVSS/m ³)	0.79	1.57	1.57	1.46
UPO VSS Concentration (kgUPOVSS/m ³)	0.119	0.239	0.239	0.221

Mass TSS wasted per day 2792.4 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 1128.5 m³/d

COD mass balance	
COD in (influent)	8596 kgCOD/d
COD out	8596 kgCOD/d
$Q_i S_{io} + Q_o S_{oe}$	504 kgCOD/d
$Q_o X_{f,ox}$ or $f_{ox} MX_o/Rs$	2823 kgCOD/d
FO_2	5269 kgO/d

N Mass balance	
TKN in (influent)	669 kgN/d
TKN out	669 kgN/d
N_{no}	85 kgN/d
N_{waste}	198 kgN/d
$N_{denitrified}$	386 kgN/d

TOD balance	
TOD in (influent)	11655 kgTOD/d
TOD out	11655 kgTOD/d
$TOD_{effluent}$	620 kgTOD/d
TOD_{waste}	3749 kgTOD/d
$TOD_{n2, gas}$	1105 kgTOD/d
FO_2	6181.54 kgTOD/d

Effluent Concentrations		General		Special	Unit
Unbioid Sol COD	S_{uox}	36.30	75	30	mgCOD/l
Unbioid Sol Org N	N_{uoxe}	0.90	-	-	mgN/l
FSA-N	N_{fsa}	1.78	6	2	mgFSA-N/l
TKN-N	N_{tkn}	2.68	-	-	mgTKN-N/l
Nitrate	N_{nit}	3.97	15	1.5	mgNO ₃ -N/l
Unbioid Sol Org P	P_{uoxe}	0.60	-	-	mgP/l
Ortho P as P	P_{ox}	8.67	10	2.5	mgP/l
TP	P_{tp}	9.27	-	-	mgP/l

COD mass balance	
COD in (influent)	8595.8 kgCOD/d
COD out	8595.8 kgCOD/d
$Q_i S_{io} + Q_o S_{oe}$	504.2 kgCOD/d
$Q_o X_{f,ox}$ or $f_{ox} MX_o/Rs$	2631.6 kgCOD/d
FO_2	5460.1 kgO/d

N Mass balance	
TKN in (influent)	669.44 kgN/d
TKN out	669.44 kgN/d
N_{no}	74.58 kgN/d
N_{waste}	184.3 kgN/d
$N_{denitrified}$	410.6 kgN/d

TOD balance	
TOD in (influent)	11655.19 kgTOD/d
TOD out	11655.19 kgTOD/d
$TOD_{effluent}$	557.75 kgTOD/d
TOD_{waste}	3492.98 kgTOD/d
$TOD_{n2, gas}$	1174.26 kgTOD/d
FO_2	6430.21 kgTOD/d

Effluent Concentrations		General		Special	Unit
Unbioid Sol COD	S_{uox}	36.30	75	30	mgCOD/l
Unbioid Sol Org N	N_{uoxe}	0.90	-	-	mgN/l
FSA-N	N_{fsa}	0.72	6	2	mgFSA-N/l
TKN-N	N_{tkn}	1.62	-	-	mgTKN-N/l
Nitrate	N_{nit}	4.22	15	1.5	mgNO ₃ -N/l
Unbioid Sol Org P	P_{uoxe}	0.60	-	-	mgP/l
Ortho P as P	P_{ox}	9.03	10	2.5	mgP/l
TP	P_{tp}	9.63	-	-	mgP/l

UCT Reactor @ 15 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	13.89 Ml/d
Sludge Age	SRT	15.0 days
Reactor TSS concentration	X _r	8537.11 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	S _{ti}	619	8596
BPO COD	S _{bpi}	479	6651
UPO COD	S _{upi}	29	399
	f _{S'up}		0.046
VFA COD	S _{bis,a}	0.0	0
FBSD COD	S _{bifi}	75	1042
BSO COD	S _{bisi}	75	1042
USO COD	S _{usi}	36.3	504
	f _{S'us}		0.059
BO COD	S _{bi}	554	7693
UO COD	S _{ui}	65	903
TSS		241	3343
SS		51.4	714
VSS		189	2629
UPO VSS		19	269
BPO VSS		170	2360
TKN	N _{ti}	48.2	669
Org N	N _{oi}	13.8	192
FSA	N _{ai}	34.4	478
BSO	N _{bosi}	2.90	40
USO	N _{ousi}	0.90	13
BPO	N _{bopi}	8.70	121
UPO	N _{oupi}	1.30	18
Total P	P _{ti}	15.50	215
OP	P _{ai}	12.80	178
Org P	P _{oi}	2.70	38
BSO	P _{bosi}	0.70	10
USO	P _{ousi}	0.60	8
BPO	P _{bopi}	0.78	11
UPO	P _{oupi}	0.62	9

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _{th}	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{tho}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _d	0.2
SS content of OHO's	f _{csso}	0.15
Yield coefficient of ANO's	Y _a	0.10 mgVSS/mgSA
COD per mass fraction of FBSO	f _{co,bsso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{co,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,uvo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,uvo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,uvo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
Endogenous respiration rate heterotrophs	b _{h20}	0.24 /d
	θ	1.029
	b _{h17}	0.2141 /d
	θ _{h20}	0.45 /d
nitrifiers max spec. growth rate	θ	1.123
	θ _{h20}	0.2829 /d
Endogenous respiration rate autotrophs	b _{a20}	0.0400 /d
	θ	1.029
	b _{a17}	0.0357 /d
Nitrification	K _{s20}	1.0 mgSA/l
Half Saturation Coefficient	K _{s17}	0.6288 mgSA/l
Denitrification	K _{d20}	0.72
Half Saturation Coefficient	K _{d17}	0.3472
Denitrification	K _{d20}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{d17}	0.0742
Denitrification	K _{d20}	0.255
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K _{d17}	0.1874

Factor of safety reducing μ _{max}	SF	1.25
total un aerated mass fraction	f _{ut}	0.351
Minimum sludge age for nitrification	SRT _{min}	6.76 days
SRT _{min} (with safety factor)	SRT _{min}	8.45 Nitrifies!

Max un aerated sludge mass fraction	f _{um}	0.55
Total un aerated sludge mass fraction	f _{ut}	0.35
Anoxic mass fraction primary anox 2	f _{primary anox 2}	0.27
Anaerobic mass fraction	f _{anaerob}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments		2
r-recycle ratio	r	1.0 :1
r-recycle NO ₂ concentration	N _{br}	4.3 mgNO ₂ -N/l
r-recycle O ₂ concentration	S _{O2,r}	0.0 mgO ₂ /l

influent NO ₂ concentration	S _{NO2,i}	0.0 mgNO ₂ -N/l
influent DO concentration	O _i	0.0 mgO ₂ /l

r-recycle ratio	r	1.000 :1
r-recycle DO concentration	O _r	2.0 mgO ₂ /l

a-recycle DO concentration	O _a	2.0 mgO ₂ /l

Influent RBCOD fraction (S _{bis} /S _{bi})	f _{bis1}	0.135

Influent TKN	N _{ti}	48.2 mgTKN-N/l
Flux of N in waste VSS	FN _i	168 kgN/d
Equiv conc in influent	N _i	12.10 mgN/l
Effluent Sol Unbiode Org N	N _{u,uvo}	0.90 mgN/l
Effluent ammonia	N _{ue}	0.79 mgSA-SA-N/l
TKN in effluent	N _{te}	1.69 mgTKN-N/l
Nitrification capacity	N _i	34.41 mgN/l influent

Denitrification potential BSO (K1)	D _{bsso}	1.2 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D _{bpo}	42.71 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D _{ai}	43.93 mgNO ₂ -N/l influent

	A	0.6993
	B	-7.7715
	C	52.751
Optimal a-recycle ratio	a _{opt}	15.87
Maximum practical a-recycle ratio	a _{max}	6
chosen a-recycle ratio	a	6.00
	recycle limited set = a _{opt} for balanced UCT	

Effluent Nitrate if recycle limited		4.30 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-4.97 mgNO ₂ -N/l
Actual Effluent Nitrate	N _{ue}	4.30 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₂)	N _{te} + N _{ue}	5.99 mgN/l
N removal		87.6%

Alkalinity consumed by nitrification		246 mg CaCO ₃
Alkalinity recovered by denitrification		107 mg CaCO ₃
Total Alkalinity consumption		138 mg CaCO ₃

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	13.89 Ml/d
Sludge Age	SRT	15.0 days
Reactor TSS concentration	X _r	3354 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	S _{ti}	619	8596
BPO COD	S _{bpi}	479	6651
UPO COD	S _{upi}	29	399
	f _{S'up}		0.046
VFA COD	S _{bis,a}	0	0
FBSD COD	S _{bifi}	75	1042
BSO COD	S _{bisi}	75	1042
USO COD	S _{usi}	36	504
	f _{S'us}		0.059
BO COD	S _{bi}	554	7693
UO COD	S _{ui}	65	903
TSS		241	3343
SS		51	714
VSS		189	2629
UPO VSS		19	269
BPO VSS		170	2360
TKN	N _{ti}	48	669
Org N	N _{oi}	14	192
FSA	N _{ai}	34	478
BSO	N _{bosi}	2.90	40
USO	N _{ousi}	0.90	13
BPO	N _{bopi}	8.70	121
UPO	N _{oupi}	1.30	18
Total P	P _{ti}	15.50	215
OP	P _{ai}	12.80	178
Org P	P _{oi}	2.70	38
BSO	P _{bosi}	0.70	10
USO	P _{ousi}	0.60	8
BPO	P _{bopi}	0.78	11
UPO	P _{oupi}	0.62	9

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _{th}	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{tho}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _d	0.2
SS content of OHO's	f _{csso}	0.15
Yield coefficient of ANO's	Y _a	0.1 mgVSS/mgSA
COD per mass fraction of FBSO	f _{co,bsso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{co,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,uvo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,uvo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,uvo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
Endogenous respiration rate OHO	b _{h20}	0.24 /d
	θ	1.029
	b _{h17}	0.2691 /d
	θ _{h20}	0.45 /d
nitrifiers max spec. growth rate	θ	1.123
	θ _{h20}	0.7157 /d
Endogenous respiration rate autotrophs	b _{a20}	0.0400 /d
	θ	1.029
	b _{a17}	0.0448 /d
Nitrification	K _{s20}	1.0
Half Saturation Coefficient	K _{s17}	1.123
Denitrification	K _{d20}	0.72
Half Saturation Coefficient	K _{d17}	1.4930
Denitrification	K _{d20}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{d17}	0.1374
Denitrification	K _{d20}	0.255
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K _{d17}	0.3469

Factor of safety reducing μ _{max}	SF	1.25
total un aerated mass fraction	f _{ut}	0.351
Minimum sludge age for nitrification	SRT _{min}	2.38 days
SRT _{min} (with safety factor)	SRT _{min}	2.98 Nitrifies!

Max un aerated sludge mass fraction	f _{um}	0.81
Total un aerated sludge mass fraction	f _{ut}	0.35
Anoxic mass fraction primary anox 2	f _{primary anox 2}	0.27
Anaerobic mass fraction	f _{anaerob}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments		2
r-recycle ratio	r	1.0 :1
r-recycle NO ₂ concentration	N _{br}	4.3 mgNO ₂ -N/l
r-recycle O ₂ concentration	S _{O2,r}	0.0 mgO ₂ /l

influent NO ₂ concentration	S _{NO2,i}	0.0 mgNO ₂ -N/l
influent DO concentration	O _i	0.0 mgO ₂ /l

r-recycle ratio	r	1.0 :1
r-recycle DO concentration	O _r	1.0 mgO ₂ /l

a-recycle DO concentration	O _a	2.0 mgO ₂ /l

Influent RBCOD fraction (S _{bis} /S _{bi})	f _{bis1}	0.135

Influent TKN	N _{ti}	48.2 mgTKN-N/l
Flux of N in waste VSS	FN _i	157 kgN/d
Equiv conc in influent	N _i	11.32 mgN/l
Effluent Sol Unbiode Org N	N _{u,uvo}	0.90 mgN/l
Effluent ammonia	N _{ue}	0.50 mgSA-SA-N/l
TKN in effluent	N _{te}	1.40 mgTKN-N/l
Nitrification capacity	N _i	35.48 mgN/l influent

Denitrification potential BSO (K1)	D _{bsso}	1.2 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D _{bpo}	66.04 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D _{ai}	67.20 mgNO ₂ -N/l influent

	A	0.6993
	B	-29.9740
	C	98.225
Optimal a-recycle ratio	a _{opt}	45.92
Maximum practical a-recycle ratio	a _{max}	6
chosen a-recycle ratio	a	6.00
	recycle limited	

Effluent Nitrate if recycle limited		4.44 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-27.18 mgNO ₂ -N/l
Actual Effluent Nitrate	N _{ue}	4.44 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₂)	N _{te} + N _{ue}	5.84 mgN/l
N removal		87.9%

Alkalinity consumed by nitrification		253 mg CaCO ₃
Alkalinity recovered by denitrification		111 mg CaCO ₃
Total Alkalinity consumption		142 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	S_{COD}	0 mgCOD/l
FBSO COD	S_{FBSO}	75 mgCOD/l
BSO COD	S_{BSO}	75 mgCOD/l
BO COD	S_{BO}	554 mgCOD/l

S_{O_2} reduction due to O_2 & NO_3	36.55 mgCOD/l
Reduced FBSO concentration	$S_{FBSO,red}$ 38.45 mgCOD/l

$k_{r,T10}$	$\frac{0.06}{0.035}$ m ³ /gVSS.d
θ	1.029
Fermentation rate	$k_{r,T}$ 0.0535 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	S_{DHO}	MX_{DHO}/Q_L	S_{DHO}	
Trial 1	0.00	826	691	5.35
Trial 2	5.35	843	705	5.24
Trial 3	5.24	843	704	5.24
Trial 4	5.24	843	704	5.24

Flux BO COD obtained by OHO's	95%	7305 kgCOD/d
Flux BO COD obtained by PAO's	5%	388 kgCOD/d
Check total BO COD		7693 kgCOD/d

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{Gv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

b_{DHO}	0.04 /d
θ	1.029
Endogenous respiration rate PAO's	b_{D1} 0.0357 /d

Activated Sludge Masses

OHO VSS		
Ordinary Heterotrophic Organisms VSS	MX_{DHO}	11709 kgVSS
Endogenous Residue VSS OHO	MX_{DHO}	7520 kgVSS

PAO VSS		
Polyphosphate Acc. Organisms VSS	MX_{PAO}	1707 kgVSS
Endogenous Residue VSS PAO	MX_{PAO}	228 kgVSS

Unbiodegradable Organic VSS	MX_u	4037 kgVSS
Total VSS	MX_v	25202 kgVSS

ISS from influent		10710 kgISS
ISS of OHO's		1756 kgISS
ISS of PAO's		2248 kgISS
ISS	MX_{D1}	14715 kgISS
TSS	MX_t	39916 kgTSS
VSS/TSS ratio		0.631 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{pp,PAO}$	0.380 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.91 mgP/l
biomass P-content	ΔP_{DHO}	3.02 mgP/l
Potential P-removal		5.93 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{pp,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.91 mgP/l
biomass P-content	ΔP_{DHO}	3.02 mgP/l
Total Actual P-Removal		5.93 mgP/l

TP effluent	P_w	9.57 mgP/l

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{DHO}	5406 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	197 kgO/d
Carbonaceous Oxygen flux	FO_c	5603 kgO/d
Nitrogenous Oxygen flux	FO_n	2184 kgO/d
Oxygen dmdnd recover by denitrification	FO_d	1196 kgO/d
Total Oxygen Demand ($FO_c + FO_n + FO_d$)	FO_t	6592 kgO/d
Oxygen utilisation rate	O_t	37.5 mgO/L/h

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	0.08	0.27	0.65	1.000
Concentration TSS (kgTSS/m ³)	3236	10786	25892	39916
Volume (m ³)	1.77	3.54	3.272	12200
Volume fraction	15%	25%	60%	100%
Concentration VSS (kgVSS/m ³)	1.12	2.23	2.23	2.07
LIPO VSS Concentration (kgLIPOVSS/m ³)	0.179	0.358	0.358	0.331

Mass TSS wasted per day		2661.1 kgTSS/d
Waste Flow Rate (note not V/Rb)	Q_w	752.3 m ³ /d

COD mass balance		
COD in (influent)		8595.8 kgCOD/d
COD out		8595.8 kgCOD/d
$Q_L S_{in} + Q_w S_w$		504.2 kgCOD/d
$Q_L X_{f,ss} + f_{ss} MX_v/R_s$		2488.3 kgCOD/d
FO_d		5603.4 kgO/d

N Mass balance		
TKN in (influent)		669.44 kgN/d
TKN out		669.44 kgN/d
N_u		76.74 kgN/d
N_{waste}		172.5 kgN/d
$N_{denitrified}$		418.2 kgN/d

TOD balance		
TOD in (influent)		11655.19 kgTOD/d
TOD out		11655.19 kgTOD/d
$TOD_{effluent}$		578.47 kgTOD/d
TOD_{waste}		3288.20 kgTOD/d
$TOD_{d,den}$		1196.00 kgTOD/d
FO_d		6591.52 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S_{COD}	36.30	75	mgCOD/l
Unbiol Sol Org N	N_{waste}	0.90	-	mgN/l
PSA-N	N_{PSA}	0.79	6	2 mgPSA-N/l
TKN-N	N_{TKN}	1.69	-	mgTKN-N/l
Nitrate	N_{NO_3}	4.30	15	1.5 mgNO ₃ -N/l
Unbiol Sol Org P	P_{waste}	0.60	-	mgP/l
Ortho P as P	P_{orth}	9.57	10	2.5 mgP/l
TP	P_w	10.17	-	mgP/l

ANAEROBIC REACTOR

VFA COD	S_{COD}	0 mgCOD/l
FBSO COD	S_{FBSO}	75 mgCOD/l
BSO COD	S_{BSO}	75 mgCOD/l
BO COD	S_{BO}	554 mgCOD/l

S_{O_2} reduction due to O_2 & NO_3	36.55 mgCOD/l
Reduced FBSO concentration	$S_{FBSO,red}$ 38.45 mgCOD/l

$k_{r,T10}$	0.06 m ³ /gVSS.d
θ	1.029
Fermentation rate	$k_{r,T}$ 0.0673 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	S_{DHO}	MX_{DHO}/Q_L	S_{DHO}	
Trial 1	0.00	826	691	5.10
Trial 2	5.10	705	705	5.00
Trial 3	5.00	704	704	5.00
Trial 4	5.00	704	704	5.00

Flux BO COD obtained by OHO's	95%	7298 kgCOD/d
Flux BO COD obtained by PAO's	5%	395 kgCOD/d
Check total BO COD		7693 kgCOD/d

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{Gv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

b_{DHO}	0.04 /d
θ	1.029
Endogenous respiration rate PAO's	b_{D1} 0.0448 /d

Activated Sludge Masses

OHO VSS		
Ordinary Heterotrophic Organisms VSS	MX_{DHO}	9782 kgVSS
Endogenous Residue VSS OHO	MX_{DHO}	7896 kgVSS

PAO VSS		
Polyphosphate Acc. Organisms VSS	MX_{PAO}	1594 kgVSS
Endogenous Residue VSS PAO	MX_{PAO}	268 kgVSS

Unbiodegradable Organic VSS	MX_u	4037 kgVSS
Total VSS	MX_v	23577 kgVSS

ISS from influent		10710 kgISS
ISS of OHO's		1467 kgISS
ISS of PAO's		2099 kgISS
ISS	MX_{D1}	14276 kgISS
TSS	MX_t	37854 kgTSS
VSS/TSS ratio		0.623 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{pp,PAO}$	0.355 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.72 mgP/l
biomass P-content	ΔP_{DHO}	2.83 mgP/l
Potential P-removal		5.55 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{pp,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.72 mgP/l
biomass P-content	ΔP_{DHO}	2.83 mgP/l
Total Actual P-removal		5.55 mgP/l

TP effluent	P_w	9.95 mgP/l

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{DHO}	5553 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	211 kgO/d
Carbonaceous Oxygen flux	FO_c	5764 kgO/d
Nitrogenous Oxygen flux	FO_n	2252 kgO/d
Oxygen dmdnd recover by denitrification	FO_d	1233 kgO/d
Total Oxygen Demand ($FO_c + FO_n + FO_d$)	FO_t	6783 kgO/d
Oxygen utilisation rate	O_t	38.6 mgO/L/h

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	3069	10231	24554	37854
Concentration TSS (kgTSS/m ³)	1.68	3.35	3.35	3.103
Volume (m ³)	1830	3050	7320	12200
Concentration VSS (kgVSS/m ³)	1.04	2.09	2.09	1.93
LIPO VSS Concentration (kgLIPOVSS/m ³)	0.179	0.358	0.358	0.331

Mass TSS wasted per day		2523.6 kgTSS/d
Waste Flow Rate (note not V/Rb)	Q_w	752.3 m ³ /d

COD mass balance		
COD in (influent)		8595.8 kgCOD/d
COD out		8595.8 kgCOD/d
$Q_L S_{in} + Q_w S_w$		504.2 kgCOD/d
$Q_L X_{f,ss} + f_{ss} MX_v/R_s$		2327.9 kgCOD/d
FO_d		5763.8 kgO/d

N Mass balance		
TKN in (influent)		669.44 kgN/d
TKN out		669.44 kgN/d
N_u		76.69 kgN/d
N_{waste}		161.6 kgN/d
$N_{denitrified}$		431.2 kgN/d

TOD balance		
TOD in (influent)		11655.19 kgTOD/d
TOD out		11655.19 kgTOD/d
$TOD_{effluent}$		561.07 kgTOD/d
TOD_{waste}		3078.31 kgTOD/d
$TOD_{d,den}$		1233.18 kgTOD/d
FO_d		6782.63 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S_{COD}	36.30	75	mgCOD/l
Unbiol Sol Org N	N_{waste}	0.90	-	mgN/l
PSA-N	N_{PSA}	0.50	6	2 mgPSA-N/l
TKN-N	N_{TKN}	1.40	-	mgTKN-N/l
Nitrate	N_{NO_3}	4.44	15	1.5 mgNO ₃ -N/l
Unbiol Sol Org P	P_{waste}	0.60	-	mgP/l
Ortho P as P	P_{orth}	9.95	10	2.5 mgP/l
TP	P_w	10.55	-	mgP/l

UCT Reactor @ 20 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	13.89 Ml/d
Sludge Age	SRT	20.0 days
Reactor TSS concentration	X _r	4402.26 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	S _{Ti}	8596
BPO COD	S _{bpl}	6651
UPO COD	S _{upi}	399
	f _{S'up}	0.046
VFA COD	S _{Sol,a}	0
FBSO COD	S _{bfl}	75
BSO COD	S _{bsl}	1042
USO COD	S _{usi}	504
	f _{S'us}	0.059
BO COD	S _{bi}	7693
UO COD	S _{ul}	903
TSS		241
SS		51.4
VSS		189
UPO VSS		19.4
BPO VSS		170
TKN	N _{Ti}	48.2
Org N	N _{oi}	13.8
PSA	N _{ai}	34.4
BSO	N _{obsl}	2.90
USO	N _{ousl}	0.90
BPO	N _{obpl}	8.70
UPO	N _{oupl}	1.30
Total P	P _{Ti}	15.50
OP	P _{ai}	12.80
Org P	P _{oi}	2.70
BSO	P _{obsl}	0.70
USO	P _{ousl}	0.60
BPO	P _{obpl}	0.78
UPO	P _{oupl}	0.62

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _{ho}	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{no}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _h	0.2
ISS content of OHO's	f _{hso}	0.15
Yield coefficient of ANO's	Y _a	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{co,fbsa}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{co,usa}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{N,uvo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{P,uvo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{C,uvo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{hso}	0.34 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _h	0.2141 /d
	μ _{hso}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{hso}	0.2829 /d
	b _{hso}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _a	0.0357 /d
	K _{so}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{so}	0.6288 mgFSA/l
	K _{spoi}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{so}	0.3472
	K _{spoi}	0.101
Denitrification	θ	1.08
for ND system	K _{so}	0.0742
Half Saturation Coefficient	K _{so}	0.255
Denitrification	K _{so}	0.108
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K _{so}	0.1874

Factor of safety reducing μ _{hso}	SF	1.25
total unaerated mass fraction	f _u	0.351
Minimum sludge age for nitrification	SRT _u	6.76 days
SRT _u (with safety factor)	SRT _u	8.45 Nitrifies!

Max unaerated sludge mass fraction	f _u	0.62
Total unaerated sludge mass fraction	f _u	0.35
Anoxic mass fraction primary anox 2	f _{u,prim anox 2}	0.27
Anaerobic mass fraction	f _{u,anaer}	0.08
Aerobic mass fraction	f _{u,aer}	0.65

Nr of equal size compartments		2

r-recycle ratio	r	1.0 : 1
r-recycle NO ₂ concentration	N _{re}	1.4 mgNO ₂ -N/l
r-recycle O ₂ concentration	S _{re,o}	0.0 mgO/l

influent NO ₂ concentration	S _{hso}	0.0 mgNO ₂ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	1.000 : 1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (S _{bs} /S _{bi})	f _{bs}	0.135

influent TKN	N _i	48.2 mgTKN-N/l
Flux of N in waste VSS	FN _i	154 kgN/d
Equiv conc in influent	N _i	11.12 mgN/l
Effluent Sol Unbiol Org N	N _{u,uo}	0.90 mgN/l
Effluent ammonia	N _u	0.55 mgFSA-N/l
TKN in effluent	N _u	1.45 mgTKN-N/l
Nitrification capacity	N _i	35.63 mgN/l influent

Denitrification potential BSO (K1)	D _{hso}	1.1 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D _{hso}	45.43 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D _h	46.55 mgNO ₂ -N/l influent

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	13.89 Ml/d
Sludge Age	SRT	20.0 days
Reactor TSS concentration	X _r	4190 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	S _{Ti}	8596
BPO COD	S _{bpl}	6651
UPO COD	S _{upi}	399
	f _{S'up}	0.046
VFA COD	S _{Sol,a}	0
FBSO COD	S _{bfl}	75
BSO COD	S _{bsl}	1042
USO COD	S _{usi}	504
	f _{S'us}	0.059
BO COD	S _{bi}	7693
UO COD	S _{ul}	903
TSS		241
SS		51.4
VSS		189
UPO VSS		19
BPO VSS		170
TKN	N _{Ti}	48
Org N	N _{oi}	14
PSA	N _{ai}	34
BSO	N _{obsl}	2.90
USO	N _{ousl}	0.90
BPO	N _{obpl}	8.70
UPO	N _{oupl}	1.30
Total P	P _{Ti}	15.50
OP	P _{ai}	12.80
Org P	P _{oi}	2.70
BSO	P _{obsl}	0.70
USO	P _{ousl}	0.60
BPO	P _{obpl}	0.78
UPO	P _{oupl}	0.62

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _{ho}	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{no}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _h	0.2
ISS content of OHO's	f _{hso}	0.15
Yield coefficient of ANO's	Y _a	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{co,fbsa}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{co,usa}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{N,uvo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{P,uvo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{C,uvo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{hso}	0.34 /d
	θ	1.029
Endogenous respiration rate OHO	b _h	0.2691 /d
	μ _{hso}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{hso}	0.7157 /d
	b _{hso}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _a	0.0448 /d
	K _{so}	1.0
Nitrification	θ	1.123
Half Saturation Coefficient	K _{so}	1.5904
	K _{spoi}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{so}	1.4930
Denitrification	K _{spoi}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{so}	0.1374
Denitrification	K _{so}	0.255
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K _{so}	0.3469

Factor of safety reducing μ _{hso}	SF	1.25
total unaerated mass fraction	f _u	0.351
Minimum sludge age for nitrification	SRT _u	2.38 days
SRT _u (with safety factor)	SRT _u	2.98 Nitrifies!

Max unaerated sludge mass fraction	f _u	0.83
Total unaerated sludge mass fraction	f _u	0.35
Anoxic mass fraction primary anox 2	f _{u,prim anox 2}	0.27
Anaerobic mass fraction	f _{u,anaer}	0.08
Aerobic mass fraction	f _{u,aer}	0.65

Nr of equal size compartments		2

r-recycle ratio	r	1.0 : 1
r-recycle NO ₂ concentration	N _{re}	4.4 mgNO ₂ -N/l
r-recycle O ₂ concentration	S _{re,o}	0.0 mgO/l

influent NO ₂ concentration	S _{hso}	0.0 mgNO ₂ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	1.0 : 1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (S _{bs} /S _{bi})	f _{bs}	0.135

influent TKN	N _i	48.2 mgTKN-N/l
Flux of N in waste VSS	FN _i	145 kgN/d
Equiv conc in influent	N _i	10.45 mgN/l
Effluent Sol Unbiol Org N	N _{u,uo}	0.90 mgN/l
Effluent ammonia	N _u	0.41 mgFSA-N/l
TKN in effluent	N _u	1.31 mgTKN-N/l
Nitrification capacity	N _i	36.44 mgN/l influent

Denitrification potential BSO (K1)	D _{hso}	1.1 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D _{hso}	69.55 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D _h	70.62 mgNO ₂ -N/l influent

UCT Reactor @ 20 Days SRT

	A	0.6993
	B	-9.1644
	C	56.759
Optimal a-recycle ratio	R_{opt}	17.69
Maximum practical a-recycle ratio	R_{max}	6
chosen a-recycle ratio	a	6.00 set = a_{opt} for balanced UCT recycle limited

Effluent Nitrate if recycle limited	4.45 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited	4.37 mgNO ₃ -N/l
Actual Effluent Nitrate	4.45 mgNO₃-N/l influent

Effluent total N (TKN + NO ₃)	$N_{tot} + N_{no}$	5.90 mgN/l
N removal		87.7%

Alkalinity consumed by nitrification	254 mg CaCO ₃
Alkalinity recovered by denitrification	111 mg CaCO ₃
Total Alkalinity consumption	143 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{vfa,a}$	0 mgCOD/l
FBSO COD	S_{fbs}	75 mgCOD/l
BPO COD	S_{bpo}	75 mgCOD/l
BO COD	S_{bo}	354 mgCOD/l

$S_{r,1}$ reduction due to O_2 & NO_3		37.84 mgCOD/l
Reduced FBSO concentration	$S_{f,1,conv}$	37.16 mgCOD/l

	$k_{f,120}$	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	$k_{f,17}$	0.0535 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	S_{fbs}	MX_{fbs}/Q_L	S_{fbs}	
Trial 1	0.00	881		4.86
Trial 2	4.86	897		4.77
Trial 3	4.77	897		4.77
Trial 4	4.77	897		4.77

Flux BO COD obtained by OHO's	95%	7310 kgCOD/d
Flux BO COD obtained by PAO's	5%	384 kgCOD/d
Check total BO COD		7693 kgCOD/d

Yield coefficient of PAO's	Y_{pa}	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{po}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_d	0.25
ISS content of PAO's	f_{paod}	0.15

	b_{d20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{d17}	0.0357 /d

Activated Sludge Masses

OHO VSS		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	12456 kgVSS
Endogenous Residue VSS OHO	$MX_{L,OHO}$	10666 kgVSS

PAO VSS		
Polyphosphate Acc Organisms VSS	MX_{PAO}	2014 kgVSS
Endogenous Residue VSS PAO	$MX_{L,PAO}$	359 kgVSS

Unbiodegradable Organic VSS	MX_u	5383 kgVSS
Total VSS	MX_v	30879 kgVSS

ISS from influent		14280 kgTSS
ISS of OHO's		1868 kgISS
ISS of PAO's		2652 kgISS
ISS	MX_{O3}	18801 kgISS
TSS	MX_t	49679 kgTSS
VSS/TSS ratio		0.622 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{p,PAO}$	0.355 mgP/mgPAOVSS
		0.380 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.57 mgP/l
biomass P-content	ΔP_{OHO}	2.78 mgP/l
Potential P-removal		5.35 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{pp,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.57 mgP/l
biomass P-content	ΔP_{OHO}	2.78 mgP/l
Total Actual P-removal		5.35 mgP/l

TP effluent

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	5597 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	208 kgO/d
Carbonaceous Oxygen flux	FO_c	5805 kgO/d
Nitrogenous Oxygen flux	FO_N	2262 kgO/d
Oxygen dmd recover by denitrification	FO_d	1238 kgO/d
Total Oxygen Demand (FO _c + FO _N - FO _d)	FO_t	6828 kgO/d
Oxygen utilisation rate	O_r	38.9 mgO/l/h

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Check	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	4028	13427	32225	49679
Concentration TSS (kgTSS/m ³)	2.20	4.40	4.40	4.072
Volume (m ³)	1830	3050	7320	12200
Volume fraction	15%	25%	60%	
Concentration VSS (kgVSS/m ³)	1.37	2.74	2.74	2.53
UPO VSS Concentration (kgUPOVSS/m ³)	0.239	0.477	0.477	0.441

Mass TSS wasted per day		2484.0 kgTSS/d
Waste Flow Rate (note not V/Rs)	Q_w	564.3 m ³ /d

COD mass balance		
COD in (influent)		8595.8 kgCOD/d
COD out		8595.8 kgCOD/d
$Q_L S_{in} + Q_w S_w$		504.2 kgCOD/d
$Q_L X_{f,bo} + f_{bo} MX_{bo}/Rs$		2286.6 kgCOD/d
FO_c		5805.1 kgO/d

	A	0.6993
	B	-32.4288
	C	104.096
Optimal a-recycle ratio	R_{opt}	49.39
Maximum practical a-recycle ratio	R_{max}	6
chosen a-recycle ratio	a	6.00

Effluent Nitrate if recycle limited	4.56 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited	29.63 mgNO ₃ -N/l
Actual Effluent Nitrate	4.56 mgNO₃-N/l influent

Effluent total N (TKN + NO ₃)	$N_{tot} + N_{no}$	5.86 mgN/l
N removal		87.8%

Alkalinity consumed by nitrification	260 mg CaCO ₃
Alkalinity recovered by denitrification	114 mg CaCO ₃
Total Alkalinity consumption	146 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{vfa,a}$	0 mgCOD/l
FBSO COD	S_{fbs}	75 mgCOD/l
BPO COD	S_{bpo}	75 mgCOD/l
BO COD	S_{bo}	554 mgCOD/l

$S_{r,1}$ reduction due to O_2 & NO_3		37.84 mgCOD/l
Reduced FBSO concentration	$S_{f,1,conv}$	37.16 mgCOD/l

	$k_{f,120}$	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	$k_{f,17}$	0.0673 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	S_{fbs}	MX_{fbs}/Q_L	S_{fbs}	
Trial 1	0.00	729		4.67
Trial 2	4.67	742		4.59
Trial 3	4.59	742		4.59
Trial 4	4.59	742		4.59

Flux BO COD obtained by OHO's	95%	7305 kgCOD/d
Flux BO COD obtained by PAO's	5%	389 kgCOD/d
Check total BO COD		7693 kgCOD/d

Yield coefficient of PAO's	Y_{pa}	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{po}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_d	0.25
ISS content of PAO's	f_{paod}	0.15

	b_{d20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{d17}	0.0448 /d

Activated Sludge Masses

OHO VSS		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	10302 kgVSS
Endogenous Residue VSS OHO	$MX_{L,OHO}$	11088 kgVSS

PAO VSS		
Polyphosphate Acc Organisms VSS	MX_{PAO}	1843 kgVSS
Endogenous Residue VSS PAO	$MX_{L,PAO}$	413 kgVSS

Unbiodegradable Organic VSS	MX_u	5383 kgVSS
Total VSS	MX_v	29029 kgVSS

ISS from influent		14280 kgISS
ISS of OHO's		1545 kgISS
ISS of PAO's		2427 kgISS
ISS	MX_{O3}	18253 kgISS
TSS	MX_t	47282 kgTSS
VSS/TSS ratio		0.614 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{p,PAO}$	0.355 mgP/mgPAOVSS
		0.38 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.36 mgP/l
biomass P-content	ΔP_{OHO}	2.61 mgP/l
Potential P-removal		4.97 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{pp,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.36 mgP/l
biomass P-content	ΔP_{OHO}	2.61 mgP/l
Total Actual P-removal		4.97 mgP/l

TP effluent

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	5721 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	221 kgO/d
Carbonaceous Oxygen flux	FO_c	5942 kgO/d
Nitrogenous Oxygen flux	FO_N	2313 kgO/d
Oxygen dmd recover by denitrification	FO_d	1267 kgO/d
Total Oxygen Demand (FO _c + FO _N - FO _d)	FO_t	6988 kgO/d
Oxygen utilisation rate	O_r	39.8 mgO/l/h

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	3834	12779	30669	47282
Concentration TSS (kgTSS/m ³)	2.09	4.19	4.19	3.876
Volume (m ³)	1830	3050	7320	12200
	3834			
Concentration VSS (kgVSS/m ³)	1.29	2.57	2.57	2.38
UPO VSS Concentration (kgUPOVSS/m ³)	0.239	0.477	0.477	0.441

Mass TSS wasted per day		2364.1 kgTSS/d
Waste Flow Rate (note not V/Rs)	Q_w	564.3 m ³ /d

COD mass balance		
COD in (influent)		8595.8 kgCOD/d
COD out		8595.8 kgCOD/d
$Q_L S_{in} + Q_w S_w$		504.2 kgCOD/d
$Q_L X_{f,bo} + f_{bo} MX_{bo}/Rs$		2149.6 kgCOD/d
FO_c		5942.0 kgO/d

UCT Reactor @ 20 Days SRT

N Mass balance	
TKN in (influent)	669.44 kgN/d
TKN out	669.44 kgN/d
N_{NH_4}	78.68 kgN/d
$N_{nitrates}$	157.7 kgN/d
$N_{nitrified}$	433.0 kgN/d

TOD balance	
TOD in (influent)	11655.19 kgTOD/d
TOD out	11655.19 kgTOD/d
TOD _{effluent}	572.01 kgTOD/d
TOD _{settles}	3016.38 kgTOD/d
TOD _{not gas}	1238.50 kgTOD/d
FO ₂	6828.30 kgTOD/d

Effluent Concentrations		General		Special	Unit
Unbiol Sol COD	S_{COD}	36.30	75	30	mgCOD/l
Unbiol Sol Org N	N_{unbiol}	0.90	-	-	mgN/l
PSA-N	N_{PSA}	0.55	6	2	mgPSA-N/l
TKN-N	N_{TKN}	1.45	-	-	mgTKN-N/l
Nitrate	N_{NO_3}	4.45	15	1.5	mgNO ₃ -N/l
Unbiol Sol Org P	P_{unbiol}	0.60	-	-	mgP/l
Ortho P as P	P_{ortho}	10.15	10	2.5	mgP/l
TP	P_{TP}	10.75	-	-	mgP/l

N Mass balance	
TKN in (influent)	669.44 kgN/d
TKN out	669.44 kgN/d
N_{NH_4}	78.13 kgN/d
$N_{nitrates}$	148.5 kgN/d
$N_{nitrified}$	442.9 kgN/d

TOD balance	
TOD in (influent)	11655.19 kgTOD/d
TOD out	11655.19 kgTOD/d
TOD _{effluent}	563.36 kgTOD/d
TOD _{settles}	2836.80 kgTOD/d
TOD _{not gas}	1266.58 kgTOD/d
FO ₂	6988.46 kgTOD/d

Effluent Concentrations		General		Special	Unit
Unbiol Sol COD	S_{COD}	36.30	75	30	mgCOD/l
Unbiol Sol Org N	N_{unbiol}	0.90	-	-	mgN/l
PSA-N	N_{PSA}	0.41	6	2	mgPSA-N/l
TKN-N	N_{TKN}	1.31	-	-	mgTKN-N/l
Nitrate	N_{NO_3}	4.56	15	1.5	mgNO ₃ -N/l
Unbiol Sol Org P	P_{unbiol}	0.60	-	-	mgP/l
Ortho P as P	P_{ortho}	10.53	10	2.5	mgP/l
TP	P_{TP}	11.13	-	-	mgP/l

UCT Reactor @ 25 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	13.89 Ml/d
Sludge Age	SRT	25.0 days
Reactor TSS concentration	X _r	5234.59 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	619	8596
BPO COD	Sbpi	479	6651
UPO COD	Supi	29	399
	fS'up		0.046
VFA COD	Sbsi,a	0.0	0
FBSO COD	Sbsfi	75	1042
BSO COD	Sbsi	75	1042
USO COD	Susi	36.3	504
	fS'us		0.059
BO COD	Sbi	554	7693
UO COD	Sui	65	903
TSS		241	3343
ISS		51.4	714
VSS		189	2629
UPO VSS		19.4	269
BPO VSS		170	2360
TKN	Nti	48.2	669
Org N	Noi	13.8	192
FSA	Nai	34.4	478
BSO	Nobsi	2.90	40
USO	Nousi	0.90	13
BPO	Nobpi	8.70	121
UPO	Noupi	1.30	18
Total P	Pti	15.50	215
OP	Pai	12.80	178
Org P	Poi	2.70	38
BSO	Pobsi	0.70	10
USO	Pousi	0.60	8
BPO	Pobpi	0.78	11
UPO	Poupi	0.62	9

Constants		
COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{OHO}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cv,FBSO}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cv,USO}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{N,UPO}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{P,UPO}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{C,UPO}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{H2O}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2141 /d
	μ _{AH2O}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{AHnT}	0.2829 /d
	b _{A2O}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0357 /d
	K _{s2O}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{sT}	0.6288 mgFSA/l
	K _{s2O}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{sT}	0.3472
Denitrification	K _{s2O}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{sT}	0.0742
Denitrification	K ["] _{s2O}	0.255
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K ["] _{sT}	0.1874
Factor of safety reducing μ _{AHnT}	Sf	1.25
total unaerated mass fraction	fx _t	0.351
Minimum sludge age for nitrification	SRT _{min}	6.76 days
SRT _{min} (with safety factor)	SRT _{min}	8.45 Nitrifies!

Max unaerated sludge mass fraction	f _{un}	0.67
Total unaerated sludge mass fraction	f _u	0.35
Anoxic mass fraction primary anox 2	f _{s,prim anox 2}	0.27
Anaerobic mass fraction	f _{anaer}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments		2
r-recyle ratio	r	1.0 :1
r-recyle NO ₃ concentration	N _{or}	4.5 mgNO ₃ -N/l
r-recyle O ₂ concentration	S _{O2,s}	0.0 mgO/l

influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recyle ratio	s	1.000 :1
s-recyle DO concentration	O _s	1.0 mgO/l

a-recyle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)	f _{Sb/s}	0.135

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	13.89 Ml/d
Sludge Age	SRT	25.0 days
Reactor TSS concentration	X _r	4999 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	619	8596
BPO COD	Sbpi	479	6651
UPO COD	Supi	29	399
	fS'up		0.046
VFA COD	Sbsi,a	0	0
FBSO COD	Sbsfi	75	1042
BSO COD	Sbsi	75	1042
USO COD	Susi	36	504
	fS'us		0.059
BO COD	Sbi	554	7693
UO COD	Sui	65	903
TSS		241	3343
ISS		51	714
VSS		189	2629
UPO VSS		19	269
BPO VSS		170	2360
TKN	Nti	48	669
Org N	Noi	14	192
FSA	Nai	34	478
BSO	Nobsi	2.90	40
USO	Nousi	0.90	13
BPO	Nobpi	8.70	121
UPO	Noupi	1.30	18
Total P	Pti	15.50	215
OP	Pai	12.80	178
Org P	Poi	2.70	38
BSO	Pobsi	0.70	10
USO	Pousi	0.60	8
BPO	Pobpi	0.78	11
UPO	Poupi	0.62	9

Constants		
COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{OHO}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cv,FBSO}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cv,USO}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{N,UPO}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{P,UPO}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{C,UPO}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{H2O}	0.24 /d
	θ	1.029
Endogenous respiration rate OHO	b _{HT}	0.2691 /d
	μ _{AHn2O}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{AHnT}	0.7157 /d
	b _{A2O}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0448 /d
	K _{s2O}	1.0
Nitrification	θ	1.123
Half Saturation Coefficient	K _{sT}	1.5904
	K _{s2O}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{sT}	1.4930
Denitrification	K _{s2O}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{sT}	0.1374
Denitrification	K ["] _{s2O}	0.255
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K ["] _{sT}	0.3469
Factor of safety reducing μ _{AHnT}	Sf	1.25
total unaerated mass fraction	fx _t	0.351
Minimum sludge age for nitrification	SRT _{min}	2.38 days
SRT _{min} (with safety factor)	SRT _{min}	2.98 Nitrifies!

Max unaerated sludge mass fraction	f _{un}	0.85
Total unaerated sludge mass fraction	f _u	0.35
Anoxic mass fraction primary anox 2	f _{s,prim anox 2}	0.27
Anaerobic mass fraction	f _{anaer}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments		2
r-recyle ratio	r	1.0 :1
r-recyle NO ₃ concentration	N _{or}	4.5 mgNO ₃ -N/l
r-recyle O ₂ concentration	S _{O2,s}	0.0 mgO/l

influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recyle ratio	s	1.0 :1
s-recyle DO concentration	O _s	1.0 mgO/l

a-recyle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)	f _{Sb/s}	0.135

UCT Reactor @ 25 Days SRT

Influent TKN	N_{ti}	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_b	145 kgN/d
Equiv conc in influent	N_i	10.46 mgN/l
Effluent Sol Unbiobd Org N	N_{dude}	0.90 mgN/l
Effluent ammonia	N_{am}	0.44 mgFSA-N/l
TKN in effluent	N_{te}	1.34 mgTKN-N/l
Nitrification capacity	N_c	36.40 mgN/l influent

Denitrification potential BSO (K1)	D_{BBSO}	1.0 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BBPO}	47.25 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	48.29 mgNO ₂ -N/l influent

	A	0.6993
	B	-10.1413
	C	59.482
Optimal a-recycle ratio	a_{opt}	18.98
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00 set = a_{opt} for balanced UCT recycle limited

Effluent Nitrate if recycle limited		4.55 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-7.34 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{ne}	4.55 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₃)	$N_{te} + N_{te}$	5.89 mgN/l
N removal		87.8%

Alkalinity consumed by nitrification		260 mg CaCO ₃
Alkalinity recovered by denitrification		114 mg CaCO ₃
Total Alkalinity consumption		146 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{baf,a}$	0 mgCOD/l
FBSO COD	S_{baf}	75 mgCOD/l
BSO COD	S_{bi}	75 mgCOD/l
BO COD	S_{bi}	554 mgCOD/l

S_{rj} reduction due to O ₂ & NO ₃		38.7 mgCOD/l
Reduced FBSO concentration	$S_{rj,LOHv}$	36.3 mgCOD/l

	$k_{r,220}$	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	$k_{r,T}$	0.0535 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	S_{bafm}	MX_{baf}/Q_i	S_{bafm}	
Trial 1	0.00	917		4.56
Trial 2	4.56	933		4.48
Trial 3	4.48	933		4.48
Trial 4	4.48	933		4.48

Flux BO COD obtained by OHO's	95%	7313 kgCOD/d
Flux BO COD obtained by PAO's	5%	380 kgCOD/d
Check total BO COD		7693 kgCOD/d

error!

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_d	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{G20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{GT}	0.0357 /d

Activated Sludge Masses

OHO VSS		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	12954 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	13865 kgVSS

PAO VSS		
Polyphosphate Acc Organisms VSS	MX_{PAO}	2257 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	503 kgVSS

Unbiodegradable Organic VSS	MX_{iv}	6729 kgVSS
Total VSS	MX_v	36307 kgVSS

ISS from influent		17850 kgISS
ISS of OHO's		1943 kgISS
ISS of PAO's		2972 kgISS
ISS	$MX_{(O)}$	22765 kgISS
TSS	MX_t	59072 kgTSS
VSS/TSS ratio		0.615 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{pp,PAO}$	0.355 mgP/mgPAOVSS
		0.380 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.31 mgP/l
biomass P-content	ΔP_{OHO}	2.61 mgP/l
Potential P-removal		4.92 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{pp,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.31 mgP/l
biomass P-content	ΔP_{OHO}	2.61 mgP/l
Total Actual P-removal		4.92 mgP/l

TP effluent P_{te} 10.58 mgP/l

Note: Add P content of TSS in effluent

Influent TKN	N_{ti}	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_b	137 kgN/d
Equiv conc in influent	N_i	9.88 mgN/l
Effluent Sol Unbiobd Org N	N_{dude}	0.90 mgN/l
Effluent ammonia	N_{am}	0.36 mgFSA-N/l
TKN in effluent	N_{te}	1.26 mgTKN-N/l
Nitrification capacity	N_c	37.07 mgN/l influent

Denitrification potential BSO (K1)	D_{BBSO}	1.0 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BBPO}	71.85 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	72.86 mgNO ₂ -N/l influent

	A	0.6993
	B	-34.0422
	C	107.949
Optimal a-recycle ratio	a_{opt}	51.67
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00 recycle limited

Effluent Nitrate if recycle limited		4.63 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-31.24 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{ne}	4.63 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₃)	$N_{te} + N_{te}$	5.89 mgN/l
N removal		87.8%

Alkalinity consumed by nitrification		265 mg CaCO ₃
Alkalinity recovered by denitrification		116 mg CaCO ₃
Total Alkalinity consumption		149 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{baf,a}$	0 mgCOD/l
FBSO COD	S_{baf}	75 mgCOD/l
BSO COD	S_{bi}	75 mgCOD/l
BO COD	S_{bi}	554 mgCOD/l

S_{rj} reduction due to O ₂ & NO ₃		38.7 mgCOD/l
Reduced FBSO concentration	$S_{rj,LOHv}$	36.3 mgCOD/l

	$k_{r,220}$	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	$k_{r,T}$	0.0673 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	S_{bafm}	MX_{baf}/Q_i	S_{bafm}	
Trial 1	0.00	754		4.41
Trial 2	4.41	766		4.34
Trial 3	4.34	766		4.34
Trial 4	4.34	766		4.34

Flux BO COD obtained by OHO's	95%	7309 kgCOD/d
Flux BO COD obtained by PAO's	5%	384 kgCOD/d
Check total BO COD		7693 kgCOD/d

correct

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_d	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{G20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{GT}	0.0448 /d

Activated Sludge Masses

OHO VSS		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	10642 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	14318 kgVSS

PAO VSS		
Polyphosphate Acc Organisms VSS	MX_{PAO}	2034 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	570 kgVSS

Unbiodegradable Organic VSS	MX_{iv}	6729 kgVSS
Total VSS	MX_v	34294 kgVSS

ISS from influent		17850 kgISS
ISS of OHO's		1596 kgISS
ISS of PAO's		2678 kgISS
ISS	$MX_{(O)}$	22125 kgISS
TSS	MX_t	56419 kgTSS
VSS/TSS ratio		0.608 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{pp,PAO}$	0.355 mgP/mgPAOVSS
		0.38 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.08 mgP/l
biomass P-content	ΔP_{OHO}	2.47 mgP/l
Potential P-removal		4.55 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{pp,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.08 mgP/l
biomass P-content	ΔP_{OHO}	2.47 mgP/l
Total Actual P-removal		4.55 mgP/l

TP effluent P_{te} 10.95 mgP/l

Note: Add P content of TSS in effluent

UCT Reactor @ 25 Days SRT

Carbonaceous Oxygen flux OHO's	FO _{OHO}	5725 kgO/d
Carbonaceous Oxygen flux PAO's	FO _{PAO}	216 kgO/d
Carbonaceous Oxygen flux	FO _c	5941 kgO/d
Nitrogenous Oxygen flux	FO _n	2311 kgO/d
Oxygen dmnd recover by denitrification	FO _D	1265 kgO/d
Total Oxygen Demand (FO _c + FO _n + FO _D)	FO _T	6986 kgO/d
Oxygen utilisation rate	O _T	39.8 mgO/l.h

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Check	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	4790	15965	38317	59072
Concentration TSS (kgTSS/m ³)	2.62	5.23	5.23	4.842
Volume (m ³)	1830	3050	7320	12200
Volume fraction	15%	25%	60%	100%
Concentration VSS (kgVSS/m ³)	1.61	3.22	3.22	2.98
UPO VSS Concentration (kgUPOVSS/m ³)	0.298	0.596	0.596	0.552

Mass TSS wasted per day 2362.9 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 451.4 m³/d

COD mass balance	
COD in (influent)	8595.8 kgCOD/d
COD out	8595.8 kgCOD/d
Q _L S _{in} + Q _w S _{in}	504.2 kgCOD/d
Q _w X _{f,cs} or f _{cs} MX _d /Rs	2150.8 kgCOD/d
FO _c	5940.8 kgCOD/d

N Mass balance	
TKN in (influent)	669.44 kgN/d
TKN out	669.44 kgN/d
N _{in}	79.17 kgN/d
N _{waste}	147.9 kgN/d
N _{denitrified}	442.4 kgN/d

TOD balance	
TOD in (influent)	11655.19 kgTOD/d
TOD out	11655.19 kgTOD/d
TOD _{effluent}	570.14 kgTOD/d
TOD _{waste}	2833.70 kgTOD/d
TOD _{N2 gas}	1265.23 kgTOD/d
FO _L	6986.12 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S _{unbiol}	36.30	75	30 mgCOD/l
Unbiol Sol Org N	N _{unbiol}	0.90	-	mgN/l
FSA-N	N _{ae}	0.44	6	2 mgFSA-N/l
TKN-N	N _{in}	1.34	-	mgTKN-N/l
Nitrate	N _{in}	4.55	15	1.5 mgNO ₃ -N/l
Unbiol Sol Org P	P _{unbiol}	0.60	-	mgP/l
Ortho P as P	P _{ae}	10.58	10	2.5 mgP/l
TP	P _{in}	11.18	-	mgP/l

Carbonaceous Oxygen flux OHO's	FO _{OHO}	5831 kgO/d
Carbonaceous Oxygen flux PAO's	FO _{PAO}	229 kgO/d
Carbonaceous Oxygen flux	FO _c	6060 kgO/d
Nitrogenous Oxygen flux	FO _n	2353 kgO/d
Oxygen dmnd recover by denitrification	FO _D	1288 kgO/d
Total Oxygen Demand (FO _c + FO _n + FO _D)	FO _T	7125 kgO/d
Oxygen utilisation rate	O _T	40.6 mgO/l.h

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	4574	15248	36596	56419
Concentration TSS (kgTSS/m ³)	2.50	5.00	5.00	4.624
Volume (m ³)	1830	3050	7320	12200
	4574			
Concentration VSS (kgVSS/m ³)	1.52	3.04	3.04	2.81
UPO VSS Concentration (kgUPOVSS/m ³)	0.298	0.596	0.596	0.552

Mass TSS wasted per day 2256.7 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 451.4 m³/d

COD mass balance	
COD in (influent)	8595.8 kgCOD/d
COD out	8595.8 kgCOD/d
Q _L S _{in} + Q _w S _{in}	504.2 kgCOD/d
Q _w X _{f,cs} or f _{cs} MX _d /Rs	2031.6 kgCOD/d
FO _c	6060.1 kgO/d

N Mass balance	
TKN in (influent)	669.44 kgN/d
TKN out	669.44 kgN/d
N _{in}	79.14 kgN/d
N _{waste}	139.8 kgN/d
N _{denitrified}	450.5 kgN/d

TOD balance	
TOD in (influent)	11655.19 kgTOD/d
TOD out	11655.19 kgTOD/d
TOD _{effluent}	564.89 kgTOD/d
TOD _{waste}	2677.41 kgTOD/d
TOD _{N2 gas}	1288.36 kgTOD/d
FO _L	7124.53 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S _{unbiol}	36.30	75	30 mgCOD/l
Unbiol Sol Org N	N _{unbiol}	0.90	-	mgN/l
FSA-N	N _{ae}	0.36	6	2 mgFSA-N/l
TKN-N	N _{in}	1.26	-	mgTKN-N/l
Nitrate	N _{in}	4.63	15	1.5 mgNO ₃ -N/l
Unbiol Sol Org P	P _{unbiol}	0.60	-	mgP/l
Ortho P as P	P _{ae}	10.95	10	2.5 mgP/l
TP	P _{in}	11.55	-	mgP/l

UCT Reactor @ 30 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	13.89 Ml/d
Sludge Age	SRT	30.0 days
Reactor TSS concentration	X _r	6042.05 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti	619 8596
BPO COD	Sbpi	479 6651
UPO COD	Supi	29 399
	fs'up	0.046
VFA COD	Sbsi,a	0 0
FBSO COD	Sbsfi	75 1042
BSO COD	Sbsi	75 1042
USO COD	Susi	36.3 504
	fs'us	0.059
BO COD	Sbi	554 7693
UO COD	Sui	65 903
TSS		241 3343
ISS		51.4 714
VSS		189 2629
UPO VSS		19.4 269
BPO VSS		170 2360
TKN	Nti	48.2 669
Org N	Noi	13.8 192
FSA	Nai	34.4 478
BSO	Nobsi	2.90 40
USO	Nousi	0.90 13
BPO	Nobpi	8.70 121
UPO	Noupi	1.30 18
Total P	Pti	15.50 215
OP	Pai	12.80 178
Org P	Poi	2.70 38
BSO	Pobsi	0.70 10
USO	Pousi	0.60 8
BPO	Pobpi	0.78 11
UPO	Poupi	0.62 9

Constants	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{div}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{CHO}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{CN3so}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{CN3uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{N,uPO}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{P,uPO}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{C,uPO}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{H2O}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2141 /d
	μ _{AH2O}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.2829 /d
	b _{A2O}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0357 /d
	K _{s2O}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{sT}	0.6288 mgFSA/l
	K _{s2O}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{sT}	0.3472
Denitrification	K _{s2O}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{sT}	0.0742
Denitrification	K _{s2O}	0.255
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K _{sT}	0.1874
Factor of safety reducing μ _{AmT}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _{min}	6.76 days
SRT _{min} (with safety factor)	SRT _{min}	8.45 Nitrifies!

Max unaerated sludge mass fraction	f _{xm}	0.70
Total unaerated sludge mass fraction	f _{xt}	0.35
Anoxic mass fraction primary anox 2	f _{x,prim anox 2}	0.27
Anaerobic mass fraction	f _{xanaer}	0.08
Aerobic mass fraction	f _{xaer}	0.65

Nr of equal size compartments		2
r-recyle ratio	r	1.0 :1
r-recyle NO ₃ concentration	N _{ox}	4.6 mgNO ₃ -N/l
r-recyle O ₂ concentration	S _{O2,L}	0.0 mgO/l
Influent NO ₃ concentration	S _{NO3+i}	0.0 mgNO ₃ -N/l
Influent DO concentration	O _i	0.0 mgO/l
s-recyle ratio	s	1.075 :1
s-recyle DO concentration	O _s	1.0 mgO/l
a-recyle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)	f _{so/s}	0.135

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	13.89 Ml/d
Sludge Age	SRT	30.0 days
Reactor TSS concentration	X _r	5789 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti	619 8596
BPO COD	Sbpi	479 6651
UPO COD	Supi	29 399
	fs'up	0.046
VFA COD	Sbsi,a	0 0
FBSO COD	Sbsfi	75 1042
BSO COD	Sbsi	75 1042
USO COD	Susi	36 504
	fs'us	0.059
BO COD	Sbi	554 7693
UO COD	Sui	65 903
TSS		241 3343
ISS		51 714
VSS		189 2629
UPO VSS		19 269
BPO VSS		170 2360
TKN	Nti	48 669
Org N	Noi	14 192
FSA	Nai	34 478
BSO	Nobsi	2.90 40
USO	Nousi	0.90 13
BPO	Nobpi	8.70 121
UPO	Noupi	1.30 18
Total P	Pti	15.50 215
OP	Pai	12.80 178
Org P	Poi	2.70 38
BSO	Pobsi	0.70 10
USO	Pousi	0.60 8
BPO	Pobpi	0.78 11
UPO	Poupi	0.62 9

Constants	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{div}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{CHO}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{CN3so}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{CN3uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{N,uPO}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{P,uPO}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{C,uPO}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{H2O}	0.24 /d
	θ	1.029
Endogenous respiration rate OHO	b _{HT}	0.2691 /d
	μ _{AH2O}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.7157 /d
	b _{A2O}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0448 /d
	K _{s2O}	1.0
Nitrification	θ	1.123
Half Saturation Coefficient	K _{sT}	1.5904
	K _{s2O}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{sT}	1.4930
Denitrification	K _{s2O}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{sT}	0.1374
Denitrification	K _{s2O}	0.255
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K _{sT}	0.3469
Factor of safety reducing μ _{AmT}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _{min}	2.38 days
SRT _{min} (with safety factor)	SRT _{min}	2.98 Nitrifies!

Max unaerated sludge mass fraction	f _{xm}	0.86
Total unaerated sludge mass fraction	f _{xt}	0.35
Anoxic mass fraction primary anox 2	f _{x,prim anox 2}	0.27
Anaerobic mass fraction	f _{xanaer}	0.08
Aerobic mass fraction	f _{xaer}	0.65

Nr of equal size compartments		2
r-recyle ratio	r	1.0 :1
r-recyle NO ₃ concentration	N _{ox}	4.6 mgNO ₃ -N/l
r-recyle O ₂ concentration	S _{O2,L}	0.0 mgO/l
Influent NO ₃ concentration	S _{NO3+i}	0.0 mgNO ₃ -N/l
Influent DO concentration	O _i	0.0 mgO/l
s-recyle ratio	s	1.1 :1
s-recyle DO concentration	O _s	1.0 mgO/l
a-recyle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)	f _{so/s}	0.135

UCT Reactor @ 30 Days SRT

Influent TKN	N_i	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_i	139 kgN/d
Equiv conc in influent	N_i	9.98 mgN/l
Effluent Sol Unbiol Org N	N_{out}	0.90 mgN/l
Effluent ammonia	N_{ae}	0.38 mgFSA-N/l
TKN in effluent	N_{te}	1.28 mgTKN-N/l
Nitrification capacity	N_c	36.94 mgN/l influent

Denitrification potential BSO (K1)	D_{pBSO}	1.0 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	48.57 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	49.56 mgNO ₂ -N/l influent

	A	0.6993
	B	-10.7845
	C	62.339
Optimal a-recycle ratio	a_{opt}	19.90
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00 set = a_{opt} for balanced UCT recycle limited

Effluent Nitrate if recycle limited		4.57 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-8.04 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{ne}	4.57 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₃)	$N_{\text{te}} + N_{\text{te}}$	5.85 mgN/l
N removal		87.9%

Alkalinity consumed by nitrification		264 mg CaCO ₃
Alkalinity recovered by denitrification		116 mg CaCO ₃
Total Alkalinity consumption		148 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{\text{sol,a}}$	0 mgCOD/l
FBSD COD	$S_{\text{sol,f}}$	75 mgCOD/l
BSO COD	S_{sol}	75 mgCOD/l
BO COD	S_{bi}	554 mgCOD/l

S_{fj} reduction due to O ₂ & NO ₃		39.71498628 mgCOD/l
Reduced FBSD concentration	$S_{\text{fj,OHV}}$	35.28501372 mgCOD/l

	$k_{\text{c},\text{T20}}$	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	$k_{\text{f},\text{T}}$	0.0535 m ³ /gVSS.d

PAO's get all VFA's + FBSD converted to VFA
OHO's get BPO and remaining FBSD

	S_{solfH}	MX_{sol}/Q_i	S_{solH}	
Trial 1	0.00	943		4.31
Trial 2	4.31	959		4.24
Trial 3	4.24	959		4.24
Trial 4	4.24	959		4.24

Flux BO COD obtained by OHO's	95%	7321 kgCOD/d
Flux BO COD obtained by PAO's	5%	372 kgCOD/d
Check total BO COD		7693 kgCOD/d

correct
7693

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_d	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{G20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{GT}	0.0357 /d

Activated Sludge Masses

OHO VSS		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	13316 kgVSS
Endogenous Residue VSS OHO	$MX_{\text{E,OHO}}$	17103 kgVSS

PAO VSS		
Polyphosphate Acc Organisms VSS	MX_{PAO}	2428 kgVSS
Endogenous Residue VSS PAO	$MX_{\text{E,PAO}}$	650 kgVSS

Unbiodegradable Organic VSS	MX_{U}	8074 kgVSS
Total VSS	MX_{V}	41571 kgVSS

ISS from influent		21420 kgISS
ISS of OHO's		1997 kgISS
ISS of PAO's		3196 kgISS
ISS	MX_{IDi}	26614 kgISS
TSS	MX_{I}	68185 kgTSS
VSS/TSS ratio		0.610 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{\text{pB,PAO}}$	0.350 mgP/mgPAOVSS
		0.380 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{\text{PAO},2}$	2.07 mgP/l
biomass P-content	ΔP_{OHO}	2.49 mgP/l
Potential P-removal		4.56 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{\text{pB,PAO}}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{\text{PAO},2}$	2.07 mgP/l
biomass P-content	ΔP_{OHO}	2.49 mgP/l
Total Actual P-removal		4.56 mgP/l

TP effluent P_{te} 10.94 mgP/l

Note: Add P content of TSS in effluent

Influent TKN	N_i	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_i	131 kgN/d
Equiv conc in influent	N_i	9.46 mgN/l
Effluent Sol Unbiol Org N	N_{out}	0.90 mgN/l
Effluent ammonia	N_{ae}	0.32 mgFSA-N/l
TKN in effluent	N_{te}	1.22 mgTKN-N/l
Nitrification capacity	N_c	37.51 mgN/l influent

Denitrification potential BSO (K1)	D_{pBSO}	1.0 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	73.51 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	74.47 mgNO ₂ -N/l influent

	A	0.6993
	B	-35.1296
	C	113.435
Optimal a-recycle ratio	a_{opt}	53.28
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00 recycle limited

Effluent Nitrate if recycle limited		4.65 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-32.39 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{ne}	4.65 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₃)	$N_{\text{te}} + N_{\text{te}}$	5.87 mgN/l
N removal		87.8%

Alkalinity consumed by nitrification		268 mg CaCO ₃
Alkalinity recovered by denitrification		117 mg CaCO ₃
Total Alkalinity consumption		151 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{\text{sol,a}}$	0 mgCOD/l
FBSD COD	$S_{\text{sol,f}}$	75 mgCOD/l
BSO COD	S_{sol}	75 mgCOD/l
BO COD	S_{bi}	554 mgCOD/l

S_{fj} reduction due to O ₂ & NO ₃		39.71498628 mgCOD/l
Reduced FBSD concentration	$S_{\text{fj,OHV}}$	35.28501372 mgCOD/l

	$k_{\text{c},\text{T20}}$	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	$k_{\text{f},\text{T}}$	0.0673 m ³ /gVSS.d

PAO's get all VFA's + FBSD converted to VFA
OHO's get BPO and remaining FBSD

	S_{solfH}	MX_{sol}/Q_i	S_{solH}	
Trial 1	0.00	772		4.19
Trial 2	4.19	784		4.12
Trial 3	4.12	784		4.12
Trial 4	4.12	784		4.12

Flux BO COD obtained by OHO's	95%	7317 kgCOD/d
Flux BO COD obtained by PAO's	5%	376 kgCOD/d
Check total BO COD		7693 kgCOD/d

correct

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_d	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{G20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{GT}	0.0448 /d

Activated Sludge Masses

OHO VSS		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	10889 kgVSS
Endogenous Residue VSS OHO	$MX_{\text{E,OHO}}$	17579 kgVSS

PAO VSS		
Polyphosphate Acc Organisms VSS	MX_{PAO}	2162 kgVSS
Endogenous Residue VSS PAO	$MX_{\text{E,PAO}}$	727 kgVSS

Unbiodegradable Organic VSS	MX_{U}	8074 kgVSS
Total VSS	MX_{V}	39432 kgVSS

ISS from influent		21420 kgISS
ISS of OHO's		1633 kgISS
ISS of PAO's		2846 kgISS
ISS	MX_{IDi}	25900 kgISS
TSS	MX_{I}	65332 kgTSS
VSS/TSS ratio		0.604 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{\text{pB,PAO}}$	0.355 mgP/mgPAOVSS
		0.38 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{\text{PAO},2}$	1.84 mgP/l
biomass P-content	ΔP_{OHO}	2.37 mgP/l
Potential P-removal		4.21 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{\text{pB,PAO}}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{\text{PAO},2}$	1.84 mgP/l
biomass P-content	ΔP_{OHO}	2.37 mgP/l
Total Actual P-removal		4.21 mgP/l

TP effluent P_{te} 11.29 mgP/l

Note: Add P content of TSS in effluent

UCT Reactor @ 30 Days SRT

Carbonaceous Oxygen flux OHO's	FO _{OHO}	5819 kgO/d
Carbonaceous Oxygen flux PAO's	FO _{PAO}	220 kgO/d
Carbonaceous Oxygen flux	FO _c	6039 kgO/d
Nitrogenous Oxygen flux	FO _n	2345 kgO/d
Oxygen dimnd recover by denitrification	FO _D	1286 kgO/d
Total Oxygen Demand (FO _c + FO _n + FO _D)	FO _T	7099 kgO/d
Oxygen utilisation rate	O _T	40.4 mgO/l/h

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Check	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	5528	18428	44228	68185
Concentration TSS (kgTSS/m ³)	3.02	6.04	6.04	5.589
Volume (m ³)	1830	3050	7320	12200
Volume fraction	15%	25%	60%	100%
Concentration VSS (kgVSS/m ³)	1.84	3.68	3.68	3.41
UPO VSS Concentration (kgUPOVSS/m ³)	0.358	0.716	0.716	0.662

Mass TSS wasted per day 2272.8 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 376.2 m³/d

COD mass balance	
COD in (influent)	8595.8 kgCOD/d
COD out	8595.8 kgCOD/d
Q _s S _{in} + Q _s S _o	504.2 kgCOD/d
Q _s X _f _o or f _o ·MX _d /Rs	2052.2 kgCOD/d
FO _c	6039.5 kgO/d

N Mass balance	
TKN in (influent)	669.44 kgN/d
TKN out	669.44 kgN/d
N _{to}	79.10 kgN/d
N _{waste}	140.8 kgN/d
N _{denitrified}	449.6 kgN/d

TOD balance	
TOD in (influent)	11655.19 kgTOD/d
TOD out	11655.19 kgTOD/d
TOD _{effluent}	569.49 kgTOD/d
TOD _{waste}	2701.31 kgTOD/d
TOD _{N2 gas}	1285.78 kgTOD/d
FO _L	7098.62 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S _{out}	36.30	75	30 mgCOD/l
Unbiol Sol Org N	N _{out}	0.90	-	mgN/l
FSA-N	N _{ae}	0.38	6	2 mgFSA-N/l
TKN-N	N _{to}	1.28	-	mgTKN-N/l
Nitrate	N _{oe}	4.57	15	1.5 mgNO ₃ -N/l
Unbiol Sol Org P	P _{out}	0.60	-	mgP/l
Ortho P as P	P _{oe}	10.94	10	2.5 mgP/l
TP	P _{te}	11.54	-	mgP/l

Carbonaceous Oxygen flux OHO's	FO _{OHO}	5912 kgO/d
Carbonaceous Oxygen flux PAO's	FO _{PAO}	233 kgO/d
Carbonaceous Oxygen flux	FO _c	6145 kgO/d
Nitrogenous Oxygen flux	FO _n	2381 kgO/d
Oxygen dimnd recover by denitrification	FO _D	1306 kgO/d
Total Oxygen Demand (FO _c + FO _n + FO _D)	FO _T	7221 kgO/d
Oxygen utilisation rate	O _T	41.1 mgO/l/h

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	5297	17657	42377	65332
Concentration TSS (kgTSS/m ³)	2.89	5.79	5.79	5.355
Volume (m ³)	1830	3050	7320	12200
	5297			
Concentration VSS (kgVSS/m ³)	1.75	3.49	3.49	3.23
UPO VSS Concentration (kgUPOVSS/m ³)	0.358	0.716	0.716	0.662

Mass TSS wasted per day 2177.7 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 376.2 m³/d

COD mass balance	
COD in (influent)	8595.8 kgCOD/d
COD out	8595.8 kgCOD/d
Q _s S _{in} + Q _s S _o	504.2 kgCOD/d
Q _s X _f _o or f _o ·MX _d /Rs	1946.6 kgCOD/d
FO _c	6145.1 kgO/d

N Mass balance	
TKN in (influent)	669.44 kgN/d
TKN out	669.44 kgN/d
N _{to}	79.29 kgN/d
N _{waste}	133.6 kgN/d
N _{denitrified}	456.5 kgN/d

TOD balance	
TOD in (influent)	11655.19 kgTOD/d
TOD out	11655.19 kgTOD/d
TOD _{effluent}	565.98 kgTOD/d
TOD _{waste}	2563.05 kgTOD/d
TOD _{N2 gas}	1305.62 kgTOD/d
FO _L	7220.55 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S _{out}	36.30	75	30 mgCOD/l
Unbiol Sol Org N	N _{out}	0.90	-	mgN/l
FSA-N	N _{ae}	0.32	6	2 mgFSA-N/l
TKN-N	N _{to}	1.22	-	mgTKN-N/l
Nitrate	N _{oe}	4.65	15	1.5 mgNO ₃ -N/l
Unbiol Sol Org P	P _{out}	0.60	-	mgP/l
Ortho P as P	P _{oe}	11.29	10	2.5 mgP/l
TP	P _{te}	11.89	-	mgP/l

**Annexure A3 – Detailed Reactor Model for Influent
Flow of 30 ML/d**

MLE Reactor @ 10 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	13.3 MI/d
Sludge Age	SRT	10.0 days
Reactor TSS concentration	X _T	2122 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	619	8252
BPO COD	Sbpi	479	6385
UPO COD	Supi	29	383
	fs'up		0.0464
VFA COD	Sbsi,a	0.0	0
FBSO COD	Sbsfi	75	1000
BSO COD	Sbsi	75	1000
USO COD	Susi	36.3	484
	fs'us		0.0587
BO COD	Sbi	554	7385
UO COD	Sui	65	867
TSS		241	3210
ISS		51.4	685
VSS		189	2524
UPO VSS		19.4	259
BPO VSS		170	2266
TKN	Nti	48.2	643
Org N	Noi	13.8	184
FSA	Nai	34.4	459
BSO	Nobsi	2.90	39
USO	Nousi	0.90	12
BPO	Nobpi	8.70	116
UPO	Noupi	1.30	17
Total P	Pti	15.50	207
OP	Pai	12.80	171
Org P	Poi	2.70	36
BSO	Pobsi	0.70	9
USO	Pousi	0.60	8
BPO	Pobpi	0.78	10
UPO	Poupi	0.62	8

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{HV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,Bso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,uipo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,uipo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,uipo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{H20}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2141 /d
	μ _{Am20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.2829 /d
	b _{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0357 /d
	K _{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K _{nT}	0.6288 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	10582 kgVSS
Endogenous Residue VSS	MX _{EH}	4530 kgVSS
Unbiodegradeable Organic VSS	MX _{UV}	2586 kgVSS
Total VSS	MX _V	17698 kgVSS
ISS from influent		6855 kgISS
ISS of OHO's		1587 kgISS
ISS	MX _{IOI}	8442 kgISS
TSS	MX _T	26140 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{tn}	22.2 hr

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	13.3 MI/d
Sludge Age	SRT	10.0 days
Reactor TSS concentration	X _T	2000 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	618.9	8252
BPO COD	Sbpi	479	6385
UPO COD	Supi	29	383
	fs'up		0.04637
VFA COD	Sbsi,a	0	0
FBSO COD	Sbsfi	75	1000
BSO COD	Sbsi	75	1000
USO COD	Susi	36.3	484
	fs'us		0.05865
BO COD	Sbi	554	7385
UO COD	Sui	65	867
TSS		240.72727	3210
ISS		51.4	685
VSS		189.31818	2524
UPO VSS		19.39	259
BPO VSS		170	2266
TKN	Nti	48.2	643
Org N	Noi	13.8	184
FSA	Nai	34.4	459
BSO	Nobsi	2.90	38.7
USO	Nousi	0.90	12.0
BPO	Nobpi	8.70	116
UPO	Noupi	1.30	17
Total P	Pti	15.5	207
OP	Pai	12.8	171
Org P	Poi	2.7	36.0
BSO	Pobsi	0.7	9.3
USO	Pousi		
BPO	Pobpi	0.78	10
UPO	Poupi	0.62	8.27

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{HV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,Bso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,uipo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,uipo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,uipo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{H20}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2691 /d
	μ _{Am20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.7157 /d
	b _{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0448 /d
	K _{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K _{nT}	1.5904 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	9005 kgVSS
Endogenous Residue VSS	MX _{EH}	4846 kgVSS
Unbiodegradeable Organic VSS	MX _{UV}	2586 kgVSS
Total VSS	MX _V	16436 kgVSS
ISS from influent		6855 kgISS
ISS of OHO's		1351 kgISS
ISS	MX _{IOI}	8205 kgISS
TSS	MX _T	24641 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{tn}	22.2 hr

MLE Reactor @ 10 Days SRT

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	859 mgVSS/l
Endogenous Residue VSS	X_{EH}	368 mgVSS/l
Unbiodegradeable Organic VSS	X_I	210 mgVSS/l
Total VSS	X_U	1437 mgVSS/l
Influent Biodegradeable ISS	X_{IOI}	685 mgISS/l
TSS	X_t	2122 mgTSS/l

Active fraction of VSS	f_{av}	0.598 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.405 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.677 kgVSS/kgTSS

Waste Flow Rate	Q_w	1232 m ³ /d
TSS wasted per day		2614 kgTSS/d
VSS wasted per day		1770 kgVSS/d

Flux of N in waste VSS	FN_L	177 kgN/d
Equiv conc in influent	N_s	13.27 mgN/l influent
Effluent Sol Unbiol Org N	N_{ouse}	0.90 mgN/l

Factor of safety reducing μ_{AINT}	Sf	1.25
total unaerated mass fraction	f_{xt}	0.148
Minimum sludge age for nitrification	SRT_m	4.87 days
SRT_m with Safety factor	$SRT_{m(SF)}$	6.09 Nitrifies!

<u>If no nitrification</u>		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	34.9 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	34.0 mgFSA-N/l

<u>If complete nitrification</u>		
Effluent NO ₃	N_{ne}	34.0 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ae}	0.0 mgFSA-N/l

<u>Nitrification Results</u>		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	33.22 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	1.71 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.810 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.810 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	326.4 kgVSS

Denitrification	$K_{1(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	θ	1.2
	K_{1T}	0.3472 mgFSA/l
Denitrification	$K_{2(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	θ	1.08
	K_{2T}	0.0742 mgFSA/l

s-recycle ratio	s	1.00 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.401
Anoxic sludge mass fraction	f_{x1}	0.148 set = f_{xm} for balanced MLE
Min anoxic sludge mass fraction	f_{x1min}	0.032

Influent RBCOD fraction (Sbsi/Sbi)	$f_{Sb's}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	8.74 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	17.49 mgNO ₃ -N/l influent

	A	0.6993
	B	17.4756
	C	1.062
Optimal a-recycle ratio	a_{opt}	0.06
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00 set = a_{opt} for balanced MLE
	recycle limited	

Effluent Nitrate if recycle limited		16.61 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		16.08 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	16.61 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{te}$	18.32 mgN/l
N removal		62.0%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	731 mgVSS/l
Endogenous Residue VSS	X_{EH}	393 mgVSS/l
Unbiodegradeable Organic VSS	X_I	210 mgVSS/l
Total VSS	X_U	1334 mgVSS/l
Influent Biodegradeable ISS	X_{IOI}	666 mgISS/l
TSS	X_t	2000 mgTSS/l

Active fraction of VSS	f_{av}	0.548 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.365 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.667 kgVSS/kgTSS

Waste Flow Rate	Q_w	1232 m ³ /d
TSS wasted per day		2464 kgTSS/d
VSS wasted per day		1644 kgVSS/d

Flux of N in waste VSS	FN_L	164 kgN/d
Equiv conc in influent	N_s	12.33 mgN/l influent
Effluent Sol Unbiol Org N	N_{ouse}	0.90 mgN/l

Factor of safety reducing μ_{AINT}	Sf	1.25
total unaerated mass fraction	f_{xt}	0.148
Minimum sludge age for nitrification	SRT_m	1.77 days
SRT_m with Safety factor	$SRT_{m(SF)}$	2.21 Nitrifies!

<u>If no nitrification</u>		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	35.9 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	35.0 mgFSA-N/l

<u>If complete nitrification</u>		
Effluent NO ₃	N_{ne}	35.0 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ae}	0.0 mgFSA-N/l

<u>Nitrification Results</u>		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	34.48 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	1.40 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.496 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.496 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	317.4 kgVSS

Denitrification	$K_{1(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	θ	1.2
	K_{1T}	1.4930 mgFSA/l
Denitrification	$K_{2(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	θ	1.08
	K_{2T}	0.1374 mgFSA/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.747
Anoxic sludge mass fraction	f_{x1}	0.148
Min anoxic sludge mass fraction	f_{x1min}	0.009

Influent RBCOD fraction (Sbsi/Sbi)	$f_{Sb's}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	13.77 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	22.52 mgNO ₃ -N/l influent

	A	0.6993
	B	13.7091
	C	9.856
Optimal a-recycle ratio	a_{opt}	0.69
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00
	recycle limited	

Effluent Nitrate if recycle limited		17.24 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		12.31 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	17.24 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{te}$	18.63 mgN/l
N removal		61.3%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

MLE Reactor @ 10 Days SRT

Carbonaceous Oxygen flux	FO_c	5147 kgO/d
Nitrogenous Oxygen flux	FO_N	2024 kgO/d
Oxygen dmnd recover by denitrification	FO_D	633 kgO/d
Total Oxygen Demand ($FO_c + FO_N - FO_D$)	FO_T	6538 kgO/d
Oxygen utilisation rate	O_T	26.0 mgO/l.h

Alkalinity consumed by nitrification	237 mg CaCO ₃
Alkalinity recovered by denitrification	59 mg CaCO ₃
Total Alkalinity consumption	178 mg CaCO ₃

COD mass balance	
COD in (influent)	8252.0 kgCOD/d
COD out	8252.3 kgCOD/d
$Q_e S_{te} + Q_w S_{te}$	484.0 kgCOD/d
$Q_w X_{fv}$	2621.1 kgCOD/d
$V_P O_c$	5147.2 kgO/d

N mass balance	
N in (influent)	642.7 kgTKN-N/d
N out	642.7 kgTKN-N/d
$Q_e N_{te} + Q_w N_{te}$	22.8 kgTKN-N/d
$Q_i N_i$	177.0 kgTKN-N/d
$Q_i N_{ne}$	442.9 kgNO ₃ -N/d

TOD balance	
TOD in (influent)	11188.99 kgTOD/d
TOD out	11189.25 kgTOD/d
TOD _{effluent}	533.86 kgTOD/d
TOD _{waste}	3484.19 kgTOD/d
TOD _{N2-gas}	633.32 kgTOD/d
FO_t	6537.87 kgTOD/d

Flux of P in waste VSS	FP_s	44 kgP/d
Equiv conc in influent	P_s	3.32 mgP/l
Effluent Sol Unbiod Org P	P_{ouse}	0.60 mgP/l
Effluent TP	P_{te}	12.18 mgP/l
Effluent Ortho-P as P	P_{oe}	11.58 mgOP-P/l

Carbonaceous Oxygen flux	FO_c	5334 kgO/d
Nitrogenous Oxygen flux	FO_N	2101 kgO/d
Oxygen dmnd recover by denitrification	FO_D	657 kgO/d
Total Oxygen Demand ($FO_c + FO_N - FO_D$)	FO_T	6778 kgO/d
Oxygen utilisation rate	O_T	26.9 mgO/l.h

Alkalinity consumed by nitrification	246 mg CaCO ₃
Alkalinity recovered by denitrification	62 mg CaCO ₃
Total Alkalinity consumption	185 mg CaCO ₃

COD mass balance	
COD in (influent)	8252.0 kgCOD/d
COD out	8252.3 kgCOD/d
$Q_e S_{te} + Q_w S_{te}$	484.0 kgCOD/d
$Q_w X_{fv}$	2434.2 kgCOD/d
$V_P O_c$	5334.1 kgO/d

N mass balance	
N in (influent)	642.7 kgTKN-N/d
N out	642.7 kgTKN-N/d
$Q_e N_{te} + Q_w N_{te}$	18.6 kgTKN-N/d
$Q_i N_i$	164.4 kgTKN-N/d
$Q_i N_{ne}$	459.7 kgNO ₃ -N/d

TOD balance	
TOD in (influent)	11188.99 kgTOD/d
TOD out	11189.25 kgTOD/d
TOD _{effluent}	516.47 kgTOD/d
TOD _{waste}	3237.90 kgTOD/d
TOD _{N2-gas}	657.36 kgTOD/d
FO_t	6777.51 kgTOD/d

Flux of P in waste VSS	FP_s	41 kgP/d
Equiv conc in influent	P_s	3.08 mgP/l
Effluent Sol Unbiod Org P	P_{ouse}	0.00 mgP/l
Effluent TP	P_{te}	12.42 mgP/l
Effluent Ortho-P as P	P_{oe}	12.42 mgOP-P/l

Effluent Concentrations			General	Special	Unit	Effluent Concentrations			General	Special	Unit
Unbiod Sol COD	S_{use}	36.30	<75	<30	mgCOD/l	Unbiod Sol COD	S_{use}	36.30	<75	<30	mgCOD/l
Undiod Sol Org N	N_{ouse}	0.90	-	-	mgN/l	Undiod Sol Org N	N_{ouse}	0.90	-	-	mgN/l
FSA-N	N_{ae}	0.81	<6	<2	mgFSA-N/l	FSA-N	N_{ae}	0.50	<6	<2	mgFSA-N/l
TKN-N	N_{te}	1.71	-	-	mgTKN-N/l	TKN-N	N_{te}	1.40	-	-	mgTKN-N/l
Nitrate	N_{ne}	16.61	<15	<1.5	mgNO ₃ -N/l	Nitrate	N_{ne}	17.24	<15	<1.5	mgNO ₃ -N/l
Undiod Sol Org P	P_{ouse}	0.60	-	-	mgP/l	Undiod Sol Org P	P_{ouse}	0.00	-	-	mgP/l
Ortho P as P	P_{oe}	11.58	<10	<2.5	mgOP-P/l	Ortho P as P	P_{oe}	12.42	<10	<2.5	mgOP-P/l
TP	P_{te}	12.18	-	-	mgP/l	TP	P_{te}	12.42	-	-	mgP/l

MLE Reactor @ 15 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	13.3 MI/d
Sludge Age	SRT	15.0 days
Reactor TSS concentration	X _T	2871 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	619	8252
BPO COD	Sbpi	479	6385
UPO COD	Supi	29	383
	fs'up		0.0464
VFA COD	Sbsi,a	0.0	0
FBSO COD	Sbsfi	75	1000
BSO COD	Sbsi	75	1000
USO COD	Susi	36.3	484
	fs'us		0.0587
BO COD	Sbi	554	7385
UO COD	Sui	65	867
TSS		241	3210
ISS		51.4	685
VSS		189	2524
UPO VSS		19.4	259
BPO VSS		170	2266
TKN	Nti	48.2	643
Org N	Noi	13.8	184
FSA	Nai	34.4	459
BSO	Nobsi	2.90	39
USO	Nousi	0.90	12
BPO	Nobpi	8.70	116
UPO	Noupi	1.30	17
Total P	Pti	15.50	207
OP	Pai	12.80	171
Org P	Poi	2.70	36
BSO	Pobsi	0.70	9
USO	Pousi	0.60	8
BPO	Pobpi	0.78	10
UPO	Poupi	0.62	8

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{HV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,Bso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,uipo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,uipo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,uipo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{H20}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2141 /d
	μ _{Am20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.2829 /d
	b _{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0357 /d
	K _{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K _{nT}	0.6288 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	11838 kgVSS
Endogenous Residue VSS	MX _{EH}	7603 kgVSS
Unbiodegradable Organic VSS	MX _{EV}	3878 kgVSS
Total VSS	MX _V	23319 kgVSS
ISS from influent		10282 kgISS
ISS of OHO's		1776 kgISS
ISS	MX _{IOI}	12058 kgISS
TSS	MX _T	35377 kgTSS

Reactor Volume	Vp	12320 m ³
Nominal hydraulic retention time	R _{tn}	22.2 hr

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	13.3 MI/d
Sludge Age	SRT	15.0 days
Reactor TSS concentration	X _T	2722 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	618.9	8252
BPO COD	Sbpi	479	6385
UPO COD	Supi	29	383
	fs'up		0.04637
VFA COD	Sbsi,a	0	0
FBSO COD	Sbsfi	75	1000
BSO COD	Sbsi	75	1000
USO COD	Susi	36.3	484
	fs'us		0.05865
BO COD	Sbi	554	7385
UO COD	Sui	65	867
TSS		240.72727	3210
ISS		51.4	685
VSS		189.31818	2524
UPO VSS		19.39	259
BPO VSS		170	2266
TKN	Nti	48.2	643
Org N	Noi	13.8	184
FSA	Nai	34.4	459
BSO	Nobsi	2.90	38.7
USO	Nousi	0.90	12.0
BPO	Nobpi	8.70	116
UPO	Noupi	1.30	17
Total P	Pti	15.5	207
OP	Pai	12.8	171
Org P	Poi	2.7	36.0
BSO	Pobsi	0.7	9.3
USO	Pousi		
BPO	Pobpi	0.78	10
UPO	Poupi	0.62	8.27

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{HV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,Bso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,uipo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,uipo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,uipo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{H20}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2691 /d
	μ _{Am20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.7157 /d
	b _{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0448 /d
	K _{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K _{nT}	1.5904 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	9899 kgVSS
Endogenous Residue VSS	MX _{EH}	7990 kgVSS
Unbiodegradable Organic VSS	MX _{EV}	3878 kgVSS
Total VSS	MX _V	21768 kgVSS
ISS from influent		10282 kgISS
ISS of OHO's		1485 kgISS
ISS	MX _{IOI}	11767 kgISS
TSS	MX _T	33534 kgTSS

Reactor Volume	Vp	12320 m ³
Nominal hydraulic retention time	R _{tn}	22.2 hr

MLE Reactor @ 15 Days SRT

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	961 mgVSS/l
Endogenous Residue VSS	X_{EH}	617 mgVSS/l
Unbiodegradable Organic VSS	X_i	315 mgVSS/l
Total VSS	X_v	1893 mgVSS/l
Influent Biodegradable ISS	X_{iDI}	979 mgISS/l
TSS	X_t	2871 mgTSS/l

Active fraction of VSS	f_{av}	0.508 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.335 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.659 kgVSS/kgTSS

Waste Flow Rate	Q_w	821 m ³ /d
TSS wasted per day		2358 kgTSS/d
VSS wasted per day		1555 kgVSS/d

Flux of N in waste VSS	FN_v	155 kgN/d
Equiv conc in influent	N_s	11.66 mgN/l influent
Effluent Sol Unbiol Org N	N_{ouse}	0.90 mgN/l

Factor of safety reducing μ_{AOT}	Sf	1.25
total unaerated mass fraction	f_{xt}	0.148
Minimum sludge age for nitrification	SRT_m	4.87 days
SRT_m with Safety factor	$SRT_{m(SF)}$	6.09 Nitrifies!

<u>If no nitrification</u>		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	36.5 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	35.6 mgFSA-N/l

<u>If complete nitrification</u>		
Effluent NO ₃	N_{ne}	35.6 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ae}	0.0 mgFSA-N/l

<u>Nitrification Results</u>		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	35.18 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	1.36 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.464 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.464 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	458.3 kgVSS

Denitrification	$K_{1(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	θ	1.2
	K_{1T}	0.3472 mgFSA/l
Denitrification	$K_{2(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	θ	1.08
	K_{2T}	0.0742 mgFSA/l

s-recycle ratio	s	1.00 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.548
Anoxic sludge mass fraction	f_{x1}	0.148 set = f_{xm} for balanced MLE
Min anoxic sludge mass fraction	f_{x1min}	0.028

Influent RBCOD fraction (Sbsi/Sbi)	$f_{Sb's}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	9.78 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	18.53 mgNO ₃ -N/l influent

	A	0.6993
	B	18.3974
	C	1.179
Optimal a-recycle ratio	a_{opt}	0.06
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00 set = a_{opt} for balanced MLE
	recycle limited	

Effluent Nitrate if recycle limited		17.59 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		17.00 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	17.59 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{te}$	18.95 mgN/l
N removal		60.7%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Carbonaceous Oxygen flux	FO_c	5466 kgO/d
Nitrogenous Oxygen flux	FO_n	2143 kgO/d
Oxygen dmnd recover by denitrification	FO_D	671 kgO/d
Total Oxygen Demand ($FO_c + FO_n - FO_D$)	FO_T	6939 kgO/d
Oxygen utilisation rate	O_T	27.6 mgO/l.h

Alkalinity consumed by nitrification		251 mg CaCO ₃
Alkalinity recovered by denitrification		63 mg CaCO ₃
Total Alkalinity consumption		188 mg CaCO ₃

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	803 mgVSS/l
Endogenous Residue VSS	X_{EH}	649 mgVSS/l
Unbiodegradable Organic VSS	X_i	315 mgVSS/l
Total VSS	X_v	1767 mgVSS/l
Influent Biodegradable ISS	X_{iDI}	955 mgISS/l
TSS	X_t	2722 mgTSS/l

Active fraction of VSS	f_{av}	0.455 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.295 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.649 kgVSS/kgTSS

Waste Flow Rate	Q_w	821 m ³ /d
TSS wasted per day		2236 kgTSS/d
VSS wasted per day		1451 kgVSS/d

Flux of N in waste VSS	FN_v	145 kgN/d
Equiv conc in influent	N_s	10.88 mgN/l influent
Effluent Sol Unbiol Org N	N_{ouse}	0.90 mgN/l

Factor of safety reducing μ_{AOT}	Sf	1.25
total unaerated mass fraction	f_{xt}	0.148
Minimum sludge age for nitrification	SRT_m	1.77 days
SRT_m with Safety factor	$SRT_{m(SF)}$	2.21 Nitrifies!

<u>If no nitrification</u>		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	37.3 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	36.4 mgFSA-N/l

<u>If complete nitrification</u>		
Effluent NO ₃	N_{ne}	36.4 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ae}	0.0 mgFSA-N/l

<u>Nitrification Results</u>		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	36.06 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	1.26 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.356 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.356 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	431.2 kgVSS

Denitrification	$K_{1(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	θ	1.2
	K_{1T}	1.4930 mgFSA/l
Denitrification	$K_{2(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	θ	1.08
	K_{2T}	0.1374 mgFSA/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.805
Anoxic sludge mass fraction	f_{x1}	0.148
Min anoxic sludge mass fraction	f_{x1min}	0.008

Influent RBCOD fraction (Sbsi/Sbi)	$f_{Sb's}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	15.14 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	23.88 mgNO ₃ -N/l influent

	A	0.6993
	B	13.9251
	C	11.007
Optimal a-recycle ratio	a_{opt}	0.76
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00
	recycle limited	

Effluent Nitrate if recycle limited		18.03 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		12.53 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	18.03 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{te}$	19.29 mgN/l
N removal		60.0%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Carbonaceous Oxygen flux	FO_c	5619 kgO/d	234.1282
Nitrogenous Oxygen flux	FO_n	2197 kgO/d	91.55258
Oxygen dmnd recover by denitrification	FO_D	688 kgO/d	
Total Oxygen Demand ($FO_c + FO_n - FO_D$)	FO_T	7129 kgO/d	297.0331
Oxygen utilisation rate	O_T	28.3 mgO/l.h	

Alkalinity consumed by nitrification		257 mg CaCO ₃
Alkalinity recovered by denitrification		64 mg CaCO ₃
Total Alkalinity consumption		193 mg CaCO ₃

MLE Reactor @ 15 Days SRT

COD mass balance		
COD in (influent)		8252.0 kgCOD/d
COD out		8252.3 kgCOD/d
$Q_e S_{te} + Q_w S_{te}$		484.0 kgCOD/d
$Q_w X_r f_{cv}$		2302.4 kgCOD/d
$V_p O_c$		5465.9 kgO/d

N mass balance		
N in (influent)		642.7 kgTKN-N/d
N out		642.7 kgTKN-N/d
$Q_e N_{te} + Q_w N_{te}$		18.2 kgTKN-N/d
$Q_i N_i$		155.5 kgTKN-N/d
$Q_i N_{ne}$		469.0 kgNO3-N/d

TOD balance		
TOD in (influent)		11188.99 kgTOD/d
TOD out		11189.25 kgTOD/d
$TOD_{effluent}$		532.19 kgTOD/d
TOD_{waste}		3047.77 kgTOD/d
TOD_{N2-gas}		670.69 kgTOD/d
FO_t		6938.59 kgTOD/d

Flux of P in waste VSS	FP_s	39 kgP/d
Equiv conc in influent	P_s	2.91 mgP/l
Effluent Sol Unbiod Org P	P_{ouse}	0.60 mgP/l
Effluent TP	P_{te}	12.59 mgP/l
Effluent Ortho-P as P	P_{oe}	11.99 mgOP-P/l

COD mass balance		
COD in (influent)		8252.0 kgCOD/d
COD out		8252.3 kgCOD/d
$Q_e S_{te} + Q_w S_{te}$		484.0 kgCOD/d
$Q_w X_r f_{cv}$		2149.2 kgCOD/d
$V_p O_c$		5619.1 kgO/d

N mass balance		
N in (influent)		642.7 kgTKN-N/d
N out		642.7 kgTKN-N/d
$Q_e N_{te} + Q_w N_{te}$		16.7 kgTKN-N/d
$Q_i N_i$		145.1 kgTKN-N/d
$Q_i N_{ne}$		480.8 kgNO3-N/d

TOD balance		
TOD in (influent)		11188.99 kgTOD/d
TOD out		11189.25 kgTOD/d
$TOD_{effluent}$		526.01 kgTOD/d
TOD_{waste}		2846.89 kgTOD/d
TOD_{N2-gas}		687.55 kgTOD/d
FO_t		7128.79 kgTOD/d

Flux of P in waste VSS	FP_s	36 kgP/d
Equiv conc in influent	P_s	2.72 mgP/l
Effluent Sol Unbiod Org P	P_{ouse}	0.00 mgP/l
Effluent TP	P_{te}	12.78 mgP/l
Effluent Ortho-P as P	P_{oe}	12.78 mgOP-P/l

Effluent Concentrations			General	Special	Unit	Effluent Concentrations			General	Special	Unit
Unbiod Sol COD	S_{use}	36.30	<75	<30	mgCOD/l	Unbiod Sol COD	S_{use}	36.30	<75	<30	mgCOD/l
Undiod Sol Org N	N_{ouse}	0.90	-	-	mgN/l	Undiod Sol Org N	N_{ouse}	0.90	-	-	mgN/l
FSA-N	N_{ae}	0.46	<6	<2	mgFSA-N/l	FSA-N	N_{ae}	0.36	<6	<2	mgFSA-N/l
TKN-N	N_{te}	1.36	-	-	mgTKN-N/l	TKN-N	N_{te}	1.26	-	-	mgTKN-N/l
Nitrate	N_{ne}	17.59	<15	<1.5	mgNO ₃ -N/l	Nitrate	N_{ne}	18.03	<15	<1.5	mgNO ₃ -N/l
Undiod Sol Org P	P_{ouse}	0.60	-	-	mgP/l	Undiod Sol Org P	P_{ouse}	0.00	-	-	mgP/l
Ortho P as P	P_{oe}	11.99	<10	<2.5	mgOP-P/l	Ortho P as P	P_{oe}	12.78	<10	<2.5	mgOP-P/l
TP	P_{te}	12.59	-	-	mgP/l	TP	P_{te}	12.78	-	-	mgP/l

MLE Reactor @ 20 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	13.3 MI/d
Sludge Age	SRT	20.0 days
Reactor TSS concentration	X _T	3582 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	619	8252
BPO COD	Sbpi	479	6385
UPO COD	Supi	29	383
	fs'up		0.0464
VFA COD	Sbsi,a	0.0	0
FBSO COD	Sbsfi	75	1000
BSO COD	Sbsi	75	1000
USO COD	Susi	36.3	484
	fs'us		0.0587
BO COD	Sbi	554	7385
UO COD	Sui	65	867
TSS		241	3210
ISS		51.4	685
VSS		189	2524
UPO VSS		19.4	259
BPO VSS		170	2266
TKN	Nti	48.2	643
Org N	Noi	13.8	184
FSA	Nai	34.4	459
BSO	Nobsi	2.90	39
USO	Nousi	0.90	12
BPO	Nobpi	8.70	116
UPO	Noupi	1.30	17
Total P	Pti	15.50	207
OP	Pai	12.80	171
Org P	Poi	2.70	36
BSO	Pobsi	0.70	9
USO	Pousi	0.60	8
BPO	Pobpi	0.78	10
UPO	Poupi	0.62	8

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{HV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,FBSO}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,USO}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{N,UPO}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{P,UPO}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{C,UPO}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{H2O}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2141 /d
	μ _{AM20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ _{AMT}	0.2829 /d
	b _{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0357 /d
	K _{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K _{nT}	0.6288 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	12585 kgVSS
Endogenous Residue VSS	MX _{EH}	10777 kgVSS
Unbiodegradable Organic VSS	MX _{EV}	5171 kgVSS
Total VSS	MX _V	28533 kgVSS
ISS from influent		13709 kgISS
ISS of OHO's		1888 kgISS
ISS	MX _{IOI}	15597 kgISS
TSS	MX _T	44130 kgTSS

Reactor Volume	Vp	12320 m ³
Nominal hydraulic retention time	R _{tn}	22.2 hr

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	13.3 MI/d
Sludge Age	SRT	20.0 days
Reactor TSS concentration	X _T	3415 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	618.9	8252
BPO COD	Sbpi	479	6385
UPO COD	Supi	29	383
	fs'up		0.04637
VFA COD	Sbsi,a	0	0
FBSO COD	Sbsfi	75	1000
BSO COD	Sbsi	75	1000
USO COD	Susi	36.3	484
	fs'us		0.05865
BO COD	Sbi	554	7385
UO COD	Sui	65	867
TSS		240.72727	3210
ISS		51.4	685
VSS		189.31818	2524
UPO VSS		19.39	259
BPO VSS		170	2266
TKN	Nti	48.2	643
Org N	Noi	13.8	184
FSA	Nai	34.4	459
BSO	Nobsi	2.90	38.7
USO	Nousi	0.90	12.0
BPO	Nobpi	8.70	116
UPO	Noupi	1.30	17
Total P	Pti	15.5	207
OP	Pai	12.8	171
Org P	Poi	2.7	36.0
BSO	Pobsi	0.7	9.3
USO	Pousi		
BPO	Pobpi	0.78	10
UPO	Poupi	0.62	8.27

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{HV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,FBSO}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,USO}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{N,UPO}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{P,UPO}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{C,UPO}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{H2O}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2691 /d
	μ _{AM20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ _{AMT}	0.7157 /d
	b _{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0448 /d
	K _{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K _{nT}	1.5904 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	10416 kgVSS
Endogenous Residue VSS	MX _{EH}	11210 kgVSS
Unbiodegradable Organic VSS	MX _{EV}	5171 kgVSS
Total VSS	MX _V	26797 kgVSS
ISS from influent		13709 kgISS
ISS of OHO's		1562 kgISS
ISS	MX _{IOI}	15271 kgISS
TSS	MX _T	42069 kgTSS

Reactor Volume	Vp	12320 m ³
Nominal hydraulic retention time	R _{tn}	22.2 hr

MLE Reactor @ 20 Days SRT

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	1022 mgVSS/l
Endogenous Residue VSS	X_{EH}	875 mgVSS/l
Unbiodegradeable Organic VSS	X_i	420 mgVSS/l
Total VSS	X_v	2316 mgVSS/l
Influent Biodegradeable ISS	X_{iDI}	1266 mgISS/l
TSS	X_t	3582 mgTSS/l

Active fraction of VSS	f_{av}	0.441 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.285 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.647 kgVSS/kgTSS

Waste Flow Rate	Q_w	616 m ³ /d
TSS wasted per day		2207 kgTSS/d
VSS wasted per day		1427 kgVSS/d

Flux of N in waste VSS	FN_v	143 kgN/d
Equiv conc in influent	N_s	10.70 mgN/l influent
Effluent Sol Unbiol Org N	N_{ouse}	0.90 mgN/l

Factor of safety reducing μ_{AINT}	Sf	1.25
total unaerated mass fraction	f_{xt}	0.148
Minimum sludge age for nitrification	SRT_m	4.87 days
SRT_m with Safety factor	$SRT_{m(SF)}$	6.09 Nitrifies!

<u>If no nitrification</u>		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	37.5 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	36.6 mgFSA-N/l

<u>If complete nitrification</u>		
Effluent NO ₃	N_{ne}	36.6 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ae}	0.0 mgFSA-N/l

<u>Nitrification Results</u>		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	36.25 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	1.25 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.347 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.347 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	564.2 kgVSS

Denitrification	$K_{1(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	θ	1.2
	K_{1T}	0.3472 mgFSA/l
Denitrification	$K_{1(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	θ	1.08
	K_{1T}	0.0742 mgFSA/l

s-recycle ratio	s	1.00 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.621
Anoxic sludge mass fraction	f_{x1}	0.148 set = f_{xm} for balanced MLE
Min anoxic sludge mass fraction	f_{x1min}	0.027

Influent RBCOD fraction (Sbsi/Sbi)	$f_{Sb's}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	10.40 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	19.14 mgNO ₃ -N/l influent

	A	0.6993
	B	18.8571
	C	1.336
Optimal a-recycle ratio	a_{opt}	0.07
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00 set = a_{opt} for balanced MLE
	recycle limited	

Effluent Nitrate if recycle limited		18.13 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		17.46 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	18.13 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{te}$	19.37 mgN/l
N removal		59.8%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Carbonaceous Oxygen flux	FO_c	5655 kgO/d
Nitrogenous Oxygen flux	FO_N	2209 kgO/d
Oxygen dmnd recover by denitrification	FO_D	691 kgO/d
Total Oxygen Demand ($FO_c + FO_N - FO_D$)	FO_T	7173 kgO/d
Oxygen utilisation rate	O_T	28.5 mgO/l.h

Alkalinity consumed by nitrification		259 mg CaCO ₃
Alkalinity recovered by denitrification		65 mg CaCO ₃
Total Alkalinity consumption		194 mg CaCO ₃

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	845 mgVSS/l
Endogenous Residue VSS	X_{EH}	910 mgVSS/l
Unbiodegradeable Organic VSS	X_i	420 mgVSS/l
Total VSS	X_v	2175 mgVSS/l
Influent Biodegradeable ISS	X_{iDI}	1240 mgISS/l
TSS	X_t	3415 mgTSS/l

Active fraction of VSS	f_{av}	0.389 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.248 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.637 kgVSS/kgTSS

Waste Flow Rate	Q_w	616 m ³ /d
TSS wasted per day		2103 kgTSS/d
VSS wasted per day		1340 kgVSS/d

Flux of N in waste VSS	FN_v	134 kgN/d
Equiv conc in influent	N_s	10.05 mgN/l influent
Effluent Sol Unbiol Org N	N_{ouse}	0.90 mgN/l

Factor of safety reducing μ_{AINT}	Sf	1.25
total unaerated mass fraction	f_{xt}	0.148
Minimum sludge age for nitrification	SRT_m	1.77 days
SRT_m with Safety factor	$SRT_{m(SF)}$	2.21 Nitrifies!

<u>If no nitrification</u>		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	38.2 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	37.3 mgFSA-N/l

<u>If complete nitrification</u>		
Effluent NO ₃	N_{ne}	37.3 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ae}	0.0 mgFSA-N/l

<u>Nitrification Results</u>		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	36.96 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	1.19 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.293 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.293 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	519.6 kgVSS

Denitrification	$K_{1(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	θ	1.2
	K_{1T}	1.4930 mgFSA/l
Denitrification	$K_{1(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	θ	1.08
	K_{1T}	0.1374 mgFSA/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.834
Anoxic sludge mass fraction	f_{x1}	0.148
Min anoxic sludge mass fraction	f_{x1min}	0.007

Influent RBCOD fraction (Sbsi/Sbi)	$f_{Sb's}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	15.93 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	24.67 mgNO ₃ -N/l influent

	A	0.6993
	B	14.0322
	C	11.691
Optimal a-recycle ratio	a_{opt}	0.80
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00
	recycle limited	

Effluent Nitrate if recycle limited		18.48 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		12.63 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	18.48 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{te}$	19.67 mgN/l
N removal		59.2%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Carbonaceous Oxygen flux	FO_c	5784 kgO/d
Nitrogenous Oxygen flux	FO_N	2252 kgO/d
Oxygen dmnd recover by denitrification	FO_D	705 kgO/d
Total Oxygen Demand ($FO_c + FO_N - FO_D$)	FO_T	7331 kgO/d
Oxygen utilisation rate	O_T	29.1 mgO/l.h

Alkalinity consumed by nitrification		264 mg CaCO ₃
Alkalinity recovered by denitrification		66 mg CaCO ₃
Total Alkalinity consumption		198 mg CaCO ₃

MLE Reactor @ 20 Days SRT

COD mass balance		
COD in (influent)		8252 kgCOD/d
COD out		8252 kgCOD/d
$Q_e S_{te} + Q_w S_{te}$		484 kgCOD/d
$Q_w X_{f, cv}$		2113 kgCOD/d
$V_{\mu} O_c$		5655 kgO/d

N mass balance		
N in (influent)		642.7 kgTKN-N/d
N out		642.7 kgTKN-N/d
$Q_e N_{te} + Q_w N_{te}$		16.6 kgTKN-N/d
$Q_i N_i$		142.7 kgTKN-N/d
$Q_i N_{ne}$		483.4 kgNO3-N/d

TOD balance		
TOD in (influent)		11189 kgTOD/d
TOD out		11189 kgTOD/d
$TOD_{effluent}$		534 kgTOD/d
TOD_{waste}		2791 kgTOD/d
TOD_{N_2-gas}		691 kgTOD/d
FO_t		7173 kgTOD/d

Flux of P in waste VSS	FP_s	36 kgP/d
Equiv conc in influent	P_s	2.67 mgP/l
Effluent Sol Unbiol Org P	P_{ouse}	0.60 mgP/l
Effluent TP	P_{te}	12.83 mgP/l
Effluent Ortho-P as P	P_{oe}	12.23 mgOP-P/l

COD mass balance		
COD in (influent)		8252 kgCOD/d
COD out		8252 kgCOD/d
$Q_e S_{te} + Q_w S_{te}$		484.0 kgCOD/d
$Q_w X_{f, cv}$		1984.3 kgCOD/d
$V_{\mu} O_c$		5783.9 kgO/d

N mass balance		
N in (influent)		642.7 kgTKN-N/d
N out		642.7 kgTKN-N/d
$Q_e N_{te} + Q_w N_{te}$		15.9 kgTKN-N/d
$Q_i N_i$		134.0 kgTKN-N/d
$Q_i N_{ne}$		492.8 kgNO3-N/d

TOD balance		
TOD in (influent)		11189 kgTOD/d
TOD out		11189 kgTOD/d
$TOD_{effluent}$		531 kgTOD/d
TOD_{waste}		2622 kgTOD/d
TOD_{N_2-gas}		705 kgTOD/d
FO_t		7331 kgTOD/d

Flux of P in waste VSS	FP_s	33 kgP/d
Equiv conc in influent	P_s	2.51 mgP/l
Effluent Sol Unbiol Org P	P_{ouse}	0.00 mgP/l
Effluent TP	P_{te}	12.99 mgP/l
Effluent Ortho-P as P	P_{oe}	12.99 mgOP-P/l

Effluent Concentrations			General	Special	Unit	Effluent Concentrations			General	Special	Unit
Unbiol Sol COD	S_{use}	36.30	<75	<30	mgCOD/l	Unbiol Sol COD	S_{use}	36.30	<75	<30	mgCOD/l
Unbiol Sol Org N	N_{ouse}	0.90	-	-	mgN/l	Unbiol Sol Org N	N_{ouse}	0.90	-	-	mgN/l
FSA-N	N_{ae}	0.35	<6	<2	mgFSA-N/l	FSA-N	N_{ae}	0.29	<6	<2	mgFSA-N/l
TKN-N	N_{te}	1.25	-	-	mgTKN-N/l	TKN-N	N_{te}	1.19	-	-	mgTKN-N/l
Nitrate	N_{ne}	18.13	<15	<1.5	mgNO ₃ -N/l	Nitrate	N_{ne}	18.48	<15	<1.5	mgNO ₃ -N/l
Unbiol Sol Org P	P_{ouse}	0.60	-	-	mgP/l	Unbiol Sol Org P	P_{ouse}	0.00	-	-	mgP/l
Ortho P as P	P_{oe}	12.23	<10	<2.5	mgOP-P/l	Ortho P as P	P_{oe}	12.99	<10	<2.5	mgOP-P/l
TP	P_{te}	12.83	-	-	mgP/l	TP	P_{te}	12.99	-	-	mgP/l

MLE Reactor @ 25 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	13.3 MI/d
Sludge Age	SRT	25.0 days
Reactor TSS concentration	X _T	4273 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	619	8252
BPO COD	Sbpi	479	6385
UPO COD	Supi	29	383
	fs'up		0.0464
VFA COD	Sbsi,a	0.0	0
FBSO COD	Sbsfi	75	1000
BSO COD	Sbsi	75	1000
USO COD	Susi	36.3	484
	fs'us		0.0587
BO COD	Sbi	554	7385
UO COD	Sui	65	867
TSS		241	3210
ISS		51.4	685
VSS		189	2524
UPO VSS		19.4	259
BPO VSS		170	2266
TKN	Nti	48.2	643
Org N	Noi	13.8	184
FSA	Nai	34.4	459
BSO	Nobsi	2.90	39
USO	Nousi	0.90	12
BPO	Nobpi	8.70	116
UPO	Noupi	1.30	17
Total P	Pti	15.50	207
OP	Pai	12.80	171
Org P	Poi	2.70	36
BSO	Pobsi	0.70	9
USO	Pousi	0.60	8
BPO	Pobpi	0.78	10
UPO	Poupi	0.62	8

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{HV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,FBSO}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,USO}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,UPO}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,UPO}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,UPO}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{H2O}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2141 /d
	μ _{AM20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ _{AMT}	0.2829 /d
	b _{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0357 /d
	K _{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K _{nT}	0.6288 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	13081 kgVSS
Endogenous Residue VSS	MX _{EH}	14001 kgVSS
Unbiodegradable Organic VSS	MX _{UV}	6464 kgVSS
Total VSS	MX _V	33546 kgVSS
ISS from influent		17136 kgISS
ISS of OHO's		1962 kgISS
ISS	MX _{IOI}	19098 kgISS
TSS	MX _T	52644 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{tn}	22.2 hr

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	13.3 MI/d
Sludge Age	SRT	25.0 days
Reactor TSS concentration	X _T	4094 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	618.9	8252
BPO COD	Sbpi	479	6385
UPO COD	Supi	29	383
	fs'up		0.04637
VFA COD	Sbsi,a	0	0
FBSO COD	Sbsfi	75	1000
BSO COD	Sbsi	75	1000
USO COD	Susi	36.3	484
	fs'us		0.05865
BO COD	Sbi	554	7385
UO COD	Sui	65	867
TSS		240.72727	3210
ISS		51.4	685
VSS		189.31818	2524
UPO VSS		19.39	259
BPO VSS		170	2266
TKN	Nti	48.2	643
Org N	Noi	13.8	184
FSA	Nai	34.4	459
BSO	Nobsi	2.90	38.7
USO	Nousi	0.90	12.0
BPO	Nobpi	8.70	116
UPO	Noupi	1.30	17
Total P	Pti	15.5	207
OP	Pai	12.8	171
Org P	Poi	2.7	36.0
BSO	Pobsi	0.7	9.3
USO	Pousi		
BPO	Pobpi	0.78	10
UPO	Poupi	0.62	8.27

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{HV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,FBSO}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,USO}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,UPO}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,UPO}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,UPO}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{H2O}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2691 /d
	μ _{AM20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ _{AMT}	0.7157 /d
	b _{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0448 /d
	K _{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K _{nT}	1.5904 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	10753 kgVSS
Endogenous Residue VSS	MX _{EH}	14466 kgVSS
Unbiodegradable Organic VSS	MX _{UV}	6464 kgVSS
Total VSS	MX _V	31683 kgVSS
ISS from influent		17136 kgISS
ISS of OHO's		1613 kgISS
ISS	MX _{IOI}	18749 kgISS
TSS	MX _T	50432 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{tn}	22.2 hr

MLE Reactor @ 25 Days SRT

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	1062 mgVSS/l
Endogenous Residue VSS	X_{EH}	1136 mgVSS/l
Unbiodegradeable Organic VSS	X_i	525 mgVSS/l
Total VSS	X_v	2723 mgVSS/l
Influent Biodegradeable ISS	X_{iDI}	1550 mgISS/l
TSS	X_t	4273 mgTSS/l

Active fraction of VSS	f_{av}	0.390 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.248 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.637 kgVSS/kgTSS

Waste Flow Rate	Q_w	493 m ³ /d
TSS wasted per day		2106 kgTSS/d
VSS wasted per day		1342 kgVSS/d

Flux of N in waste VSS	FN_i	134 kgN/d
Equiv conc in influent	N_s	10.06 mgN/l influent
Effluent Sol Unbiol Org N	N_{ouse}	0.90 mgN/l

Factor of safety reducing μ_{AINT}	Sf	1.25
total unaerated mass fraction	f_{xt}	0.148
Minimum sludge age for nitrification	SRT_m	4.87 days
SRT_m with Safety factor	$SRT_{m(SF)}$	6.09 Nitrifies!

<u>If no nitrification</u>		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{ie}	38.1 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	37.2 mgFSA-N/l

<u>If complete nitrification</u>		
Effluent NO ₃	N_{ne}	37.2 mgNO ₃ -N/l
Effluent TKN-N	N_{ie}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ae}	0.0 mgFSA-N/l

<u>Nitrification Results</u>		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	36.95 mgNO ₃ -N/l
Effluent TKN-N	N_{ie}	1.19 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.288 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.288 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	651.0 kgVSS

Denitrification	$K_{1(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	θ	1.2
	K_{1T}	0.3472 mgFSA/l
Denitrification	$K_{2(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	θ	1.08
	K_{2T}	0.0742 mgFSA/l

s-recycle ratio	s	1.00 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.666
Anoxic sludge mass fraction	f_{x1}	0.148 set = f_{xm} for balanced MLE
Min anoxic sludge mass fraction	f_{x1min}	0.026

Influent RBCOD fraction (Sbsi/Sbi)	$f_{Sb's}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	10.81 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	19.55 mgNO ₃ -N/l influent

	A	0.6993
	B	19.1432
	C	1.459
Optimal a-recycle ratio	a_{opt}	0.08
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00 set = a_{opt} for balanced MLE
	recycle limited	

Effluent Nitrate if recycle limited		18.47 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		17.74 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	18.47 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{ie}$	19.66 mgN/l
N removal		59.2%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Carbonaceous Oxygen flux	FO_c	5781 kgO/d
Nitrogenous Oxygen flux	FO_n	2251 kgO/d
Oxygen dmnd recover by denitrification	FO_D	704 kgO/d
Total Oxygen Demand ($FO_c + FO_n - FO_D$)	FO_T	7328 kgO/d
Oxygen utilisation rate	O_T	29.1 mgO/l.h

Alkalinity consumed by nitrification		264 mg CaCO ₃
Alkalinity recovered by denitrification		66 mg CaCO ₃
Total Alkalinity consumption		198 mg CaCO ₃

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	873 mgVSS/l
Endogenous Residue VSS	X_{EH}	1174 mgVSS/l
Unbiodegradeable Organic VSS	X_i	525 mgVSS/l
Total VSS	X_v	2572 mgVSS/l
Influent Biodegradeable ISS	X_{iDI}	1522 mgISS/l
TSS	X_t	4094 mgTSS/l

Active fraction of VSS	f_{av}	0.339 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.213 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.628 kgVSS/kgTSS

Waste Flow Rate	Q_w	493 m ³ /d
TSS wasted per day		2017 kgTSS/d
VSS wasted per day		1267 kgVSS/d

Flux of N in waste VSS	FN_i	127 kgN/d
Equiv conc in influent	N_s	9.50 mgN/l influent
Effluent Sol Unbiol Org N	N_{ouse}	0.90 mgN/l

Factor of safety reducing μ_{AINT}	Sf	1.25
total unaerated mass fraction	f_{xt}	0.148
Minimum sludge age for nitrification	SRT_m	1.77 days
SRT_m with Safety factor	$SRT_{m(SF)}$	2.21 Nitrifies!

<u>If no nitrification</u>		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{ie}	38.7 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	37.8 mgFSA-N/l

<u>If complete nitrification</u>		
Effluent NO ₃	N_{ne}	37.8 mgNO ₃ -N/l
Effluent TKN-N	N_{ie}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ae}	0.0 mgFSA-N/l

<u>Nitrification Results</u>		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	37.54 mgNO ₃ -N/l
Effluent TKN-N	N_{ie}	1.16 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.257 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.257 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	589.9 kgVSS

Denitrification	$K_{1(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	θ	1.2
	K_{1T}	1.4930 mgFSA/l
Denitrification	$K_{2(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	θ	1.08
	K_{2T}	0.1374 mgFSA/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.852
Anoxic sludge mass fraction	f_{x1}	0.148
Min anoxic sludge mass fraction	f_{x1min}	0.007

Influent RBCOD fraction (Sbsi/Sbi)	$f_{Sb's}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	16.44 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	25.19 mgNO ₃ -N/l influent

	A	0.6993
	B	14.0969
	C	12.141
Optimal a-recycle ratio	a_{opt}	0.83
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00
	recycle limited	

Effluent Nitrate if recycle limited		18.77 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		12.70 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	18.77 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{ie}$	19.93 mgN/l
N removal		58.7%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Carbonaceous Oxygen flux	FO_c	5891 kgO/d
Nitrogenous Oxygen flux	FO_n	2287 kgO/d
Oxygen dmnd recover by denitrification	FO_D	716 kgO/d
Total Oxygen Demand ($FO_c + FO_n - FO_D$)	FO_T	7463 kgO/d
Oxygen utilisation rate	O_T	29.6 mgO/l.h

Alkalinity consumed by nitrification		268 mg CaCO ₃
Alkalinity recovered by denitrification		67 mg CaCO ₃
Total Alkalinity consumption		201 mg CaCO ₃

MLE Reactor @ 25 Days SRT

COD mass balance		
COD in (influent)		8252.0 kgCOD/d
COD out		8252.3 kgCOD/d
$Q_e S_{te} + Q_w S_{te}$		484.0 kgCOD/d
$Q_w X_{f, cv}$		1987.2 kgCOD/d
$V_P O_c$		5781.0 kgO/d

N mass balance		
N in (influent)		642.7 kgTKN-N/d
N out		642.7 kgTKN-N/d
$Q_e N_{te} + Q_w N_{te}$		15.8 kgTKN-N/d
$Q_i N_i$		134.2 kgTKN-N/d
$Q_i N_{ne}$		492.6 kgNO3-N/d

TOD balance		
TOD in (influent)		11188.99 kgTOD/d
TOD out		11189.25 kgTOD/d
TOD _{effluent}		535.82 kgTOD/d
TOD _{waste}		2621.02 kgTOD/d
TOD _{N2-gas}		704.48 kgTOD/d
FO _t		7327.92 kgTOD/d

Flux of P in waste VSS	FP _s	34 kgP/d
Equiv conc in influent	P _s	2.52 mgP/l
Effluent Sol Unbiol Org P	P _{ouse}	0.60 mgP/l
Effluent TP	P _{te}	12.98 mgP/l
Effluent Ortho-P as P	P _{oe}	12.38 mgOP-P/l

COD mass balance		
COD in (influent)		8252.0 kgCOD/d
COD out		8252.3 kgCOD/d
$Q_e S_{te} + Q_w S_{te}$		484.0 kgCOD/d
$Q_w X_{f, cv}$		1876.9 kgCOD/d
$V_P O_c$		5891.3 kgO/d

N mass balance		
N in (influent)		642.7 kgTKN-N/d
N out		642.7 kgTKN-N/d
$Q_e N_{te} + Q_w N_{te}$		15.4 kgTKN-N/d
$Q_i N_i$		126.7 kgTKN-N/d
$Q_i N_{ne}$		500.5 kgNO3-N/d

TOD balance		
TOD in (influent)		11188.99 kgTOD/d
TOD out		11189.25 kgTOD/d
TOD _{effluent}		534.02 kgTOD/d
TOD _{waste}		2476.57 kgTOD/d
TOD _{N2-gas}		715.72 kgTOD/d
FO _t		7462.93 kgTOD/d

Flux of P in waste VSS	FP _s	32 kgP/d
Equiv conc in influent	P _s	2.38 mgP/l
Effluent Sol Unbiol Org P	P _{ouse}	0.00 mgP/l
Effluent TP	P _{te}	13.12 mgP/l
Effluent Ortho-P as P	P _{oe}	13.12 mgOP-P/l

Effluent Concentrations			General	Special	Unit	Effluent Concentrations			General	Special	Unit
Unbiol Sol COD	S _{use}	36.30	<75	<30	mgCOD/l	Unbiol Sol COD	S _{use}	36.30	<75	<30	mgCOD/l
Unbiol Sol Org N	N _{ouse}	0.90	-	-	mgN/l	Unbiol Sol Org N	N _{ouse}	0.90	-	-	mgN/l
FSA-N	N _{ae}	0.29	<6	<2	mgFSA-N/l	FSA-N	N _{ae}	0.26	<6	<2	mgFSA-N/l
TKN-N	N _{te}	1.19	-	-	mgTKN-N/l	TKN-N	N _{te}	1.16	-	-	mgTKN-N/l
Nitrate	N _{ne}	18.47	<15	<1.5	mgNO ₃ -N/l	Nitrate	N _{ne}	18.77	<15	<1.5	mgNO ₃ -N/l
Unbiol Sol Org P	P _{ouse}	0.60	-	-	mgP/l	Unbiol Sol Org P	P _{ouse}	0.00	-	-	mgP/l
Ortho P as P	P _{oe}	12.38	<10	<2.5	mgOP-P/l	Ortho P as P	P _{oe}	13.12	<10	<2.5	mgOP-P/l
TP	P _{te}	12.98	-	-	mgP/l	TP	P _{te}	13.12	-	-	mgP/l

MLE Reactor @ 30 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	13.3 MI/d
Sludge Age	SRT	30.0 days
Reactor TSS concentration	X _T	4953 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	619	8252
BPO COD	Sbpi	479	6385
UPO COD	Supi	29	383
	fs'up		0.0464
VFA COD	Sbsi,a	0.0	0
FBSO COD	Sbsfi	75	1000
BSO COD	Sbsi	75	1000
USO COD	Susi	36.3	484
	fs'us		0.0587
BO COD	Sbi	554	7385
UO COD	Sui	65	867
TSS		241	3210
ISS		51.4	685
VSS		189	2524
UPO VSS		19.4	259
BPO VSS		170	2266
TKN	Nti	48.2	643
Org N	Noi	13.8	184
FSA	Nai	34.4	459
BSO	Nobsi	2.90	39
USO	Nousi	0.90	12
BPO	Nobpi	8.70	116
UPO	Noupi	1.30	17
Total P	Pti	15.50	207
OP	Pai	12.80	171
Org P	Poi	2.70	36
BSO	Pobsi	0.70	9
USO	Pousi	0.60	8
BPO	Pobpi	0.78	10
UPO	Poupi	0.62	8

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{HV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,BSO}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,USO}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{N,UPO}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{P,UPO}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{C,UPO}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{H20}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2141 /d
	μ _{AM20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ _{AMT}	0.2829 /d
	b _{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0357 /d
	K _{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K _{nT}	0.6288 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	13433 kgVSS
Endogenous Residue VSS	MX _{EH}	17254 kgVSS
Unbiodegradeable Organic VSS	MX _{UV}	7757 kgVSS
Total VSS	MX _V	38444 kgVSS
ISS from influent		20564 kgISS
ISS of OHO's		2015 kgISS
ISS	MX _{IOI}	22579 kgISS
TSS	MX _T	61022 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{tn}	22.2 hr

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	13.3 MI/d
Sludge Age	SRT	30.0 days
Reactor TSS concentration	X _T	4765 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	618.9	8252
BPO COD	Sbpi	479	6385
UPO COD	Supi	29	383
	fs'up		0.04637
VFA COD	Sbsi,a	0	0
FBSO COD	Sbsfi	75	1000
BSO COD	Sbsi	75	1000
USO COD	Susi	36.3	484
	fs'us		0.05865
BO COD	Sbi	554	7385
UO COD	Sui	65	867
TSS		240.72727	3210
ISS		51.4	685
VSS		189.31818	2524
UPO VSS		19.39	259
BPO VSS		170	2266
TKN	Nti	48.2	643
Org N	Noi	13.8	184
FSA	Nai	34.4	459
BSO	Nobsi	2.90	38.7
USO	Nousi	0.90	12.0
BPO	Nobpi	8.70	116
UPO	Noupi	1.30	17
Total P	Pti	15.5	207
OP	Pai	12.8	171
Org P	Poi	2.7	36.0
BSO	Pobsi	0.7	9.3
USO	Pousi		
BPO	Pobpi	0.78	10
UPO	Poupi	0.62	8.27

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{HV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,BSO}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,USO}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{N,UPO}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{P,UPO}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{C,UPO}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{H20}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2691 /d
	μ _{AM20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ _{AMT}	0.7157 /d
	b _{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0448 /d
	K _{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K _{nT}	1.5904 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	10990 kgVSS
Endogenous Residue VSS	MX _{EH}	17742 kgVSS
Unbiodegradeable Organic VSS	MX _{UV}	7757 kgVSS
Total VSS	MX _V	36489 kgVSS
ISS from influent		20564 kgISS
ISS of OHO's		1648 kgISS
ISS	MX _{IOI}	22212 kgISS
TSS	MX _T	58701 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{tn}	22.2 hr

MLE Reactor @ 30 Days SRT

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	1090 mgVSS/l
Endogenous Residue VSS	X_{EH}	1400 mgVSS/l
Unbiodegradeable Organic VSS	X_i	630 mgVSS/l
Total VSS	X_v	3120 mgVSS/l
Influent Biodegradeable ISS	X_{iDI}	1833 mgISS/l
TSS	X_t	4953 mgTSS/l

Active fraction of VSS	f_{av}	0.349 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.220 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.630 kgVSS/kgTSS

Waste Flow Rate	Q_w	411 m ³ /d
TSS wasted per day		2034 kgTSS/d
VSS wasted per day		1281 kgVSS/d

Flux of N in waste VSS	FN_v	128 kgN/d
Equiv conc in influent	N_s	9.61 mgN/l influent
Effluent Sol Unbiol Org N	N_{ouse}	0.90 mgN/l

Factor of safety reducing μ_{AINT}	Sf	1.25
total unaerated mass fraction	f_{xt}	0.148
Minimum sludge age for nitrification	SRT_m	4.87 days
SRT_m with Safety factor	$SRT_{m(SF)}$	6.09 Nitrifies!

<u>If no nitrification</u>		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	38.6 mgTKN-N/l
Effluent FSA-N	$N_{be} = N_{bn}$	37.7 mgFSA-N/l

<u>If complete nitrification</u>		
Effluent NO ₃	N_{ne}	37.7 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	0.9 mgTKN-N/l
Effluent FSA-N	N_{be}	0.0 mgFSA-N/l

<u>Nitrification Results</u>		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	37.44 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	1.15 mgTKN-N/l
(calculated N_{be})	(N_{be})	0.252 mgFSA-N/l
Effluent FSA-N	N_{be}	0.252 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	723.3 kgVSS

Denitrification	$K_{1(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	θ	1.2
	K_{1T}	0.3472 mgFSA/l
Denitrification	$K_{2(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	θ	1.08
	K_{2T}	0.0742 mgFSA/l

s-recycle ratio	s	1.00 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.695
Anoxic sludge mass fraction	f_{x1}	0.148 set = f_{xm} for balanced MLE
Min anoxic sludge mass fraction	f_{x1min}	0.025

Influent RBCOD fraction (Sbsi/Sbi)	$f_{Sb's}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	11.10 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	19.84 mgNO ₃ -N/l influent

	A	0.6993
	B	19.3403
	C	1.553
Optimal a-recycle ratio	a_{opt}	0.08
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00 set = a_{opt} for balanced MLE
	recycle limited	

Effluent Nitrate if recycle limited		18.72 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		17.94 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	18.72 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{te}$	19.87 mgN/l
N removal		58.8%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Carbonaceous Oxygen flux	FO_c	5870 kgO/d
Nitrogenous Oxygen flux	FO_N	2281 kgO/d
Oxygen dmnd recover by denitrification	FO_D	714 kgO/d
Total Oxygen Demand ($FO_c + FO_N - FO_D$)	FO_T	7438 kgO/d
Oxygen utilisation rate	O_T	29.5 mgO/l.h

Alkalinity consumed by nitrification		267 mg CaCO ₃
Alkalinity recovered by denitrification		67 mg CaCO ₃
Total Alkalinity consumption		200 mg CaCO ₃

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	892 mgVSS/l
Endogenous Residue VSS	X_{EH}	1440 mgVSS/l
Unbiodegradeable Organic VSS	X_i	630 mgVSS/l
Total VSS	X_v	2962 mgVSS/l
Influent Biodegradeable ISS	X_{iDI}	1803 mgISS/l
TSS	X_t	4765 mgTSS/l

Active fraction of VSS	f_{av}	0.301 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.187 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.622 kgVSS/kgTSS

Waste Flow Rate	Q_w	411 m ³ /d
TSS wasted per day		1957 kgTSS/d
VSS wasted per day		1216 kgVSS/d

Flux of N in waste VSS	FN_v	122 kgN/d
Equiv conc in influent	N_s	9.12 mgN/l influent
Effluent Sol Unbiol Org N	N_{ouse}	0.90 mgN/l

Factor of safety reducing μ_{AINT}	Sf	1.25
total unaerated mass fraction	f_{xt}	0.148
Minimum sludge age for nitrification	SRT_m	1.77 days
SRT_m with Safety factor	$SRT_{m(SF)}$	2.21 Nitrifies!

<u>If no nitrification</u>		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	39.1 mgTKN-N/l
Effluent FSA-N	$N_{be} = N_{bn}$	38.2 mgFSA-N/l

<u>If complete nitrification</u>		
Effluent NO ₃	N_{ne}	38.2 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	0.9 mgTKN-N/l
Effluent FSA-N	N_{be}	0.0 mgFSA-N/l

<u>Nitrification Results</u>		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	37.94 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	1.13 mgTKN-N/l
(calculated N_{be})	(N_{be})	0.234 mgFSA-N/l
Effluent FSA-N	N_{be}	0.234 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	647.1 kgVSS

Denitrification	$K_{1(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	θ	1.2
	K_{1T}	1.4930 mgFSA/l
Denitrification	$K_{2(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	θ	1.08
	K_{2T}	0.1374 mgFSA/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.863
Anoxic sludge mass fraction	f_{x1}	0.148
Min anoxic sludge mass fraction	f_{x1min}	0.007

Influent RBCOD fraction (Sbsi/Sbi)	$f_{Sb's}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	16.80 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	25.55 mgNO ₃ -N/l influent

	A	0.6993
	B	14.1403
	C	12.460
Optimal a-recycle ratio	a_{opt}	0.85
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00
	recycle limited	

Effluent Nitrate if recycle limited		18.97 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		12.74 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	18.97 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{te}$	20.11 mgN/l
N removal		58.3%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Carbonaceous Oxygen flux	FO_c	5967 kgO/d
Nitrogenous Oxygen flux	FO_N	2312 kgO/d
Oxygen dmnd recover by denitrification	FO_D	723 kgO/d
Total Oxygen Demand ($FO_c + FO_N - FO_D$)	FO_T	7555 kgO/d
Oxygen utilisation rate	O_T	30.0 mgO/l.h

Alkalinity consumed by nitrification		271 mg CaCO ₃
Alkalinity recovered by denitrification		68 mg CaCO ₃
Total Alkalinity consumption		203 mg CaCO ₃

MLE Reactor @ 30 Days SRT

COD mass balance		
COD in (influent)	8252.0	kgCOD/d
COD out	8252.3	kgCOD/d
$Q_e S_{te} + Q_w S_{te}$	484.0	kgCOD/d
$Q_w X_{f, cv}$	1897.8	kgCOD/d
$V_{\mu} O_c$	5870.4	kgO/d

N mass balance		
N in (influent)	642.7	kgTKN-N/d
N out	642.7	kgTKN-N/d
$Q_e N_{te} + Q_w N_{te}$	15.4	kgTKN-N/d
$Q_i N_i$	128.1	kgTKN-N/d
$Q_i N_{ne}$	499.2	kgNO3-N/d

TOD balance		
TOD in (influent)	11188.99	kgTOD/d
TOD out	11189.25	kgTOD/d
TOD _{effluent}	537.15	kgTOD/d
TOD _{waste}	2500.54	kgTOD/d
TOD _{N2-gas}	713.79	kgTOD/d
FO _t	7437.77	kgTOD/d

Flux of P in waste VSS	FP _s	32	kgP/d
Equiv conc in influent	P _s	2.40	mgP/l
Effluent Sol Unbiol Org P	P _{ouse}	0.60	mgP/l
Effluent TP	P _{te}	13.10	mgP/l
Effluent Ortho-P as P	P _{oe}	12.50	mgOP-P/l

COD mass balance		
COD in (influent)	8252.0	kgCOD/d
COD out	8252.3	kgCOD/d
$Q_e S_{te} + Q_w S_{te}$	484.0	kgCOD/d
$Q_w X_{f, cv}$	1801.3	kgCOD/d
$V_{\mu} O_c$	5966.9	kgO/d

N mass balance		
N in (influent)	642.7	kgTKN-N/d
N out	642.7	kgTKN-N/d
$Q_e N_{te} + Q_w N_{te}$	15.1	kgTKN-N/d
$Q_i N_i$	121.6	kgTKN-N/d
$Q_i N_{ne}$	505.9	kgNO3-N/d

TOD balance		
TOD in (influent)	11188.99	kgTOD/d
TOD out	11189.25	kgTOD/d
TOD _{effluent}	536.06	kgTOD/d
TOD _{waste}	2374.22	kgTOD/d
TOD _{N2-gas}	723.46	kgTOD/d
FO _t	7555.50	kgTOD/d

Flux of P in waste VSS	FP _s	30	kgP/d
Equiv conc in influent	P _s	2.28	mgP/l
Effluent Sol Unbiol Org P	P _{ouse}	0.00	mgP/l
Effluent TP	P _{te}	13.22	mgP/l
Effluent Ortho-P as P	P _{oe}	13.22	mgOP-P/l

Effluent Concentrations			General	Special	Unit	Effluent Concentrations			General	Special	Unit
Unbiol Sol COD	S _{use}	36.30	<75	<30	mgCOD/l	Unbiol Sol COD	S _{use}	36.30	<75	<30	mgCOD/l
Unbiol Sol Org N	N _{ouse}	0.90	-	-	mgN/l	Unbiol Sol Org N	N _{ouse}	0.90	-	-	mgN/l
FSA-N	N _{ae}	0.25	<6	<2	mgFSA-N/l	FSA-N	N _{ae}	0.23	<6	<2	mgFSA-N/l
TKN-N	N _{te}	1.15	-	-	mgTKN-N/l	TKN-N	N _{te}	1.13	-	-	mgTKN-N/l
Nitrate	N _{ne}	18.72	<15	<1.5	mgNO ₃ -N/l	Nitrate	N _{ne}	18.97	<15	<1.5	mgNO ₃ -N/l
Unbiol Sol Org P	P _{ouse}	0.60	-	-	mgP/l	Unbiol Sol Org P	P _{ouse}	0.00	-	-	mgP/l
Ortho P as P	P _{oe}	12.50	<10	<2.5	mgOP-P/l	Ortho P as P	P _{oe}	13.22	<10	<2.5	mgOP-P/l
TP	P _{te}	13.10	-	-	mgP/l	TP	P _{te}	13.22	-	-	mgP/l

UCT Reactor @ 10 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	16.67 Ml/d
Sludge Age	SRT	10.0 days
Reactor TSS concentration	X _r	3139.16 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti 619	10315
BPO COD	Sbpi 479	7982
UPO COD	Supi 29	478
	f _S up	0.046
VFA COD	Sbsi,a 0.0	0
FBSO COD	Sbsfi 75	1250
BSO COD	Sbsi 75	1250
USO COD	Susi 36.3	605
	f _S us	0.059
BO COD	Sbi 554	9232
UO COD	Sui 65	1083
TSS	241	4012
ISS	51.4	857
VSS	189	3155
UPO VSS	19.4	323
BPO VSS	170	2832
TKN	Nti 48.2	803
Org N	Noi 13.8	230
FSA	Nai 34.4	573
BSO	Nobsi 2.90	48
USO	Nousi 0.90	15
BPO	Nobpi 8.70	145
UPO	Noupi 1.30	22
Total P	Pti 15.50	258
OP	Pai 12.80	213
Org P	Poi 2.70	45
BSO	Pobsi 0.70	12
USO	Pousi 0.60	10
BPO	Pobpi 0.78	13
UPO	Poupi 0.62	10

COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _h	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{hco}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{er}	0.2
ISS content of OHO's	f _{coHO}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{co,FBSO}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{co,USO}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{N,UPO}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{P,UPO}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{C,UPO}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{h20}	0.24 /d
Endogenous respiration rate heterotrophs	θ _h	1.029
	b _{h,T}	0.2141 /d
	θ _{h20}	0.45 /d
nitrifiers max spec. growth rate	θ _{h20}	1.123
	θ _{h20}	0.2829 /d
Endogenous respiration rate autotrophs	b _{a20}	0.0400 /d
	θ _a	1.029
	b _{a,T}	0.0357 /d
Nitrification	K _{a20}	1.0 mgFSA/l
Half Saturation Coefficient	θ _a	1.123
	K _{a,T}	0.6288 mgFSA/l
Denitrification	K _{s(20)}	0.72
Half Saturation Coefficient	θ _d	1.2
	K _{d,T}	0.3472
Denitrification	K _{s(20)}	0.101
for ND system	θ _d	1.08
Half Saturation Coefficient	K _{d,T}	0.0742
Denitrification	K ⁺ _{s(20)}	0.255
primary anoxic of NDBPER system	θ _d	1.08
Half Saturation Coefficient	K ⁺ _{d,T}	0.1874

Factor of safety reducing μ _{h,nit}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _{min}	6.76 days
SRT _{min} (with safety factor)	SRT _{min}	8.45 Nitrifies!

Max unaerated sludge mass fraction	f _{xm}	0.40
Total unaerated sludge mass fraction	f _{xt}	0.35
Anoxic mass fraction primary anox 2	f _{x,prim anox 2}	0.21
Anaerobic mass fraction	f _{x,anox}	0.08
Aerobic mass fraction	f _{bio}	0.65

Nr of equal size compartments 2

r-recycle ratio	r	1.0 : 1
r-recycle NO ₃ concentration	N _{br}	3.9 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{O2,s}	0.0 mgO/l

influent NO ₃ concentration	S _{NO3br}	0.0 mgNO ₃ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	1.000 : 1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)	f _{Sb/s}	0.135

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	16.67 Ml/d
Sludge Age	SRT	10.0 days
Reactor TSS concentration	X _r	2969 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti 619	10315
BPO COD	Sbpi 479	7982
UPO COD	Supi 29	478
	f _S up	0.046
VFA COD	Sbsi,a 0	0
FBSO COD	Sbsfi 75	1250
BSO COD	Sbsi 75	1250
USO COD	Susi 36	605
	f _S us	0.059
BO COD	Sbi 554	9232
UO COD	Sui 65	1083
TSS	241	4012
ISS	51	857
VSS	189	3155
UPO VSS	19	323
BPO VSS	170	2832
TKN	Nti 48	803
Org N	Noi 14	230
FSA	Nai 34	573
BSO	Nobsi 2.90	48
USO	Nousi 0.90	15
BPO	Nobpi 8.70	145
UPO	Noupi 1.30	22
Total P	Pti 15.50	258
OP	Pai 12.80	213
Org P	Poi 2.70	45
BSO	Pobsi 0.70	12
USO	Pousi 0.60	10
BPO	Pobpi 0.78	13
UPO	Poupi 0.62	10

COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _h	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{hco}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{er}	0.2
ISS content of OHO's	f _{coHO}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{co,FBSO}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{co,USO}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{N,UPO}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{P,UPO}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{C,UPO}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{h20}	0.24 /d
Endogenous respiration rate OHO	θ _h	1.029
	b _{h,T}	0.2691 /d
	θ _{h20}	0.45 /d
nitrifiers max spec. growth rate	θ _{h20}	1.123
	θ _{h20}	0.7157 /d
Endogenous respiration rate autotrophs	b _{a20}	0.0400 /d
	θ _a	1.029
	b _{a,T}	0.0448 /d
Nitrification	K _{a20}	1.0
Half Saturation Coefficient	θ _a	1.123
	K _{a,T}	1.5904
Denitrification	K _{s(20)}	0.72
Half Saturation Coefficient	θ _d	1.2
	K _{d,T}	1.4930
Denitrification	K _{s(20)}	0.101
for ND system	θ _d	1.08
Half Saturation Coefficient	K _{d,T}	0.1374
Denitrification	K ⁺ _{s(20)}	0.255
primary anoxic of NDBPER system	θ _d	1.08
Half Saturation Coefficient	K ⁺ _{d,T}	0.3469

Factor of safety reducing μ _{h,nit}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _{min}	2.38 days
SRT _{min} (with safety factor)	SRT _{min}	2.98 Nitrifies!

Max unaerated sludge mass fraction	f _{xm}	0.75
Total unaerated sludge mass fraction	f _{xt}	0.35
Anoxic mass fraction primary anox 2	f _{x,prim anox 2}	0.27
Anaerobic mass fraction	f _{x,anox}	0.08
Aerobic mass fraction	f _{bio}	0.65

Nr of equal size compartments 2

r-recycle ratio	r	1.0 : 1
r-recycle NO ₃ concentration	N _{br}	3.9 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{O2,s}	0.0 mgO/l

influent NO ₃ concentration	S _{NO3br}	0.0 mgNO ₃ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	1.0 : 1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)	f _{Sb/s}	0.135

UCT Reactor @ 10 Days SRT

Influent TKN	N_i	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_i	229 kgN/d
Equiv conc in influent	N_i	13.72 mgN/l
Effluent Sol Unbioid Org N	$N_{u,se}$	0.90 mgN/l
Effluent ammonia	N_{se}	1.78 mgFSA-N/l
TKN in effluent	N_e	2.68 mgTKN-N/l
Nitrification capacity	N_c	31.79 mgN/l influent

Denitrification potential BSO (K1)	D_{BPO}	1.5 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BPO}	38.11 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	39.57 mgNO ₂ -N/l influent

	A	0.6993
	B	-6.0320
	C	46.654
Optimal a-recycle ratio	a_{opt}	13.55
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00 set = a_{opt} for balanced UCT
		recycle limited

Effluent Nitrate if recycle limited		3.97 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-3.23 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{se}	3.97 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₃)	$N_{se} + N_{se}$	6.66 mgN/l
N removal		86.2%

Alkalinity consumed by nitrification		227 mg CaCO ₃
Alkalinity recovered by denitrification		99 mg CaCO ₃
Total Alkalinity consumption		128 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{u,LA}$	0 mgCOD/l
FBSO COD	$S_{u,fl}$	75 mgCOD/l
BSO COD	$S_{u,i}$	75 mgCOD/l
BO COD	$S_{u,i}$	554 mgCOD/l

$S_{r,i}$ reduction due to O ₂ & NO ₃		33.54 mgCOD/l
Reduced FBSO concentration	$S_{r,i,conv}$	41.46 mgCOD/l

	$k_{r,120}$	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	$k_{r,T}$	0.0535 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	$S_{u,fl}$	MX_{su}/Q_L	$S_{u,fl}$	
Trial 1	0.00	734		6.42
Trial 2	6.42	753		6.28
Trial 3	6.28	752		6.29
Trial 4	6.29	752		6.29

Flux BO COD obtained by OHO's	95%	8750 kgCOD/d
Flux BO COD obtained by PAO's	5%	481 kgCOD/d
Check total BO COD		9232 kgCOD/d

correct
9232

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	$b_{r,20}$	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	$b_{r,T}$	0.0357 /d

Activated Sludge Masses

OHO VSS			
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	12537 kgVSS	
Endogenous Residue VSS OHO	$MX_{E,OHO}$	5368 kgVSS	

PAO VSS			
Polyphosphate Acc Organisms VSS	MX_{PAO}	1597 kgVSS	
Endogenous Residue VSS PAO	$MX_{E,PAO}$	142 kgVSS	

Unbiodegradable Organic VSS	MX_u	3230 kgVSS	
Total VSS	MX_v	22874 kgVSS	
ISS from influent		8568 kgISS	
ISS of OHO's		1881 kgISS	
ISS of PAO's		2102 kgISS	
ISS	$MX_{O,i}$	12551 kgISS	
TSS	MX_t	35425 kgTSS	
VSS/TSS ratio		0.646 kgVSS/kgTSS	

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.353 mgP/mgPAOVSS
		0.380 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	3.40 mgP/l
biomass P-content	ΔP_{OHO}	3.43 mgP/l
Potential P-removal		6.83 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	3.40 mgP/l
biomass P-content	ΔP_{OHO}	3.43 mgP/l
Total Actual P-removal		6.83 mgP/l

TP effluent

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	6098 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	224 kgO/d
Carbonaceous Oxygen flux	FO_c	6322 kgO/d
Nitrogenous Oxygen flux	FO_N	2422 kgO/d
Oxygen dmnd recover by denitrification	FO_D	1326 kgO/d
Total Oxygen Demand (FO _c + FO _N - FO _D)	FO_T	7418 kgO/d
Oxygen utilisation rate	O_T	42.2 mgO/l.h

Influent TKN	N_i	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_i	213 kgN/d
Equiv conc in influent	N_i	12.79 mgN/l
Effluent Sol Unbioid Org N	$N_{u,se}$	0.90 mgN/l
Effluent ammonia	N_{se}	0.72 mgFSA-N/l
TKN in effluent	N_e	1.62 mgTKN-N/l
Nitrification capacity	N_c	33.78 mgN/l influent

Denitrification potential BSO (K1)	D_{BPO}	1.4 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BPO}	59.94 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	61.32 mgNO ₂ -N/l influent

	A	0.6993
	B	-25.7836
	C	88.149
Optimal a-recycle ratio	a_{opt}	40.02
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00
		recycle limited

Effluent Nitrate if recycle limited		4.22 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-22.99 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{se}	4.22 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₃)	$N_{se} + N_{se}$	5.84 mgN/l
N removal		87.9%

Alkalinity consumed by nitrification		241 mg CaCO ₃
Alkalinity recovered by denitrification		106 mg CaCO ₃
Total Alkalinity consumption		136 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{u,LA}$	0 mgCOD/l
FBSO COD	$S_{u,fl}$	75 mgCOD/l
BSO COD	$S_{u,i}$	75 mgCOD/l
BO COD	$S_{u,i}$	554 mgCOD/l

$S_{r,i}$ reduction due to O ₂ & NO ₃		33.54 mgCOD/l
Reduced FBSO concentration	$S_{r,i,conv}$	41.46 mgCOD/l

	$k_{r,120}$	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	$k_{r,T}$	0.0673 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	$S_{u,fl}$	MX_{su}/Q_L	$S_{u,fl}$	
Trial 1	0.00	625		6.04
Trial 2	6.04	640		5.92
Trial 3	5.92	639		5.92
Trial 4	5.92	639		5.92

Flux BO COD obtained by OHO's	95%	8738 kgCOD/d
Flux BO COD obtained by PAO's	5%	494 kgCOD/d
Check total BO COD		9232 kgCOD/d

correct

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	$b_{r,20}$	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	$b_{r,T}$	0.0448 /d

Activated Sludge Masses

OHO VSS		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	10654 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	5733 kgVSS

PAO VSS		
Polyphosphate Acc Organisms VSS	MX_{PAO}	1534 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	172 kgVSS

Unbiodegradable Organic VSS	MX_u	3230 kgVSS
Total VSS	MX_v	21323 kgVSS
ISS from influent		8568 kgISS
ISS of OHO's		1598 kgISS
ISS of PAO's		2019 kgISS
ISS	$MX_{O,i}$	12186 kgISS
TSS	MX_t	33509 kgTSS
VSS/TSS ratio		0.636 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.38 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	3.27 mgP/l
biomass P-content	ΔP_{OHO}	3.20 mgP/l
Potential P-removal		6.47 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	3.27 mgP/l
biomass P-content	ΔP_{OHO}	3.20 mgP/l
Total Actual P-removal		6.47 mgP/l

TP effluent

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	6311 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	241 kgO/d
Carbonaceous Oxygen flux	FO_c	6552 kgO/d
Nitrogenous Oxygen flux	FO_N	2573 kgO/d
Oxygen dmnd recover by denitrification	FO_D	1409 kgO/d
Total Oxygen Demand (FO _c + FO _N - FO _D)	FO_T	7716 kgO/d
Oxygen utilisation rate	O_T	43.9 mgO/l.h

UCT Reactor @ 10 Days SRT

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Check	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	2872	9574	22979	35425
Concentration TSS (kgTSS/m ³)	1.57	3.14	3.14	2.904
Volume (m ³)	1830	3050	7320	12200
Volume fraction	15%	25%	60%	100%
Concentration VSS (kgVSS/m ³)	1.01	2.03	2.03	1.87
UPO VSS Concentration (kgUPOVSS/m ³)	0.143	0.286	0.286	0.265

Mass TSS wasted per day 3542.5 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 1128.5 m³/d

COD mass balance	
COD in (influent)	10315 kgCOD/d
COD out	10315 kgCOD/d
$Q_a S_{ia} + Q_w S_{ia}$	605 kgCOD/d
$Q_a X_a f_{io}$ or $f_{io} MX_a/R_s$	3388 kgCOD/d
FO_1	6322 kgO/d

N Mass balance	
TKN in (influent)	803 kgN/d
TKN out	803 kgN/d
N_{ia}	103 kgN/d
N_{waste}	236 kgN/d
$N_{denitrified}$	464 kgN/d

TOD balance	
TOD in (influent)	13986 kgTOD/d
TOD out	13986 kgTOD/d
$TOD_{effluent}$	755 kgTOD/d
TOD_{waste}	4488 kgTOD/d
$TOD_{N_2\ gas}$	1326 kgTOD/d
FO_1	7418 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S_{uol}	36.30	75	30 mgCOD/l
Undioid Sol Org N	N_{uol}	0.90	-	mgN/l
FSA-N	N_{sa}	1.78	6	2 mgFSA-N/l
TKN-N	N_{ia}	2.68	-	mgTKN-N/l
Nitrate	N_{no}	3.97	15	1.5 mgNO ₃ -N/l
Undioid Sol Org P	P_{uol}	0.60	-	mgP/l
Ortho P as P	P_{oa}	8.67	10	2.5 mgP/l
TP	P_{ta}	9.27	-	mgP/l

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	2717	9056	21735	33509
Concentration TSS (kgTSS/m ³)	1.48	2.97	2.97	2.747
Volume (m ³)	1830	3050	7320	12200
	2717			
Concentration VSS (kgVSS/m ³)	0.94	1.89	1.89	1.75
UPO VSS Concentration (kgUPOVSS/m ³)	0.143	0.286	0.286	0.265

Mass TSS wasted per day 3350.9 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 1128.5 m³/d

COD mass balance	
COD in (influent)	10315.0 kgCOD/d
COD out	10315.0 kgCOD/d
$Q_a S_{ia} + Q_w S_{ia}$	605.0 kgCOD/d
$Q_a X_a f_{io}$ or $f_{io} MX_a/R_s$	3157.9 kgCOD/d
FO_1	6552.1 kgO/d

N Mass balance	
TKN in (influent)	803.33 kgN/d
TKN out	803.33 kgN/d
N_{ia}	90.81 kgN/d
N_{waste}	219.8 kgN/d
$N_{denitrified}$	492.7 kgN/d

TOD balance	
TOD in (influent)	13986.23 kgTOD/d
TOD out	13986.23 kgTOD/d
$TOD_{effluent}$	679.16 kgTOD/d
TOD_{waste}	4181.71 kgTOD/d
$TOD_{N_2\ gas}$	1409.11 kgTOD/d
FO_1	7716.25 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S_{uol}	36.30	75	30 mgCOD/l
Undioid Sol Org N	N_{uol}	0.90	-	mgN/l
FSA-N	N_{sa}	0.72	6	2 mgFSA-N/l
TKN-N	N_{ia}	1.62	-	mgTKN-N/l
Nitrate	N_{no}	4.22	15	1.5 mgNO ₃ -N/l
Undioid Sol Org P	P_{uol}	0.60	-	mgP/l
Ortho P as P	P_{oa}	9.03	10	2.5 mgP/l
TP	P_{ta}	9.63	-	mgP/l

UCT Reactor @ 15 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	16.67 Ml/d
Sludge Age	SRT	15.0 days
Reactor TSS concentration	X _T	4244.54 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti	619
BPO COD	Sbpi	479
UPO COD	Supi	29
	fS'up	0.046
VFA COD	Sbsi,a	0.0
FBSO COD	Sbsfi	75
BSO COD	Sbsi	75
USO COD	Susi	36.3
	fS'us	0.059
BO COD	Sbi	554
UO COD	Sui	65
TSS		241
ISS		51.4
VSS		189
UPO VSS		19.4
BPO VSS		170
TKN	Nti	48.2
Org N	Noi	13.8
FSA	Nai	34.4
BSO	Nobsi	2.90
USO	Nousi	0.90
BPO	Nobpi	8.70
UPO	Noupi	1.30
Total P	Pti	15.50
OP	Pai	12.80
Org P	Poi	2.70
BSO	Pobsi	0.70
USO	Pousi	0.60
BPO	Pobpi	0.78
UPO	Poupi	0.62

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _{oh}	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{ohv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{coHO}	0.15
Yield coefficient of ANO's	Y _a	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,fbs}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,u}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,u}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,u}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{hT}	0.2141 /d
	μ _{h,20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{hnt}	0.2829 /d
	b _{h20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{at}	0.0357 /d
	K _{s,20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{s,T}	0.6288 mgFSA/l
	K _{s,20}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{s,T}	0.3472
	K _{s,20}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{s,T}	0.0742
	K ⁺ _{s,20}	0.255
Denitrification	θ	1.08
primary anoxic of NDBPER system	K ⁺ _{s,T}	0.1874

Factor of safety reducing μ _{hnt}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _m	6.76 days
SRT _m (with safety factor)	SRT _m	8.45 Nitrifies!

Max unaerated sludge mass fraction	f _{un}	0.55
Total unaerated sludge mass fraction	f _{de}	0.35
Anoxic mass fraction primary anox 2	f _{z,prim anox 2}	0.27
Anaerobic mass fraction	f _{anox}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments 2

r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N _{re}	4.3 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{o2,s}	0.0 mgO/l

influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	1.000 :1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi) f_{bsi} 0.135

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	16.67 Ml/d
Sludge Age	SRT	15.0 days
Reactor TSS concentration	X _T	4025 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti	619
BPO COD	Sbpi	479
UPO COD	Supi	29
	fS'up	0.046
VFA COD	Sbsi,a	0
FBSO COD	Sbsfi	75
BSO COD	Sbsi	75
USO COD	Susi	36
	fS'us	0.059
BO COD	Sbi	554
UO COD	Sui	65
TSS		241
ISS		51
VSS		189
UPO VSS		19
BPO VSS		170
TKN	Nti	48
Org N	Noi	14
FSA	Nai	34
BSO	Nobsi	2.90
USO	Nousi	0.90
BPO	Nobpi	8.70
UPO	Noupi	1.30
Total P	Pti	15.50
OP	Pai	12.80
Org P	Poi	2.70
BSO	Pobsi	0.70
USO	Pousi	0.60
BPO	Pobpi	0.78
UPO	Poupi	0.62

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _{oh}	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{ohv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{coHO}	0.15
Yield coefficient of ANO's	Y _a	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,fbs}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,u}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,u}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,u}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate OHO	b _{hT}	0.2691 /d
	μ _{h,20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{hnt}	0.7157 /d
	b _{h20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{at}	0.0448 /d
	K _{s,20}	1.0
Nitrification	θ	1.123
Half Saturation Coefficient	K _{s,T}	1.5904
	K _{s,20}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{s,T}	1.4930
	K _{s,20}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{s,T}	0.1374
	K ⁺ _{s,20}	0.255
Denitrification	θ	1.08
primary anoxic of NDBPER system	K ⁺ _{s,T}	0.3469

Factor of safety reducing μ _{hnt}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _m	2.38 days
SRT _m (with safety factor)	SRT _m	2.98 Nitrifies!

Max unaerated sludge mass fraction	f _{un}	0.81
Total unaerated sludge mass fraction	f _{de}	0.35
Anoxic mass fraction primary anox 2	f _{z,prim anox 2}	0.27
Anaerobic mass fraction	f _{anox}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments 2

r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N _{re}	4.3 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{o2,s}	0.0 mgO/l

influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi) f_{bsi} 0.135

UCT Reactor @ 15 Days SRT

Influent TKN	N_0	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_L	202 kgN/d
Equiv conc in influent	N_i	12.10 mgN/l
Effluent Sol Unbiod Org N	N_{unb}	0.90 mgN/l
Effluent ammonia	N_{NH}	0.79 mgFSA-N/l
TKN in effluent	N_{eff}	1.69 mgTKN-N/l
Nitrification capacity	N_c	34.41 mgN/l influent

Denitrification potential BSO (K1)	D_{BPO}	1.2 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BPO}	42.71 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{d1}	43.93 mgNO ₂ -N/l influent

	A	0.6993
	B	-7.7715
	C	52.751
Optimal a-recycle ratio	a_{opt}	15.87
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00 set = a_{opt} for balanced UCT
		recycle limited

Effluent Nitrate if recycle limited		4.30 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-4.97 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{NH}	4.30 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₂)	$N_{NH} + N_{NH}$	5.99 mgN/l
N removal		87.6%

Alkalinity consumed by nitrification		246 mg CaCO ₃
Alkalinity recovered by denitrification		107 mg CaCO ₃
Total Alkalinity consumption		138 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{BVL,A}$	0 mgCOD/l
FBSO COD	S_{BVL}	75 mgCOD/l
BSO COD	S_{BVL}	75 mgCOD/l
BO COD	S_{BVL}	554 mgCOD/l

S_{F1} reduction due to O ₂ & NO ₃		36.55 mgCOD/l
Reduced FBSO concentration	$S_{F1,COMP}$	38.45 mgCOD/l

	k_{F120}	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	k_{F1T}	0.0535 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

Trial 1	S_{BVLN}	0.00	MX_{BVL}/Q_L	826	S_{BVLN}	5.35
Trial 2		5.35		843		5.24
Trial 3		5.24		843		5.24
Trial 4		5.24		843		5.24

Flux BO COD obtained by OHO's	95%	8766 kgCOD/d
Flux BO COD obtained by PAO's	5%	466 kgCOD/d
Check total BO COD		9232 kgCOD/d

correct
9232

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{d20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{dT}	0.0357 /d

Activated Sludge Masses

OHO VSS		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	14051 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	9023 kgVSS

PAO VSS		
Polyphosphate Acc Organisms VSS	MX_{PAO}	2049 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	274 kgVSS

Unbiodegradable Organic VSS	MX_{UO}	4845 kgVSS
Total VSS	MX_V	30242 kgVSS

ISS from influent		12852 kgISS
ISS of OHO's		2108 kgISS
ISS of PAO's		2698 kgISS
ISS	MX_{DO}	17657 kgISS
TSS	MX_T	47900 kgTSS
VSS/TSS ratio		0.631 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.380 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.91 mgP/l
biomass P-content	ΔP_{OHO}	3.02 mgP/l
Potential P-removal		5.93 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.91 mgP/l
biomass P-content	ΔP_{OHO}	3.02 mgP/l
Total Actual P-removal		5.93 mgP/l

TP effluent P_{Le} 9.57 mgP/l

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	6487 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	237 kgO/d
Carbonaceous Oxygen flux	FO_L	6724 kgO/d
Nitrogenous Oxygen flux	FO_N	2621 kgO/d
Oxygen dnmnd recover by denitrification	FO_D	1435 kgO/d
Total Oxygen Demand (FO _C + FO _N - FO _D)	FO_T	7910 kgO/d
Oxygen utilisation rate	O_T	45.0 mgO/Lh

Influent TKN	N_0	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_L	189 kgN/d
Equiv conc in influent	N_i	11.32 mgN/l
Effluent Sol Unbiod Org N	N_{unb}	0.90 mgN/l
Effluent ammonia	N_{NH}	0.50 mgFSA-N/l
TKN in effluent	N_{eff}	1.40 mgTKN-N/l
Nitrification capacity	N_c	35.48 mgN/l influent

Denitrification potential BSO (K1)	D_{BPO}	1.2 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BPO}	66.04 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{d1}	67.20 mgNO ₂ -N/l influent

	A	0.6993
	B	-29.9740
	C	98.225
Optimal a-recycle ratio	a_{opt}	45.92
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00
		recycle limited

Effluent Nitrate if recycle limited		4.44 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-27.18 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{NH}	4.44 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₂)	$N_{NH} + N_{NH}$	5.84 mgN/l
N removal		87.9%

Alkalinity consumed by nitrification		253 mg CaCO ₃
Alkalinity recovered by denitrification		111 mg CaCO ₃
Total Alkalinity consumption		142 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{BVL,A}$	0 mgCOD/l
FBSO COD	S_{BVL}	75 mgCOD/l
BSO COD	S_{BVL}	75 mgCOD/l
BO COD	S_{BVL}	554 mgCOD/l

S_{F1} reduction due to O ₂ & NO ₃		36.55 mgCOD/l
Reduced FBSO concentration	$S_{F1,COMP}$	38.45 mgCOD/l

	k_{F120}	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	k_{F1T}	0.0673 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

Trial 1	S_{BVLN}	0.00	MX_{BVL}/Q_L	691	S_{BVLN}	5.10
Trial 2		5.10		705		5.00
Trial 3		5.00		704		5.00
Trial 4		5.00		704		5.00

Flux BO COD obtained by OHO's	95%	8758 kgCOD/d
Flux BO COD obtained by PAO's	5%	474 kgCOD/d
Check total BO COD		9232 kgCOD/d

correct

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{d20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{dT}	0.0448 /d

Activated Sludge Masses

OHO VSS		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	11738 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	9475 kgVSS

PAO VSS		
Polyphosphate Acc Organisms VSS	MX_{PAO}	1913 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	322 kgVSS

Unbiodegradable Organic VSS	MX_{UO}	4845 kgVSS
Total VSS	MX_V	28293 kgVSS

ISS from influent		12852 kgISS
ISS of OHO's		1761 kgISS
ISS of PAO's		2519 kgISS
ISS	MX_{DO}	17132 kgISS
TSS	MX_T	45424 kgTSS
VSS/TSS ratio		0.623 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.38 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.72 mgP/l
biomass P-content	ΔP_{OHO}	2.83 mgP/l
Potential P-removal		5.55 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.72 mgP/l
biomass P-content	ΔP_{OHO}	2.83 mgP/l
Total Actual P-removal		5.55 mgP/l

TP effluent P_{Le} 9.95 mgP/l

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	6663 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	253 kgO/d
Carbonaceous Oxygen flux	FO_L	6917 kgO/d
Nitrogenous Oxygen flux	FO_N	2702 kgO/d
Oxygen dnmnd recover by denitrification	FO_D	1480 kgO/d
Total Oxygen Demand (FO _C + FO _N - FO _D)	FO_T	8139 kgO/d
Oxygen utilisation rate	O_T	46.3 mgO/Lh

UCT Reactor @ 15 Days SRT

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Check	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	3884	12946	31070	47900
Concentration TSS (kgTSS/m ³)	2.12	4.24	4.24	3.926
Volume (m ³)	1830	3050	7320	12200
Volume fraction	15%	25%	60%	100%
Concentration VSS (kgVSS/m ³)	1.34	2.68	2.68	2.48
UPO VSS Concentration (kgUPOVSS/m ³)	0.215	0.429	0.429	0.397

Mass TSS wasted per day 3193.3 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 752.3 m³/d

COD mass balance	
COD in (influent)	10315.0 kgCOD/d
COD out	10315.0 kgCOD/d
$Q_a S_{10} + Q_w S_{10}$	605.0 kgCOD/d
$Q_a X_{f_{10}}$ or $f_{10} \cdot MX_{10}/Rs$	2985.9 kgCOD/d
FO_L	6724.1 kgO/d

N Mass balance	
TKN in (influent)	803.33 kgN/d
TKN out	803.33 kgN/d
N_{10}	95.39 kgN/d
N_{waste}	206.1 kgN/d
$N_{denitrified}$	501.8 kgN/d

TOD balance	
TOD in (influent)	13986.23 kgTOD/d
TOD out	13986.23 kgTOD/d
$TOD_{effluent}$	700.79 kgTOD/d
TOD_{waste}	3940.41 kgTOD/d
TOD_{N_2-gas}	1435.20 kgTOD/d
FO_L	7909.82 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S_{10e}	36.30	75	30 mgCOD/l
Unbiol Sol Org N	N_{10e}	0.90	-	- mgN/l
FSA-N	N_{10}	0.79	6	2 mgFSA-N/l
TKN-N	N_{10}	1.69	-	- mgTKN-N/l
Nitrate	N_{10}	4.30	15	1.5 mgNO ₃ -N/l
Unbiol Sol Org P	P_{10e}	0.60	-	- mgP/l
Ortho P as P	P_{10}	9.57	10	2.5 mgP/l
TP	P_{10}	10.17	-	- mgP/l

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	3683	12277	29464	45424
Concentration TSS (kgTSS/m ³)	2.01	4.03	4.03	3.723
Volume (m ³)	1830	3050	7320	12200
	3683			
Concentration VSS (kgVSS/m ³)	1.25	2.51	2.51	2.32
UPO VSS Concentration (kgUPOVSS/m ³)	0.215	0.429	0.429	0.397

Mass TSS wasted per day 3028.3 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 752.3 m³/d

COD mass balance	
COD in (influent)	10315.0 kgCOD/d
COD out	10315.0 kgCOD/d
$Q_a S_{10} + Q_w S_{10}$	605.0 kgCOD/d
$Q_a X_{f_{10}}$ or $f_{10} \cdot MX_{10}/Rs$	2793.4 kgCOD/d
FO_L	6916.6 kgO/d

N Mass balance	
TKN in (influent)	803.33 kgN/d
TKN out	803.33 kgN/d
N_{10}	92.91 kgN/d
N_{waste}	193.0 kgN/d
$N_{denitrified}$	517.4 kgN/d

TOD balance	
TOD in (influent)	13986.23 kgTOD/d
TOD out	13986.23 kgTOD/d
$TOD_{effluent}$	679.71 kgTOD/d
TOD_{waste}	3687.54 kgTOD/d
TOD_{N_2-gas}	1479.82 kgTOD/d
FO_L	8139.16 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S_{10e}	36.30	75	30 mgCOD/l
Unbiol Sol Org N	N_{10e}	0.90	-	- mgN/l
FSA-N	N_{10}	0.90	6	2 mgFSA-N/l
TKN-N	N_{10}	1.40	-	- mgTKN-N/l
Nitrate	N_{10}	4.44	15	1.5 mgNO ₃ -N/l
Unbiol Sol Org P	P_{10e}	0.60	-	- mgP/l
Ortho P as P	P_{10}	9.95	10	2.5 mgP/l
TP	P_{10}	10.55	-	- mgP/l

UCT Reactor @ 20 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	16.67 Ml/d
Sludge Age	SRT	20.0 days
Reactor TSS concentration	X _r	5282.71 mgTSS/l

Influent Characteristics	Concentration	Flux
	mg/l	kg/d
Total COD	Sti	619
BPO COD	Sbpi	479
UPO COD	Supi	29
	fS'up	0.046
VFA COD	Sbsi,a	0.0
FBSO COD	Sbsfi	75
BSO COD	Sbsi	75
USO COD	Susi	36.3
	fS'us	0.059
BO COD	Sbi	554
UO COD	Sui	65
TSS		241
ISS		51.4
VSS		189
UPO VSS		19.4
BPO VSS		170
TKN	Nti	48.2
Org N	Noi	13.8
FSA	Nai	34.4
BSO	Nobsi	2.90
USO	Nousi	0.90
BPO	Nobpi	8.70
UPO	Noupi	1.30
Total P	Pti	15.50
OP	Pai	12.80
Org P	Poi	2.70
BSO	Pobsi	0.70
USO	Pousi	0.60
BPO	Pobpi	0.78
UPO	Poupi	0.62

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _{oh}	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{oh}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{coHO}	0.15
Yield coefficient of ANO's	Y _a	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cod,bsso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cod,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{N,uPO}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{P,uPO}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{C,uPO}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{h,20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{h,T}	0.2141 /d
	μ _{h,max,20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{h,nit}	0.2829 /d
	b _{h,20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{a,T}	0.0357 /d
	K _{s,20}	1.0 mgFSA/l
	θ	1.123
Nitrification	K _{s,T}	0.6288 mgFSA/l
Half Saturation Coefficient		
	K _{s,20}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{s,T}	0.3472
Denitrification	K _{s,20}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{s,T}	0.0742
Denitrification	K _{s,20}	0.255
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K _{s,T}	0.1874

Factor of safety reducing μ _{h,nit}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _{min}	6.76 days
SRT _{min} (with safety factor)	SRT _{min}	8.45 Nitrifies!

Max unaerated sludge mass fraction	f _{un}	0.62
Total unaerated sludge mass fraction	f _{xt}	0.35
Anoxic mass fraction primary anox 2	f _{prim anox 2}	0.27
Anaerobic mass fraction	f _{anaer}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments		2
r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N _{nr}	185 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{O2,r}	0.0 mgO ₂ /l
Influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
Influent DO concentration	O _i	0.0 mgO ₂ /l
s-recycle ratio	s	1.000 :1
s-recycle DO concentration	O _s	1.0 mgO ₂ /l
a-recycle DO concentration	O _a	2.0 mgO ₂ /l
Influent RBCOD fraction (Sbsi/Sbi)	f _{Sb,i}	0.135

Influent TKN	N _i	48.2 mgTKN-N/l
Flux of N in waste VSS	FN _i	185 kgN/d
Equiv conc in influent	N _i	11.12 mgN/l
Effluent Sol Unbiob Org N	N _{u,unb}	0.90 mgN/l
Effluent ammonia	N _{u,am}	0.55 mgFSA-N/l
TKN in effluent	N _u	1.45 mgTKN-N/l
Nitrification capacity	N _i	35.63 mgN/l influent

Denitrification potential BSO (K1)	D _{h,BSO}	1.1 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D _{h,BPO}	45.43 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D _{h,pt}	46.55 mgNO ₃ -N/l influent

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	16.67 Ml/d
Sludge Age	SRT	20.0 days
Reactor TSS concentration	X _r	5028 mgTSS/l

Influent Characteristics	Concentration	Flux
	mg/l	kg/d
Total COD	Sti	619
BPO COD	Sbpi	479
UPO COD	Supi	29
	fS'up	0.046
VFA COD	Sbsi,a	0
FBSO COD	Sbsfi	75
BSO COD	Sbsi	75
USO COD	Susi	36
	fS'us	0.059
BO COD	Sbi	554
UO COD	Sui	65
TSS		241
ISS		51
VSS		189
UPO VSS		19
BPO VSS		170
TKN	Nti	48
Org N	Noi	14
FSA	Nai	34
BSO	Nobsi	2.90
USO	Nousi	0.90
BPO	Nobpi	8.70
UPO	Noupi	1.30
Total P	Pti	15.50
OP	Pai	12.80
Org P	Poi	2.70
BSO	Pobsi	0.70
USO	Pousi	0.60
BPO	Pobpi	0.78
UPO	Poupi	0.62

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _{oh}	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{oh}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{coHO}	0.15
Yield coefficient of ANO's	Y _a	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cod,bsso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cod,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{N,uPO}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{P,uPO}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{C,uPO}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{h,20}	0.24 /d
	θ	1.029
Endogenous respiration rate OHO	b _{h,T}	0.2691 /d
	μ _{h,max,20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{h,nit}	0.7157 /d
	b _{h,20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{a,T}	0.0448 /d
	K _{s,20}	1.0
	θ	1.123
Nitrification	K _{s,T}	1.5904
Half Saturation Coefficient		
	K _{s,20}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{s,T}	1.4930
Denitrification	K _{s,20}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{s,T}	0.1374
Denitrification	K _{s,20}	0.255
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K _{s,T}	0.3469

Factor of safety reducing μ _{h,nit}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _{min}	2.38 days
SRT _{min} (with safety factor)	SRT _{min}	2.98 Nitrifies!

Max unaerated sludge mass fraction	f _{un}	0.83
Total unaerated sludge mass fraction	f _{xt}	0.35
Anoxic mass fraction primary anox 2	f _{prim anox 2}	0.27
Anaerobic mass fraction	f _{anaer}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments		2
r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N _{nr}	4.4 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{O2,r}	0.0 mgO ₂ /l
Influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
Influent DO concentration	O _i	0.0 mgO ₂ /l
s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O _s	1.0 mgO ₂ /l
a-recycle DO concentration	O _a	2.0 mgO ₂ /l
Influent RBCOD fraction (Sbsi/Sbi)	f _{Sb,i}	0.135

Influent TKN	N _i	48.2 mgTKN-N/l
Flux of N in waste VSS	FN _i	174 kgN/d
Equiv conc in influent	N _i	10.45 mgN/l
Effluent Sol Unbiob Org N	N _{u,unb}	0.90 mgN/l
Effluent ammonia	N _{u,am}	0.41 mgFSA-N/l
TKN in effluent	N _u	1.31 mgTKN-N/l
Nitrification capacity	N _i	36.44 mgN/l influent

Denitrification potential BSO (K1)	D _{h,BSO}	1.1 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D _{h,BPO}	69.55 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D _{h,pt}	70.62 mgNO ₃ -N/l influent

UCT Reactor @ 20 Days SRT

	A	0.6993
	B	-9.1644
	C	56.759
Optimal a-recycle ratio	a_{opt}	17.69
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.59
	set = a_{opt} for balanced UCT	
	recycle limited	

Effluent Nitrate if recycle limited		4.45 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		-6.37 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{NH}	4.45 mgNO ₃ -N/l influent

Effluent total N (TKN + NO ₃)	$N_{NH} + N_{NH}$	5.90 mgN/l
N removal		87.7%

Alkalinity consumed by nitrification		254 mg CaCO ₃
Alkalinity recovered by denitrification		111 mg CaCO ₃
Total Alkalinity consumption		143 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{BUL,A}$	0 mgCOD/l
FBSO COD	S_{BUL}	75 mgCOD/l
BSO COD	S_{BUL}	75 mgCOD/l
BO COD	S_{BUL}	554 mgCOD/l

$S_{C,T}$ reduction due to O ₂ & NO ₃		37.84 mgCOD/l
Reduced FBSO concentration	$S_{C,LODV}$	37.16 mgCOD/l

	$k_{F,T20}$	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	$k_{F,T}$	0.0535 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	S_{DUTN}	MX_{BUL}/Q_L	S_{DUTN}	
Trial 1	0.00	881		4.86
Trial 2	4.86	897		4.77
Trial 3	4.77	897		4.77
Trial 4	4.77	897		4.77

Flux BO COD obtained by OHO's	95%	8771 kgCOD/d
Flux BO COD obtained by PAO's	5%	460 kgCOD/d
Check total BO COD		9232 kgCOD/d

correct

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_E	0.25
ISS content of PAO's	f_{PAO}	0.45

	b_{D20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{DT}	0.0357 /d

Activated Sludge Masses

OHO VSS		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	14948 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	12799 kgVSS

PAO VSS		
Polyphosphate Acc Organisms VSS	MX_{PAO}	2417 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	431 kgVSS

Unbiodegradable Organic VSS	MX_u	6460 kgVSS
Total VSS	MX_v	37055 kgVSS

ISS from influent		17136 kgTSS
ISS of OHO's		2242 kgTSS
ISS of PAO's		3182 kgTSS
ISS	MX_{OI}	22561 kgTSS
TSS	MX_t	59615 kgTSS
VSS/TSS ratio		0.622 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.380 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.57 mgP/l
biomass P-content	ΔP_{OHO}	2.78 mgP/l
Potential P-removal		5.35 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.57 mgP/l
biomass P-content	ΔP_{OHO}	2.78 mgP/l
Total Actual P-removal		5.35 mgP/l

TP effluent P_{te} 10.15 mgP/l

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	6717 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	249 kgO/d
Carbonaceous Oxygen flux	FO_c	6966 kgO/d
Nitrogenous Oxygen flux	FO_{Nt}	2714 kgO/d
Oxygen dmnd recover by denitrification	FO_D	1486 kgO/d
Total Oxygen Demand (FO _c + FO _{Nt} - FO _D)	FO_t	8194 kgO/d
Oxygen utilisation rate	O_t	46.6 mgO/l.h

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Check	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	4834	16112	38669	59615
Concentration TSS (kgTSS/m ³)	2.64	5.28	5.28	4.887
Volume (m ³)	1830	3050	7320	12200
Volume fraction	15%	25%	60%	100%
Concentration VSS (kgVSS/m ³)	1.64	3.28	3.28	3.04
UPO VSS Concentration (kgUPOVSS/m ³)	0.286	0.572	0.572	0.529

Mass TSS wasted per day		2980.8 kgTSS/d
Waste Flow Rate (note not V/Rs)	Q_w	564.3 m ³ /d

COD mass balance		
COD in (influent)		10315.0 kgCOD/d
COD out		10315.0 kgCOD/d
$Q_u S_{BUL} + Q_u S_{BUL}$		605.0 kgCOD/d
$Q_u X_{F,T}$ or $f_{E,PAO} MX_{F,T}$ /Rs		2743.9 kgCOD/d
FO _c		6966.1 kgO/d

	A	0.6993
	B	-32.4288
	C	104.096
Optimal a-recycle ratio	a_{opt}	49.39
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00
	recycle limited	

Effluent Nitrate if recycle limited		4.56 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		-29.63 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{NH}	4.56 mgNO ₃ -N/l influent

Effluent total N (TKN + NO ₃)	$N_{NH} + N_{NH}$	5.86 mgN/l
N removal		87.8%

Alkalinity consumed by nitrification		260 mg CaCO ₃
Alkalinity recovered by denitrification		114 mg CaCO ₃
Total Alkalinity consumption		146 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{BUL,A}$	0 mgCOD/l
FBSO COD	S_{BUL}	75 mgCOD/l
BSO COD	S_{BUL}	75 mgCOD/l
BO COD	S_{BUL}	554 mgCOD/l

$S_{C,T}$ reduction due to O ₂ & NO ₃		37.84 mgCOD/l
Reduced FBSO concentration	$S_{C,LODV}$	37.16 mgCOD/l

	$k_{F,T20}$	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	$k_{F,T}$	0.0673 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	S_{DUTN}	MX_{BUL}/Q_L	S_{DUTN}	
Trial 1	0.00	729		4.67
Trial 2	4.67	742		4.59
Trial 3	4.59	742		4.59
Trial 4	4.59	742		4.59

Flux BO COD obtained by OHO's	95%	8765 kgCOD/d
Flux BO COD obtained by PAO's	5%	466 kgCOD/d
Check total BO COD		9232 kgCOD/d

correct

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_E	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{D20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{DT}	0.0448 /d

Activated Sludge Masses

OHO VSS		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	12362 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	13305 kgVSS

PAO VSS		
Polyphosphate Acc Organisms VSS	MX_{PAO}	2212 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	496 kgVSS

Unbiodegradable Organic VSS	MX_u	6460 kgVSS
Total VSS	MX_v	34835 kgVSS

ISS from influent		17136 kgTSS
ISS of OHO's		1854 kgTSS
ISS of PAO's		2912 kgTSS
ISS	MX_{OI}	21903 kgTSS
TSS	MX_t	56738 kgTSS
VSS/TSS ratio		0.614 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.38 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.36 mgP/l
biomass P-content	ΔP_{OHO}	2.61 mgP/l
Potential P-removal		4.97 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.36 mgP/l
biomass P-content	ΔP_{OHO}	2.61 mgP/l
Total Actual P-removal		4.97 mgP/l

TP effluent P_{te} 10.53 mgP/l

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	6865 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	266 kgO/d
Carbonaceous Oxygen flux	FO_c	7130 kgO/d
Nitrogenous Oxygen flux	FO_{Nt}	2776 kgO/d
Oxygen dmnd recover by denitrification	FO_D	1520 kgO/d
Total Oxygen Demand (FO _c + FO _{Nt} - FO _D)	FO_t	8386 kgO/d
Oxygen utilisation rate	O_t	47.7 mgO/l.h

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	4600	15335	36803	56738
Concentration TSS (kgTSS/m ³)	2.51	5.03	5.03	4.651
Volume (m ³)	1830	3050	7320	12200
	4600			
Concentration VSS (kgVSS/m ³)	1.54	3.09	3.09	2.86
UPO VSS Concentration (kgUPOVSS/m ³)	0.286	0.572	0.572	0.529

Mass TSS wasted per day		2836.9 kgTSS/d
Waste Flow Rate (note not V/Rs)	Q_w	564.3 m ³ /d

COD mass balance		
COD in (influent)		10315.0 kgCOD/d
COD out		10315.0 kgCOD/d
$Q_u S_{BUL} + Q_u S_{BUL}$		605.0 kgCOD/d
$Q_u X_{F,T}$ or $f_{E,PAO} MX_{F,T}$ /Rs		2579.5 kgCOD/d
FO _c		7130.5 kgO/d

UCT Reactor @ 20 Days SRT

N Mass balance	
TKN in (influent)	803.33 kgN/d
TKN out	803.33 kgN/d
N_{effluent}	95.08 kgN/d
N_{waste}	188.6 kgN/d
$N_{\text{denitrified}}$	519.6 kgN/d

TOD balance	
TOD in (influent)	13986.23 kgTOD/d
TOD out	13986.23 kgTOD/d
TOD_{effluent}	691.26 kgTOD/d
TOD_{waste}	3614.81 kgTOD/d
$TOD_{\text{N}_2\text{-gas}}$	1486.20 kgTOD/d
FO_2	8193.96 kgTOD/d

Effluent Concentrations		General		Special	Unit
Unbiol Sol COD	S_{uio}	36.30	75	30	mgCOD/l
Undiol Sol Org N	N_{duio}	0.90	-	-	mgN/l
FSA-N	N_{so}	0.55	6	2	mgFSA-N/l
TKN-N	N_{te}	1.45	-	-	mgTKN-N/l
Nitrate	N_{no}	4.45	15	1.5	mgNO ₃ -N/l
Undiol Sol Org P	P_{duio}	0.60	-	-	mgP/l
Ortho P as P	P_{so}	10.15	10	2.5	mgP/l
TP	P_{te}	10.75	-	-	mgP/l

N Mass balance	
TKN in (influent)	803.33 kgN/d
TKN out	803.33 kgN/d
N_{te}	94.42 kgN/d
N_{waste}	177.5 kgN/d
$N_{\text{denitrified}}$	531.4 kgN/d

TOD balance	
TOD in (influent)	13986.23 kgTOD/d
TOD out	13986.23 kgTOD/d
TOD_{effluent}	680.80 kgTOD/d
TOD_{waste}	3399.39 kgTOD/d
$TOD_{\text{N}_2\text{-gas}}$	1519.90 kgTOD/d
FO_2	8386.15 kgTOD/d

Effluent Concentrations		General		Special	Unit
Unbiol Sol COD	S_{uio}	36.30	75	30	mgCOD/l
Undiol Sol Org N	N_{duio}	0.90	-	-	mgN/l
FSA-N	N_{so}	0.41	6	2	mgFSA-N/l
TKN-N	N_{te}	1.31	-	-	mgTKN-N/l
Nitrate	N_{no}	4.56	15	1.5	mgNO ₃ -N/l
Undiol Sol Org P	P_{duio}	0.60	-	-	mgP/l
Ortho P as P	P_{so}	10.53	10	2.5	mgP/l
TP	P_{te}	11.13	-	-	mgP/l

UCT Reactor @ 25 Days SRT

TEMPERATURE T 16 °C

Influent Flow Rate Q_i 16.67 Ml/d

Sludge Age SRT 25.0 days

Reactor TSS concentration X_T 6281.51 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	S _{ti}	619	10315
BPO COD	S _{bpti}	479	7982
UPO COD	S _{upti}	29	478
	f _{S'} up		0.046
VFA COD	S _{bsi,a}	0.0	0
FBSO COD	S _{bsfi}	75	1250
BSO COD	S _{bsi}	75	1250
USO COD	S _{usi}	36.3	605
	f _{S'} us		0.059
BO COD	S _{bi}	554	9232
UO COD	S _{ui}	65	1083
TSS		241	4012
ISS		51.4	857
VSS		189	3155
UPO VSS		19.4	323
BPO VSS		170	2832
TKN	N _{ti}	48.2	803
Org N	N _{oi}	13.8	230
FSA	N _{ai}	34.4	573
BSO	N _{obsi}	2.90	48
USO	N _{ousi}	0.90	15
BPO	N _{obpi}	8.70	145
UPO	N _{oupi}	1.30	22
Total P	P _{ti}	15.50	258
OP	P _{ai}	12.80	213
Org P	P _{oi}	2.70	45
BSO	P _{obsi}	0.70	12
USO	P _{ousi}	0.60	10
BPO	P _{obpi}	0.78	13
UPO	P _{oupi}	0.62	10

COD/VSS ratio	f_{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y_h	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y_{ho}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_d	0.2
ISS content of OHO's	f_{cOHO}	0.15
Yield coefficient of ANO's	Y_A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	$f_{cm,fbsO}$	1.42 mgCOD/mg
COD per mass fraction of USO	$f_{cm,usO}$	1.493 mgCOD/mg
N Content of UPO and biomass VSS	$f_{N,UPO}$	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	$f_{P,UPO}$	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	$f_{c,UPO}$	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b_{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b_{hT}	0.2141 /d
	μ_{hmax20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ_{hmaxT}	0.2829 /d
	b_{a20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b_{aT}	0.0357 /d
	K_{h20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K_{hT}	0.6288 mgFSA/l
	K_{h20}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K_{dT}	0.3472
Denitrification	K_{d20}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K_{dT}	0.0742
Denitrification	K'_{d20}	0.255
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K''_{dT}	0.1874

Factor of safety reducing μ_{hmaxT}	Sf	1.25
total unaerated mass fraction	f_{xt}	0.351
Minimum sludge age for nitrification	SRT_{min}	6.76 days
SRT_{min} (with safety factor)	SRT_{min}	8.45 Nitrifies!

Max unaerated sludge mass fraction	f_{xm}	0.67
Total unaerated sludge mass fraction	f_{xt}	0.35
Anoxic mass fraction primary anox 2	$f_{x,prim anox 2}$	0.27
Anaerobic mass fraction	$f_{x,anox}$	0.08
Aerobic mass fraction	$f_{x,air}$	0.65

Nr of equal size compartments

r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N_{ir}	4.5 mgNO ₃ -N/l
r-recycle O ₂ concentration	$S_{O2,s}$	0.0 mgO/l

influent NO ₃ concentration	$S_{NO3,i}$	0.0 mgNO ₃ -N/l
influent DO concentration	O_i	0.0 mgO/l

s-recycle ratio	s	1.168 :1
s-recycle DO concentration	O_s	1.0 mgO/l

a-recycle DO concentration	O_a	2.0 mgO/l

Influent RBCOD fraction (S_{bsi}/S_{bi}) $f_{Sb,i}$ 0.135

TEMPERATURE T 24 °C

Influent Flow Rate Q_i 16.67 Ml/d

Sludge Age SRT 25.0 days

Reactor TSS concentration X_T 5999 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	S _{ti}	619	10315
BPO COD	S _{bpti}	479	7982
UPO COD	S _{upti}	29	478
	f _{S'} up		0.046
VFA COD	S _{bsi,a}	0	0
FBSO COD	S _{bsfi}	75	1250
BSO COD	S _{bsi}	75	1250
USO COD	S _{usi}	36	605
	f _{S'} us		0.059
BO COD	S _{bi}	554	9232
UO COD	S _{ui}	65	1083
TSS		241	4012
ISS		51	857
VSS		189	3155
UPO VSS		19	323
BPO VSS		170	2832
TKN	N _{ti}	48	803
Org N	N _{oi}	14	230
FSA	N _{ai}	34	573
BSO	N _{obsi}	2.90	48
USO	N _{ousi}	0.90	15
BPO	N _{obpi}	8.70	145
UPO	N _{oupi}	1.30	22
Total P	P _{ti}	15.50	258
OP	P _{ai}	12.80	213
Org P	P _{oi}	2.70	45
BSO	P _{obsi}	0.70	12
USO	P _{ousi}	0.60	10
BPO	P _{obpi}	0.78	13
UPO	P _{oupi}	0.62	10

COD/VSS ratio	f_{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y_h	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y_{ho}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_d	0.2
ISS content of OHO's	f_{cOHO}	0.15
Yield coefficient of ANO's	Y_A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	$f_{cm,fbsO}$	1.42 mgCOD/mg
COD per mass fraction of USO	$f_{cm,usO}$	1.493 mgCOD/mg
N Content of UPO and biomass VSS	$f_{N,UPO}$	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	$f_{P,UPO}$	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	$f_{c,UPO}$	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b_{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate OHO	b_{hT}	0.2691 /d
	μ_{hmax20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ_{hmaxT}	0.7157 /d
	b_{a20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b_{aT}	0.0448 /d
	K_{h20}	1.0
Nitrification	θ	1.123
Half Saturation Coefficient	K_{hT}	1.5904
	K_{h20}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K_{dT}	1.4930
Denitrification	K_{d20}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K_{dT}	0.1374
Denitrification	K'_{d20}	0.255
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K''_{dT}	0.3469

Factor of safety reducing μ_{hmaxT}	Sf	1.25
total unaerated mass fraction	f_{xt}	0.351
Minimum sludge age for nitrification	SRT_{min}	2.38 days
SRT_{min} (with safety factor)	SRT_{min}	2.98 Nitrifies!

Max unaerated sludge mass fraction	f_{xm}	0.85
Total unaerated sludge mass fraction	f_{xt}	0.35
Anoxic mass fraction primary anox 2	$f_{x,prim anox 2}$	0.27
Anaerobic mass fraction	$f_{x,anox}$	0.08
Aerobic mass fraction	$f_{x,air}$	0.65

Nr of equal size compartments

r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N_{ir}	4.5 mgNO ₃ -N/l
r-recycle O ₂ concentration	$S_{O2,s}$	0.0 mgO/l

influent NO ₃ concentration	$S_{NO3,i}$	0.0 mgNO ₃ -N/l
influent DO concentration	O_i	0.0 mgO/l

s-recycle ratio	s	1.2 :1
s-recycle DO concentration	O_s	1.0 mgO/l

a-recycle DO concentration	O_a	2.0 mgO/l

Influent RBCOD fraction (S_{bsi}/S_{bi}) $f_{Sb,i}$ 0.135

UCT Reactor @ 25 Days SRT

Influent TKN	N_i	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_e	174 kgN/d
Equiv conc in influent	N_i	10.46 mgN/l
Effluent Sol Unbiobd Org N	N_{sue}	0.90 mgN/l
Effluent ammonia	N_{ae}	0.44 mgFSA-N/l
TKN in effluent	N_{te}	1.34 mgTKN-N/l
Nitrification capacity	N_c	36.40 mgN/l influent

Denitrification potential BSO (K1)	D_{BPO}	1.0 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BPO}	47.25 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	48.29 mgNO ₂ -N/l influent

	A	0.6993
	B	-9.9653
	C	61.291
Optimal a-recycle ratio	a_{opt}	18.89
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00
recycle limited $set = a_{opt}$ for balanced UCT		

Effluent Nitrate if recycle limited		4.46 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-7.29 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{ne}	4.46 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₃)	$N_{te} + N_{ne}$	5.80 mgN/l
N removal		88.0%

Alkalinity consumed by nitrification		260 mg CaCO ₃
Alkalinity recovered by denitrification		114 mg CaCO ₃
Total Alkalinity consumption		146 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{BUL,A}$	0 mgCOD/l
FBSO COD	S_{BUL}	75 mgCOD/l
BSO COD	S_{BUL}	75 mgCOD/l
BO COD	S_{BUL}	554 mgCOD/l

S_{rj} reduction due to O ₂ & NO ₃		38.7 mgCOD/l
Reduced FBSO concentration	$S_{rj,conv}$	36.3 mgCOD/l

	$k_{f,120}$	0.04 m ³ /gVSS.d
	θ	1.029
Fermentation rate	$k_{f,T}$	0.0535 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	S_{BULn}	MX_{BUL}/Q_L	S_{BULn}	
Trial 1	0.00		917	4.56
Trial 2	4.56		933	4.48
Trial 3	4.48		933	4.48
Trial 4	4.48		933	4.48

Flux BO COD obtained by OHO's	95%	8776 kgCOD/d
Flux BO COD obtained by PAO's	5%	456 kgCOD/d
Check total BO COD		9232 kgCOD/d

correct
9232

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{D20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{DT}	0.0357 /d

Activated Sludge Masses

OHO VSS			
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	15544 kgVSS	
Endogenous Residue VSS OHO	$MX_{E,OHO}$	16638 kgVSS	

PAO VSS			
Polyphosphate Acc Organisms VSS	MX_{PAO}	2709 kgVSS	
Endogenous Residue VSS PAO	$MX_{E,PAO}$	604 kgVSS	

Unbiodegradable Organic VSS	MX_u	8074 kgVSS	
Total VSS	MX_v	43569 kgVSS	

ISS from influent		21420 kgISS	
ISS of OHO's		2332 kgISS	
ISS of PAO's		3566 kgISS	
ISS	$MX_{(O)}$	27318 kgISS	
TSS	MX_t	70887 kgTSS	
VSS/TSS ratio		0.615 kgVSS/kgTSS	

PAO biomass P-content		0.025 mgP/mgPAOVSS	
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.353 mgP/mgPAOVSS	
		0.380 mgP/mgPAOVSS	

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.31 mgP/l
biomass P-content	ΔP_{OHO}	2.61 mgP/l
Potential P-removal		4.92 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.31 mgP/l
biomass P-content	ΔP_{OHO}	2.61 mgP/l
Total Actual P-removal		4.92 mgP/l

TP effluent P_{te} 10.58 mgP/l

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	6870 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	259 kgO/d
Carbonaceous Oxygen flux	FO_c	7129 kgO/d
Nitrogenous Oxygen flux	FO_N	2773 kgO/d
Oxygen dmnd recover by denitrification	FO_D	1523 kgO/d
Total Oxygen Demand (FO _c + FO _N - FO _D)	FO_T	8379 kgO/d
Oxygen utilisation rate	O_T	47.7 mgO/l.h

Influent TKN	N_i	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_e	165 kgN/d
Equiv conc in influent	N_i	9.88 mgN/l
Effluent Sol Unbiobd Org N	N_{sue}	0.90 mgN/l
Effluent ammonia	N_{ae}	0.36 mgFSA-N/l
TKN in effluent	N_{te}	1.26 mgTKN-N/l
Nitrification capacity	N_c	37.07 mgN/l influent

Denitrification potential BSO (K1)	D_{BPO}	1.0 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BPO}	71.85 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	72.86 mgNO ₂ -N/l influent

	A	0.6993
	B	-33.8662
	C	113.769
Optimal a-recycle ratio	a_{opt}	51.58
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00
recycle limited		

Effluent Nitrate if recycle limited		4.54 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-31.19 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{ne}	4.54 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₃)	$N_{te} + N_{ne}$	5.79 mgN/l
N removal		88.0%

Alkalinity consumed by nitrification		265 mg CaCO ₃
Alkalinity recovered by denitrification		116 mg CaCO ₃
Total Alkalinity consumption		149 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{BUL,A}$	0 mgCOD/l
FBSO COD	S_{BUL}	75 mgCOD/l
BSO COD	S_{BUL}	75 mgCOD/l
BO COD	S_{BUL}	554 mgCOD/l

S_{rj} reduction due to O ₂ & NO ₃		38.7 mgCOD/l
Reduced FBSO concentration	$S_{rj,conv}$	36.3 mgCOD/l

	$k_{f,120}$	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	$k_{f,T}$	0.0673 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	S_{BULn}	MX_{BUL}/Q_L	S_{BULn}	
Trial 1	0.00		754	4.41
Trial 2	4.41		766	4.34
Trial 3	4.34		766	4.34
Trial 4	4.34		766	4.34

Flux BO COD obtained by OHO's	95%	8771 kgCOD/d
Flux BO COD obtained by PAO's	5%	460 kgCOD/d
Check total BO COD		9232 kgCOD/d

correct

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{D20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{DT}	0.0448 /d

Activated Sludge Masses

OHO VSS			
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	12771 kgVSS	
Endogenous Residue VSS OHO	$MX_{E,OHO}$	17181 kgVSS	

PAO VSS			
Polyphosphate Acc Organisms VSS	MX_{PAO}	2441 kgVSS	
Endogenous Residue VSS PAO	$MX_{E,PAO}$	684 kgVSS	

Unbiodegradable Organic VSS	MX_u	8074 kgVSS	
Total VSS	MX_v	41152 kgVSS	

ISS from influent		21420 kgISS	
ISS of OHO's		1916 kgISS	
ISS of PAO's		3214 kgISS	
ISS	$MX_{(O)}$	26550 kgISS	
TSS	MX_t	67702 kgTSS	
VSS/TSS ratio		0.608 kgVSS/kgTSS	

PAO biomass P-content		0.025 mgP/mgPAOVSS	
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS	
		0.38 mgP/mgPAOVSS	

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.08 mgP/l
biomass P-content	ΔP_{OHO}	2.47 mgP/l
Potential P-removal		4.55 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.08 mgP/l
biomass P-content	ΔP_{OHO}	2.47 mgP/l
Total Actual P-removal		4.55 mgP/l

TP effluent P_{te} 10.95 mgP/l

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	6997 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	275 kgO/d
Carbonaceous Oxygen flux	FO_c	7272 kgO/d
Nitrogenous Oxygen flux	FO_N	2823 kgO/d
Oxygen dmnd recover by denitrification	FO_D	1551 kgO/d
Total Oxygen Demand (FO _c + FO _N - FO _D)	FO_T	8545 kgO/d
Oxygen utilisation rate	O_T	48.6 mgO/l.h

UCT Reactor @ 25 Days SRT

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Check	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	5748	19159	45981	70887
Concentration TSS (kgTSS/m ³)	3.14	6.28	6.28	5.810
Volume (m ³)	1830	3050	7320	12200
Volume fraction	15%	25%	60%	100%
Concentration VSS (kgVSS/m ³)	1.93	3.86	3.86	3.57
UPO VSS Concentration (kgUPOVSS/m ³)	0.358	0.716	0.716	0.662

Mass TSS wasted per day 2835.5 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 451.4 m³/d

COD mass balance	
COD in (influent)	10315.0 kgCOD/d
COD out	10315.0 kgCOD/d
$Q_a S_{ia} + Q_w S_{ia}$	605.0 kgCOD/d
$Q_a X_{f_{CO_2}}$ or $f_{CO_2} MX_d/Rs$	2581.0 kgCOD/d
FO_2	7129.0 kgO/d

N Mass balance	
TKN in (influent)	803.33 kgN/d
TKN out	803.33 kgN/d
N_{ia}	94.02 kgN/d
N_{waste}	176.9 kgN/d
$N_{nitrified}$	532.4 kgN/d

TOD balance	
TOD in (influent)	13986.23 kgTOD/d
TOD out	13986.23 kgTOD/d
$TOD_{effluent}$	688.00 kgTOD/d
TOD_{waste}	3396.60 kgTOD/d
$TOD_{n2\ gas}$	1522.74 kgTOD/d
FO_2	8378.89 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S_{ua}	36.30	75	30 mgCOD/l
Unbiol Sol Org N	N_{uaa}	0.90	-	- mgN/l
FSA-N	N_{ia}	0.44	6	2 mgFSA-N/l
TKN-N	N_{ia}	1.34	-	- mgTKN-N/l
Nitrate	N_{ia}	4.46	15	1.5 mgNO ₃ -N/l
Unbiol Sol Org P	P_{uaa}	0.60	-	- mgP/l
Ortho P as P	P_{aa}	10.58	10	2.5 mgP/l
TP	P_{ia}	11.18	-	- mgP/l

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	5489	18298	43915	67702
Concentration TSS (kgTSS/m ³)	3.00	6.00	6.00	5.549
Volume (m ³)	1830	3050	7320	12200
	5489			
Concentration VSS (kgVSS/m ³)	1.82	3.65	3.65	3.37
UPO VSS Concentration (kgUPOVSS/m ³)	0.358	0.716	0.716	0.662

Mass TSS wasted per day 2708.1 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 451.4 m³/d

COD mass balance	
COD in (influent)	10315.0 kgCOD/d
COD out	10315.0 kgCOD/d
$Q_a S_{ia} + Q_w S_{ia}$	605.0 kgCOD/d
$Q_a X_{f_{CO_2}}$ or $f_{CO_2} MX_d/Rs$	2437.9 kgCOD/d
FO_2	7272.1 kgO/d

N Mass balance	
TKN in (influent)	803.33 kgN/d
TKN out	803.33 kgN/d
N_{ia}	93.95 kgN/d
N_{waste}	167.2 kgN/d
$N_{nitrified}$	542.2 kgN/d

TOD balance	
TOD in (influent)	13986.23 kgTOD/d
TOD out	13986.23 kgTOD/d
$TOD_{effluent}$	681.66 kgTOD/d
TOD_{waste}	3209.10 kgTOD/d
$TOD_{n2\ gas}$	1550.57 kgTOD/d
FO_2	8544.90 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S_{ua}	36.30	75	30 mgCOD/l
Unbiol Sol Org N	N_{uaa}	0.90	-	- mgN/l
FSA-N	N_{ia}	0.36	6	2 mgFSA-N/l
TKN-N	N_{ia}	1.26	-	- mgTKN-N/l
Nitrate	N_{ia}	4.54	15	1.5 mgNO ₃ -N/l
Unbiol Sol Org P	P_{uaa}	0.60	-	- mgP/l
Ortho P as P	P_{aa}	10.95	10	2.5 mgP/l
TP	P_{ia}	11.55	-	- mgP/l

UCT Reactor @ 30 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	16.67 Ml/d
Sludge Age	SRT	30.0 days
Reactor TSS concentration	X _T	7250.46 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	619	10315
BPO COD	Sbpi	479	7982
UPO COD	Supi	29	478
	fs'up		0.046
VFA COD	Sbsi,a	0.0	0
FBSO COD	Sbsfi	75	1250
BSO COD	Sbsi	75	1250
USO COD	Susi	36.3	605
	fs'us		0.059
BO COD	Sbi	554	9232
UO COD	Sui	65	1083
TSS		241	4012
ISS		51.4	857
VSS		189	3155
UPO VSS		19.4	323
BPO VSS		170	2832
TKN	Nti	48.2	803
Org N	Noi	13.8	230
FSA	Nai	34.4	573
BSO	Nobsi	2.90	48
USO	Nousi	0.90	15
BPO	Nobpi	8.70	145
UPO	Noupi	1.30	22
Total P	Pti	15.50	258
OP	Pai	12.80	213
Org P	Poi	2.70	45
BSO	Pobsi	0.70	12
USO	Pousi	0.60	10
BPO	Pobpi	0.78	13
UPO	Poupi	0.62	10

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _o	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{ov}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,fbs0}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso0}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,u0}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,u0}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,u0}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2141 /d
	μ _{h,m20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{amT}	0.2829 /d
	b _{h20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0357 /d
	K _{h20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{HT}	0.6288 mgFSA/l
	K _{sp(0)}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{LT}	0.3472
Denitrification	K _{sp(0)}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{LT}	0.0742
Denitrification	K ¹ _{sp(20)}	0.255
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K ¹ _{LT}	0.1874

Factor of safety reducing μ _{amT}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _m	6.76 days
SRT _m (with safety factor)	SRT _m	8.45 Nitrifies!

Max unaerated sludge mass fraction	f _{xm}	0.70
Total unaerated sludge mass fraction	f _{xt}	0.35
Anoxic mass fraction primary anox 2	f _{x prim anox 2}	0.27
Anaerobic mass fraction	f _{anoxaer}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments 2

r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N _{br}	4.6 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{O2,L}	0.0 mgO/l

influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	1.644 :1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)	f _{Sb/s}	0.135

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	16.67 Ml/d
Sludge Age	SRT	30.0 days
Reactor TSS concentration	X _T	6947 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	619	10315
BPO COD	Sbpi	479	7982
UPO COD	Supi	29	478
	fs'up		0.046
VFA COD	Sbsi,a	0	0
FBSO COD	Sbsfi	75	1250
BSO COD	Sbsi	75	1250
USO COD	Susi	36	605
	fs'us		0.059
BO COD	Sbi	554	9232
UO COD	Sui	65	1083
TSS		241	4012
ISS		51	857
VSS		189	3155
UPO VSS		19	323
BPO VSS		170	2832
TKN	Nti	48	803
Org N	Noi	14	230
FSA	Nai	34	573
BSO	Nobsi	2.90	48
USO	Nousi	0.90	15
BPO	Nobpi	8.70	145
UPO	Noupi	1.30	22
Total P	Pti	15.50	258
OP	Pai	12.80	213
Org P	Poi	2.70	45
BSO	Pobsi	0.70	12
USO	Pousi	0.60	10
BPO	Pobpi	0.78	13
UPO	Poupi	0.62	10

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _o	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{ov}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,fbs0}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso0}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,u0}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,u0}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,u0}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate OHO	b _{HT}	0.2691 /d
	μ _{h,m20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{amT}	0.7157 /d
	b _{h20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0448 /d
	K _{h20}	1.0
Nitrification	θ	1.123
Half Saturation Coefficient	K _{HT}	1.5904
	K _{sp(0)}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{LT}	1.4930
Denitrification	K _{sp(0)}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{LT}	0.1374
Denitrification	K ¹ _{sp(20)}	0.255
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K ¹ _{LT}	0.3469

Factor of safety reducing μ _{amT}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _m	2.38 days
SRT _m (with safety factor)	SRT _m	2.98 Nitrifies!

Max unaerated sludge mass fraction	f _{xm}	0.86
Total unaerated sludge mass fraction	f _{xt}	0.35
Anoxic mass fraction primary anox 2	f _{x prim anox 2}	0.27
Anaerobic mass fraction	f _{anoxaer}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments 2

r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N _{br}	4.6 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{O2,L}	0.0 mgO/l

influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	1.6 :1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)	f _{Sb/s}	0.135

UCT Reactor @ 30 Days SRT

Influent TKN	N_0	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_L	166 kgN/d
Equiv conc in influent	N_i	9.98 mgN/l
Effluent Sol Unbiode Org N	N_{unb}	0.90 mgN/l
Effluent ammonia	N_{NH}	0.38 mgFSA-N/l
TKN in effluent	N_{de}	1.28 mgTKN-N/l
Nitrification capacity	N_L	36.94 mgN/l influent

Denitrification potential BSO (K1)	D_{BBSO}	1.0 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BPO}	48.57 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{d1}	49.56 mgNO ₂ -N/l influent

	A	0.6993
	B	-10.1879
	C	68.771
Optimal a-recycle ratio	a_{opt}	19.59
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00
set = a_{opt} for balanced UCT		
recycle limited		

Effluent Nitrate if recycle limited		4.27 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-7.84 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{NH}	4.27 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₂)	$N_{NH} + N_{de}$	5.55 mgN/l
N removal		88.5%

Alkalinity consumed by nitrification		264 mg CaCO ₃
Alkalinity recovered by denitrification		117 mg CaCO ₃
Total Alkalinity consumption		147 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{bi,a}$	0 mgCOD/l
FBSO COD	S_{bi}	75 mgCOD/l
BSO COD	S_{bi}	75 mgCOD/l
BO COD	S_{bi}	554 mgCOD/l

$S_{F,i}$ reduction due to O ₂ & NO ₃		39.71498628 mgCOD/l
Reduced FBSO concentration	$S_{F,i,conv}$	35.28501372 mgCOD/l

	$k_{r,120}$	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	$k_{r,T}$	0.0535 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	$S_{bi,N}$	MX_{bi}/Q_r	$S_{bi,N}$	
Trial 1	0.00	943		4.31
Trial 2	4.31	959		4.24
Trial 3	4.24	959		4.24
Trial 4	4.24	959		4.24

Flux BO COD obtained by OHO's	95%	8785 kgCOD/d
Flux BO COD obtained by PAO's	5%	447 kgCOD/d
Check total BO COD		9232 kgCOD/d

correct
9232

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{G20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{GT}	0.0357 /d

Activated Sludge Masses

<u>OHO VSS</u>		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	15979 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	20523 kgVSS

<u>PAO VSS</u>		
Polyphosphate Acc Organisms VSS	MX_{PAO}	2913 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	780 kgVSS

Unbiodegradable Organic VSS	MX_{iu}	9689 kgVSS
Total VSS	MX_v	49885 kgVSS

ISS from influent		25705 kgISS
ISS of OHO's		2397 kgISS
ISS of PAO's		3835 kgISS
ISS	MX_{DO}	31937 kgISS
TSS	MX_t	81821 kgTSS
VSS/TSS ratio		0.610 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.380 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.07 mgP/l
biomass P-content	ΔP_{OHO}	2.49 mgP/l
Potential P-removal		4.56 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.07 mgP/l
biomass P-content	ΔP_{OHO}	2.49 mgP/l
Total Actual P-removal		4.56 mgP/l

TP effluent

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	6983 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	264 kgO/d
Carbonaceous Oxygen flux	FO_c	7247 kgO/d
Nitrogenous Oxygen flux	FO_N	2814 kgO/d
Oxygen dmdnd recover by denitrification	FO_D	1557 kgO/d
Total Oxygen Demand (FO _c + FO _N + FO _D)	FO_T	8504 kgO/d
Oxygen utilisation rate	O_r	48.4 mgO/l.h

Influent TKN	N_0	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_L	158 kgN/d
Equiv conc in influent	N_i	9.46 mgN/l
Effluent Sol Unbiode Org N	N_{unb}	0.90 mgN/l
Effluent ammonia	N_{NH}	0.32 mgFSA-N/l
TKN in effluent	N_{de}	1.22 mgTKN-N/l
Nitrification capacity	N_L	37.51 mgN/l influent

Denitrification potential BSO (K1)	D_{BBSO}	1.0 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BPO}	73.51 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{d1}	74.47 mgNO ₂ -N/l influent

	A	0.6993
	B	-34.5330
	C	133.713
Optimal a-recycle ratio	a_{opt}	52.99
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00
recycle limited		

Effluent Nitrate if recycle limited		4.34 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-32.19 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{NH}	4.34 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₂)	$N_{NH} + N_{de}$	5.56 mgN/l
N removal		88.5%

Alkalinity consumed by nitrification		268 mg CaCO ₃
Alkalinity recovered by denitrification		118 mg CaCO ₃
Total Alkalinity consumption		149 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{bi,a}$	0 mgCOD/l
FBSO COD	S_{bi}	75 mgCOD/l
BSO COD	S_{bi}	75 mgCOD/l
BO COD	S_{bi}	554 mgCOD/l

$S_{F,i}$ reduction due to O ₂ & NO ₃		39.71498628 mgCOD/l
Reduced FBSO concentration	$S_{F,i,conv}$	35.28501372 mgCOD/l

	$k_{r,120}$	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	$k_{r,T}$	0.0673 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	$S_{bi,N}$	MX_{bi}/Q_r	$S_{bi,N}$	
Trial 1	0.00	772		4.19
Trial 2	4.19	784		4.12
Trial 3	4.12	784		4.12
Trial 4	4.12	784		4.12

Flux BO COD obtained by OHO's	95%	8781 kgCOD/d
Flux BO COD obtained by PAO's	5%	451 kgCOD/d
Check total BO COD		9232 kgCOD/d

correct

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{G20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{GT}	0.0448 /d

Activated Sludge Masses

<u>OHO VSS</u>		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	13067 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	21095 kgVSS

<u>PAO VSS</u>		
Polyphosphate Acc Organisms VSS	MX_{PAO}	2594 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	873 kgVSS

Unbiodegradable Organic VSS	MX_{iu}	9689 kgVSS
Total VSS	MX_v	47318 kgVSS

ISS from influent		25705 kgISS
ISS of OHO's		1960 kgISS
ISS of PAO's		3415 kgISS
ISS	MX_{DO}	31080 kgISS
TSS	MX_t	78398 kgTSS
VSS/TSS ratio		0.604 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.38 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	1.84 mgP/l
biomass P-content	ΔP_{OHO}	2.37 mgP/l
Potential P-removal		4.21 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	1.84 mgP/l
biomass P-content	ΔP_{OHO}	2.37 mgP/l
Total Actual P-removal		4.21 mgP/l

TP effluent

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	7095 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	280 kgO/d
Carbonaceous Oxygen flux	FO_c	7374 kgO/d
Nitrogenous Oxygen flux	FO_N	2857 kgO/d
Oxygen dmdnd recover by denitrification	FO_D	1581 kgO/d
Total Oxygen Demand (FO _c + FO _N + FO _D)	FO_T	8650 kgO/d
Oxygen utilisation rate	O_r	49.2 mgO/l.h

UCT Reactor @ 30 Days SRT

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Check	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	6634	22114	53073	81821
Concentration TSS (kgTSS/m ³)	3.63	7.25	7.25	6.707
Volume (m ³)	1830	3050	7320	12200
Volume fraction	15%	25%	60%	100%
Concentration VSS (kgVSS/m ³)	2.21	4.42	4.42	4.09
UPO VSS Concentration (kgUPOVSS/m ³)	0.429	0.859	0.859	0.794

Mass TSS wasted per day 2727.4 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 376.2 m³/d

COD mass balance	
COD in (influent)	10315.0 kgCOD/d
COD out	10315.0 kgCOD/d
$Q_u S_{10} + Q_w S_{10}$	605.0 kgCOD/d
$Q_u X_{10} f_{10}$ or $f_{10} MX_u/Rs$	2462.6 kgCOD/d
FO_L	7247.4 kgO/d

N Mass balance	
TKN in (influent)	803.33 kgN/d
TKN out	803.33 kgN/d
N_{10}	90.46 kgN/d
N_{waste}	168.4 kgN/d
$N_{denitrified}$	544.5 kgN/d

TOD balance	
TOD in (influent)	13986.23 kgTOD/d
TOD out	13986.23 kgTOD/d
$TOD_{effluent}$	686.56 kgTOD/d
TOD_{waste}	3238.40 kgTOD/d
TOD_{N_2-gas}	1557.28 kgTOD/d
FO_L	8503.99 kgTOD/d

Effluent Concentrations		General	Special	Unit	
Unbiol Sol COD	S_{100}	36.30	75	30	mgCOD/l
Unbiol Sol Org N	N_{1000}	0.90	-	-	mgN/l
FSA-N	N_{10}	0.38	6	2	mgFSA-N/l
TKN-N	N_{10}	1.28	-	-	mgTKN-N/l
Nitrate	N_{10}	4.27	15	1.5	mgNO ₃ -N/l
Unbiol Sol Org P	P_{1000}	0.60	-	-	mgP/l
Ortho P as P	P_{10}	10.94	10	2.5	mgP/l
TP	P_{10}	11.54	-	-	mgP/l

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	6357	21189	50853	78398
Concentration TSS (kgTSS/m ³)	3.47	6.95	6.95	6.426
Volume (m ³)	1830	3050	7320	12200
	6357			
Concentration VSS (kgVSS/m ³)	2.10	4.19	4.19	3.88
UPO VSS Concentration (kgUPOVSS/m ³)	0.429	0.859	0.859	0.794

Mass TSS wasted per day 2613.3 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 376.2 m³/d

COD mass balance	
COD in (influent)	10315.0 kgCOD/d
COD out	10315.0 kgCOD/d
$Q_u S_{10} + Q_w S_{10}$	605.0 kgCOD/d
$Q_u X_{10} f_{10}$ or $f_{10} MX_u/Rs$	2335.9 kgCOD/d
FO_L	7374.1 kgO/d

N Mass balance	
TKN in (influent)	803.33 kgN/d
TKN out	803.33 kgN/d
N_{10}	90.61 kgN/d
N_{waste}	159.8 kgN/d
$N_{denitrified}$	552.9 kgN/d

TOD balance	
TOD in (influent)	13986.23 kgTOD/d
TOD out	13986.23 kgTOD/d
$TOD_{effluent}$	682.33 kgTOD/d
TOD_{waste}	3072.50 kgTOD/d
TOD_{N_2-gas}	1581.32 kgTOD/d
FO_L	8650.09 kgTOD/d

Effluent Concentrations		General	Special	Unit	
Unbiol Sol COD	S ₁₀₀	36.30	75	30	mgCOD/l
Unbiol Sol Org N	N ₁₀₀₀	0.90	-	-	mgN/l
FSA-N	N ₁₀	0.32	6	2	mgFSA-N/l
TKN-N	N ₁₀	1.22	-	-	mgTKN-N/l
Nitrate	N ₁₀	4.34	15	1.5	mgNO ₃ -N/l
Unbiol Sol Org P	P ₁₀₀₀	0.60	-	-	mgP/l
Ortho P as P	P ₁₀	11.29	10	2.5	mgP/l
TP	P ₁₀	11.89	-	-	mgP/l

**Annexure A4 – Detailed Reactor Model for Influent
Flow of 35 ML/d**

MLE Reactor @ 10 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	15.6 Ml/d
Sludge Age	SRT	10.0 days
Reactor TSS concentration	X _r	2475 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti 619	9627
BPO COD	Sbpi 479	7450
UPO COD	Supi 29	446
	fs'up	0.0464
VFA COD	Sbsi,a 0.0	0
FBSO COD	Sbsfi 75	1167
BSO COD	Sbsi 75	1167
USO COD	Susi 36.3	565
	fs'us	0.0587
BO COD	Sbi 554	8616
UO COD	Sui 65	1011
TSS	241	3745
ISS	51.4	800
VSS	189	2945
UPO VSS	19.4	302
BPO VSS	170	2643
TKN	Nti 48.2	750
Org N	Noi 13.8	215
FSA	Nai 34.4	535
BSO	Nobsi 2.90	45
USO	Nousi 0.90	14
BPO	Nobpi 8.70	135
UPO	Noupi 1.30	20
Total P	Pti 15.50	241
OP	Pai 12.80	199
Org P	Poi 2.70	42
BSO	Pobsi 0.70	11
USO	Pousi 0.60	9
BPO	Pobpi 0.78	12
UPO	Poupi 0.62	10

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,upo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,upo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,upo}	0.518 mgC/mgVSS

Temperature dependant coefficients

	T	16 °C
	b _{H20}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2141 /d
	μ _{Am20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.2829 /d
	b _{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0357 /d
	K _{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K _{HT}	0.6288 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	12345 kgVSS
Endogenous Residue VSS	MX _{EH}	5286 kgVSS
Unbiodegradeable Organic VSS	MX _{iv}	3017 kgVSS
Total VSS	MX _v	20647 kgVSS
ISS from influent		7997 kgISS
ISS of OHO's		1852 kgISS
ISS	MX _{IOI}	9849 kgISS
TSS	MX _t	30496 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{hn}	19.0 hr

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	15.6 Ml/d
Sludge Age	SRT	10.0 days
Reactor TSS concentration	X _T	2333 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti 618.9	9627
BPO COD	Sbpi 479	7450
UPO COD	Supi 29	446
	fs'up	0.04637
VFA COD	Sbsi,a 0	0
FBSO COD	Sbsfi 75	1167
BSO COD	Sbsi 75	1167
USO COD	Susi 36.3	565
	fs'us	0.05865
BO COD	Sbi 554	8616
UO COD	Sui 65	1011
TSS	240.72727	3745
ISS	51.4	800
VSS	189.31818	2945
UPO VSS	19.39	302
BPO VSS	170	2643
TKN	Nti 48.2	750
Org N	Noi 13.8	215
FSA	Nai 34.4	535
BSO	Nobsi 2.90	45.1
USO	Nousi 0.90	14.0
BPO	Nobpi 8.70	135
UPO	Noupi 1.30	20
Total P	Pti 15.5	241
OP	Pai 12.8	199
Org P	Poi 2.7	42.0
BSO	Pobsi 0.7	10.9
USO	Pousi	
BPO	Pobpi 0.78	12
UPO	Poupi 0.62	9.65

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,upo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,upo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,upo}	0.518 mgC/mgVSS

Temperature dependant coefficients

	T	24 °C
	b _{H20}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2691 /d
	μ _{Am20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.7157 /d
	b _{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0448 /d
	K _{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K _{HT}	1.5904 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	10505 kgVSS
Endogenous Residue VSS	MX _{EH}	5654 kgVSS
Unbiodegradeable Organic VSS	MX _{iv}	3017 kgVSS
Total VSS	MX _v	19175 kgVSS
ISS from influent		7997 kgISS
ISS of OHO's		1576 kgISS
ISS	MX _{IOI}	9573 kgISS
TSS	MX _t	28748 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{hn}	19.0 hr

MLE Reactor @ 10 Days SRT

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	1002 mgVSS/l
Endogenous Residue VSS	X_{EH}	429 mgVSS/l
Unbiodegradable Organic VSS	X_I	245 mgVSS/l
Total VSS	X_V	1676 mgVSS/l
Influent Biodegradable ISS	X_{IOI}	799 mgISS/l
TSS	X_t	2475 mgTSS/l

Active fraction of VSS	f_{av}	0.598 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.405 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.677 kgVSS/kgTSS

Waste Flow Rate	Q_w	1232 m ³ /d
TSS wasted per day		3050 kgTSS/d
VSS wasted per day		2065 kgVSS/d

Flux of N in waste VSS	FN_s	206 kgN/d
Equiv conc in influent	N_s	13.27 mgN/l influent
Effluent Sol Unbiodegradable N	N_{ouse}	0.90 mgN/l

Factor of safety reducing $\mu_{A_{minT}}$	Sf	1.25
total unaerated mass fraction	fxt	0.148
Minimum sludge age for nitrification	SRT_m	4.87 days
SRT_m with Safety factor	$SRT_{m(SF)}$	6.09 Nitrifies!

If no nitrification		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	34.9 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	34.0 mgFSA-N/l

If complete nitrification		
Effluent NO ₃	N_{ne}	34.0 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ae}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	33.22 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	1.71 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.810 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.810 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	380.8 kgVSS

Denitrification	$K_{1(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	θ	1.2
	K_{1T}	0.3472 mgFSA/l
Denitrification	$K_{2(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	θ	1.08
	K_{2T}	0.0742 mgFSA/l

s-recycle ratio	s	1.00 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.401
Anoxic sludge mass fraction	f_{x1}	0.148 set = f_{xm} for balanced MLE
Min anoxic sludge mass fraction	f_{x1min}	0.032

Influent RBCOD fraction (Sbsi/Sbi)	$f_{sb's}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	8.74 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	17.49 mgNO ₃ -N/l influent

	A	0.6993
	B	17.4756
	C	1.062
Optimal a-recycle ratio	a_{opt}	0.06
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00 set = a_{opt} for balanced MLE
recycle limited		

Effluent Nitrate if recycle limited		16.61 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		16.08 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	16.61 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{te}$	18.32 mgN/l
N removal		62.0%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Carbonaceous Oxygen flux	FO_c	6005 kgO/d
Nitrogenous Oxygen flux	FO_N	2361 kgO/d
Oxygen demand recover by denitrification	FO_D	739 kgO/d
Total Oxygen Demand ($FO_c + FO_N - FO_D$)	FO_T	7628 kgO/d
Oxygen utilisation rate	O_T	30.3 mgO/l.h

Alkalinity consumed by nitrification		237 mg CaCO ₃
Alkalinity recovered by denitrification		59 mg CaCO ₃
Total Alkalinity consumption		178 mg CaCO ₃

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	853 mgVSS/l
Endogenous Residue VSS	X_{EH}	459 mgVSS/l
Unbiodegradable Organic VSS	X_I	245 mgVSS/l
Total VSS	X_V	1556 mgVSS/l
Influent Biodegradable ISS	X_{IOI}	777 mgISS/l
TSS	X_t	2333 mgTSS/l

Active fraction of VSS	f_{av}	0.548 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.365 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.667 kgVSS/kgTSS

Waste Flow Rate	Q_w	1232 m ³ /d
TSS wasted per day		2875 kgTSS/d
VSS wasted per day		1918 kgVSS/d

Flux of N in waste VSS	FN_s	192 kgN/d
Equiv conc in influent	N_s	12.33 mgN/l influent
Effluent Sol Unbiodegradable N	N_{ouse}	0.90 mgN/l

Factor of safety reducing $\mu_{A_{minT}}$	Sf	1.25
total unaerated mass fraction	fxt	0.148
Minimum sludge age for nitrification	SRT_m	1.77 days
SRT_m with Safety factor	$SRT_{m(SF)}$	2.21 Nitrifies!

If no nitrification		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	35.9 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	35.0 mgFSA-N/l

If complete nitrification		
Effluent NO ₃	N_{ne}	35.0 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ae}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	34.48 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	1.40 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.496 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.496 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	370.3 kgVSS

Denitrification	$K_{1(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	θ	1.2
	K_{1T}	1.4930 mgFSA/l
Denitrification	$K_{2(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	θ	1.08
	K_{2T}	0.1374 mgFSA/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.747
Anoxic sludge mass fraction	f_{x1}	0.148
Min anoxic sludge mass fraction	f_{x1min}	0.009

Influent RBCOD fraction (Sbsi/Sbi)	$f_{sb's}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	13.77 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	22.52 mgNO ₃ -N/l influent

	A	0.6993
	B	13.7091
	C	9.856
Optimal a-recycle ratio	a_{opt}	0.69
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00
recycle limited		

Effluent Nitrate if recycle limited		17.24 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		12.31 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	17.24 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{te}$	18.63 mgN/l
N removal		61.3%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Carbonaceous Oxygen flux	FO_c	6223 kgO/d
Nitrogenous Oxygen flux	FO_N	2451 kgO/d
Oxygen demand recover by denitrification	FO_D	767 kgO/d
Total Oxygen Demand ($FO_c + FO_N - FO_D$)	FO_T	7907 kgO/d
Oxygen utilisation rate	O_T	31.4 mgO/l.h

Alkalinity consumed by nitrification		246 mg CaCO ₃
Alkalinity recovered by denitrification		62 mg CaCO ₃
Total Alkalinity consumption		185 mg CaCO ₃

MLE Reactor @ 10 Days SRT

COD mass balance	
COD in (influent)	9627.3 kgCOD/d
COD out	9627.6 kgCOD/d
$Q_e S_{Te} + Q_w S_{Te}$	564.7 kgCOD/d
$Q_w X_v f_{cv}$	3057.9 kgCOD/d
$V_p O_c$	6005.1 kgO/d

COD mass balance	
COD in (influent)	9627.3 kgCOD/d
COD out	9627.6 kgCOD/d
$Q_e S_{Te} + Q_w S_{Te}$	564.7 kgCOD/d
$Q_w X_v f_{cv}$	2839.9 kgCOD/d
$V_p O_c$	6223.1 kgO/d

MLE Reactor @ 10 Days SRT

N mass balance		
N in (influent)		749.8 kgTKN-N/d
N out		749.8 kgTKN-N/d
$Q_u N_{te} + Q_w N_{te}$		26.6 kgTKN-N/d
$Q N_s$		206.5 kgTKN-N/d
$Q N_{ne}$		516.7 kgNO3-N/d

TOD balance		
TOD in (influent)		13053.82 kgTOD/d
TOD out		13054.12 kgTOD/d
$TOD_{effluent}$		631.90 kgTOD/d
TOD_{waste}		4055.83 kgTOD/d
TOD_{N_2-gas}		738.88 kgTOD/d
FO_t		7627.51 kgTOD/d

Flux of P in waste VSS	FP_s	52 kgP/d
Equiv conc in influent	P_s	3.32 mgP/l
Effluent Sol Unbiol Org P	P_{ouse}	0.60 mgP/l
Effluent TP	P_{te}	12.18 mgP/l
Effluent Ortho-P as P	P_{oe}	11.58 mgOP-P/l

N mass balance		
N in (influent)		749.8 kgTKN-N/d
N out		749.8 kgTKN-N/d
$Q_u N_{te} + Q_w N_{te}$		21.7 kgTKN-N/d
$Q N_s$		191.8 kgTKN-N/d
$Q N_{ne}$		536.3 kgNO3-N/d

TOD balance		
TOD in (influent)		13053.82 kgTOD/d
TOD out		13054.12 kgTOD/d
$TOD_{effluent}$		611.31 kgTOD/d
TOD_{waste}		3768.79 kgTOD/d
TOD_{N_2-gas}		766.92 kgTOD/d
FO_t		7907.09 kgTOD/d

Flux of P in waste VSS	FP_s	48 kgP/d
Equiv conc in influent	P_s	3.08 mgP/l
Effluent Sol Unbiol Org P	P_{ouse}	0.00 mgP/l
Effluent TP	P_{te}	12.42 mgP/l
Effluent Ortho-P as P	P_{oe}	12.42 mgOP-P/l

Effluent Concentrations			General	Special	Unit	Effluent Concentrations			General	Special	Unit
Unbiol Sol COD	S_{use}	36.30	<75	<30	mgCOD	Unbiol Sol COD	S_{use}	36.30	<75	<30	mgCOD/l
Undiod Sol Org N	N_{ouse}	0.90	-	-	mgN/l	Undiod Sol Org N	N_{ouse}	0.90	-	-	mgN/l
FSA-N	N_{ae}	0.81	<6	<2	mgFSA	FSA-N	N_{ae}	0.50	<6	<2	mgFSA-N/l
TKN-N	N_{te}	1.71	-	-	mgTKN	TKN-N	N_{te}	1.40	-	-	mgTKN-N/l
Nitrate	N_{ne}	16.61	<15	<1.5	mgNO ₃	Nitrate	N_{ne}	17.24	<15	<1.5	mgNO ₃ -N/l
Undiod Sol Org P	P_{ouse}	0.60	-	-	mgP/l	Undiod Sol Org P	P_{ouse}	0.00	-	-	mgP/l
Ortho P as P	P_{oe}	11.58	<10	<2.5	mgOP-P	Ortho P as P	P_{oe}	12.42	<10	<2.5	mgOP-P/l
TP	P_{te}	12.18	-	-	mgP/l	TP	P_{te}	12.42	-	-	mgP/l

MLE Reactor @ 15 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	15.6 Ml/d
Sludge Age	SRT	15.0 days
Reactor TSS concentration	X _r	3350 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti 619	9627
BPO COD	Sbpi 479	7450
UPO COD	Supi 29	446
	fs'up	0.0464
VFA COD	Sbsi,a 0.0	0
FBSO COD	Sbsfi 75	1167
BSO COD	Sbsi 75	1167
USO COD	Susi 36.3	565
	fs'us	0.0587
BO COD	Sbi 554	8616
UO COD	Sui 65	1011
TSS	241	3745
ISS	51.4	800
VSS	189	2945
UPO VSS	19.4	302
BPO VSS	170	2643
TKN	Nti 48.2	750
Org N	Noi 13.8	215
FSA	Nai 34.4	535
BSO	Nobsi 2.90	45
USO	Nousi 0.90	14
BPO	Nobpi 8.70	135
UPO	Noupi 1.30	20
Total P	Pti 15.50	241
OP	Pai 12.80	199
Org P	Poi 2.70	42
BSO	Pobsi 0.70	11
USO	Pousi 0.60	9
BPO	Pobpi 0.78	12
UPO	Poupi 0.62	10

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,upo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,upo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,upo}	0.518 mgC/mgVSS

Temperature dependant coefficients

	T	16 °C
	b _{H20}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2141 /d
	μ _{Am20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.2829 /d
	b _{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0357 /d
	K _{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K _{HT}	0.6288 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	13811 kgVSS
Endogenous Residue VSS	MX _{EH}	8870 kgVSS
Unbiodegradeable Organic VSS	MX _{lv}	4525 kgVSS
Total VSS	MX _v	27206 kgVSS
ISS from influent		11995 kgISS
ISS of OHO's		2072 kgISS
ISS	MX _{IOI}	14067 kgISS
TSS	MX _t	41273 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{hn}	19.0 hr

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	15.6 Ml/d
Sludge Age	SRT	15.0 days
Reactor TSS concentration	X _T	3176 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti 618.9	9627
BPO COD	Sbpi 479	7450
UPO COD	Supi 29	446
	fs'up	0.04637
VFA COD	Sbsi,a 0	0
FBSO COD	Sbsfi 75	1167
BSO COD	Sbsi 75	1167
USO COD	Susi 36.3	565
	fs'us	0.05865
BO COD	Sbi 554	8616
UO COD	Sui 65	1011
TSS	240.72727	3745
ISS	51.4	800
VSS	189.31818	2945
UPO VSS	19.39	302
BPO VSS	170	2643
TKN	Nti 48.2	750
Org N	Noi 13.8	215
FSA	Nai 34.4	535
BSO	Nobsi 2.90	45.1
USO	Nousi 0.90	14.0
BPO	Nobpi 8.70	135
UPO	Noupi 1.30	20
Total P	Pti 15.5	241
OP	Pai 12.8	199
Org P	Poi 2.7	42.0
BSO	Pobsi 0.7	10.9
USO	Pousi	
BPO	Pobpi 0.78	12
UPO	Poupi 0.62	9.65

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,upo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,upo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,upo}	0.518 mgC/mgVSS

Temperature dependant coefficients

	T	24 °C
	b _{H20}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2691 /d
	μ _{Am20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.7157 /d
	b _{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0448 /d
	K _{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K _{HT}	1.5904 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	11548 kgVSS
Endogenous Residue VSS	MX _{EH}	9322 kgVSS
Unbiodegradeable Organic VSS	MX _{lv}	4525 kgVSS
Total VSS	MX _v	25395 kgVSS
ISS from influent		11995 kgISS
ISS of OHO's		1732 kgISS
ISS	MX _{IOI}	13728 kgISS
TSS	MX _t	39123 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{hn}	19.0 hr

MLE Reactor @ 15 Days SRT

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	1121 mgVSS/l
Endogenous Residue VSS	X_{EH}	720 mgVSS/l
Unbiodegradable Organic VSS	X_I	367 mgVSS/l
Total VSS	X_V	2208 mgVSS/l
Influent Biodegradable ISS	X_{IOI}	1142 mgISS/l
TSS	X_t	3350 mgTSS/l

Active fraction of VSS	f_{av}	0.508 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.335 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.659 kgVSS/kgTSS

Waste Flow Rate	Q_w	821 m ³ /d
TSS wasted per day		2752 kgTSS/d
VSS wasted per day		1814 kgVSS/d

Flux of N in waste VSS	FN_s	181 kgN/d
Equiv conc in influent	N_s	11.66 mgN/l influent
Effluent Sol Unbiol Org N	N_{ouse}	0.90 mgN/l

Factor of safety reducing $\mu_{A_{MT}}$	Sf	1.25
total unaerated mass fraction	fxt	0.148
Minimum sludge age for nitrification	SRT_m	4.87 days
SRT_m with Safety factor	$SRT_{m(SF)}$	6.09 Nitrifies!

If no nitrification		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	36.5 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	35.6 mgFSA-N/l

If complete nitrification		
Effluent NO ₃	N_{ne}	35.6 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ae}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	35.18 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	1.36 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.464 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.464 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	534.6 kgVSS

Denitrification	$K_{1(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	θ	1.2
	K_{1T}	0.3472 mgFSA/l
Denitrification	$K_{2(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	θ	1.08
	K_{2T}	0.0742 mgFSA/l

s-recycle ratio	s	1.00 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.548
Anoxic sludge mass fraction	f_{x1}	0.148 set = f_{xm} for balanced MLE
Min anoxic sludge mass fraction	f_{x1min}	0.028

Influent RBCOD fraction (Sbsi/Sbi)	$f_{sb's}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	9.78 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	18.53 mgNO ₃ -N/l influent

	A	0.6993
	B	18.3974
	C	1.179
Optimal a-recycle ratio	a_{opt}	0.06
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00 set = a_{opt} for balanced MLE
recycle limited		

Effluent Nitrate if recycle limited		17.59 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		17.00 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	17.59 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{te}$	18.95 mgN/l
N removal		60.7%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Carbonaceous Oxygen flux	FO_c	6377 kgO/d
Nitrogenous Oxygen flux	FO_N	2501 kgO/d
Oxygen dmnd recover by denitrification	FO_D	782 kgO/d
Total Oxygen Demand ($FO_c + FO_N - FO_D$)	FO_T	8095 kgO/d
Oxygen utilisation rate	O_T	32.1 mgO/l.h

Alkalinity consumed by nitrification		251 mg CaCO ₃
Alkalinity recovered by denitrification		63 mg CaCO ₃
Total Alkalinity consumption		188 mg CaCO ₃

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	937 mgVSS/l
Endogenous Residue VSS	X_{EH}	757 mgVSS/l
Unbiodegradable Organic VSS	X_I	367 mgVSS/l
Total VSS	X_V	2061 mgVSS/l
Influent Biodegradable ISS	X_{IOI}	1114 mgISS/l
TSS	X_t	3176 mgTSS/l

Active fraction of VSS	f_{av}	0.455 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.295 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.649 kgVSS/kgTSS

Waste Flow Rate	Q_w	821 m ³ /d
TSS wasted per day		2608 kgTSS/d
VSS wasted per day		1693 kgVSS/d

Flux of N in waste VSS	FN_s	169 kgN/d
Equiv conc in influent	N_s	10.88 mgN/l influent
Effluent Sol Unbiol Org N	N_{ouse}	0.90 mgN/l

Factor of safety reducing $\mu_{A_{MT}}$	Sf	1.25
total unaerated mass fraction	fxt	0.148
Minimum sludge age for nitrification	SRT_m	1.77 days
SRT_m with Safety factor	$SRT_{m(SF)}$	2.21 Nitrifies!

If no nitrification		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	37.3 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	36.4 mgFSA-N/l

If complete nitrification		
Effluent NO ₃	N_{ne}	36.4 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ae}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	36.06 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	1.26 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.356 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.356 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	503.0 kgVSS

Denitrification	$K_{1(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	θ	1.2
	K_{1T}	1.4930 mgFSA/l
Denitrification	$K_{2(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	θ	1.08
	K_{2T}	0.1374 mgFSA/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.805
Anoxic sludge mass fraction	f_{x1}	0.148
Min anoxic sludge mass fraction	f_{x1min}	0.008

Influent RBCOD fraction (Sbsi/Sbi)	$f_{sb's}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	15.14 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	23.88 mgNO ₃ -N/l influent

	A	0.6993
	B	13.9251
	C	11.007
Optimal a-recycle ratio	a_{opt}	0.76
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00
recycle limited		

Effluent Nitrate if recycle limited		18.03 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		12.53 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	18.03 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{te}$	19.29 mgN/l
N removal		60.0%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Carbonaceous Oxygen flux	FO_c	6556 kgO/d
Nitrogenous Oxygen flux	FO_N	2563 kgO/d
Oxygen dmnd recover by denitrification	FO_D	802 kgO/d
Total Oxygen Demand ($FO_c + FO_N - FO_D$)	FO_T	8317 kgO/d
Oxygen utilisation rate	O_T	33.0 mgO/l.h

Alkalinity consumed by nitrification		257 mg CaCO ₃
Alkalinity recovered by denitrification		64 mg CaCO ₃
Total Alkalinity consumption		193 mg CaCO ₃

MLE Reactor @ 15 Days SRT

COD mass balance	
COD in (influent)	9627.3 kgCOD/d
COD out	9627.6 kgCOD/d
$Q_e S_{Te} + Q_w S_{Te}$	564.7 kgCOD/d
$Q_w X_v f_{cv}$	2686.1 kgCOD/d
$V_p O_c$	6376.9 kgO/d

COD mass balance	
COD in (influent)	9627.3 kgCOD/d
COD out	9627.6 kgCOD/d
$Q_e S_{Te} + Q_w S_{Te}$	564.7 kgCOD/d
$Q_w X_v f_{cv}$	2507.4 kgCOD/d
$V_p O_c$	6555.6 kgO/d

MLE Reactor @ 15 Days SRT

N mass balance		
N in (influent)		749.8 kgTKN-N/d
N out		749.8 kgTKN-N/d
$Q_u N_{ie} + Q_w N_{te}$		21.2 kgTKN-N/d
$Q N_s$		181.4 kgTKN-N/d
$Q N_{ne}$		547.2 kgNO3-N/d

TOD balance		
TOD in (influent)		13053.82 kgTOD/d
TOD out		13054.12 kgTOD/d
$TOD_{effluent}$		626.71 kgTOD/d
TOD_{waste}		3549.91 kgTOD/d
TOD_{N_2-gas}		782.47 kgTOD/d
FO_t		8095.02 kgTOD/d

Flux of P in waste VSS	FP_s	45 kgP/d
Equiv conc in influent	P_s	2.91 mgP/l
Effluent Sol Unbiod Org P	P_{ouse}	0.60 mgP/l
Effluent TP	P_{te}	12.59 mgP/l
Effluent Ortho-P as P	P_{oe}	11.99 mgOP-P/l

N mass balance		
N in (influent)		749.8 kgTKN-N/d
N out		749.8 kgTKN-N/d
$Q_u N_{ie} + Q_w N_{te}$		19.5 kgTKN-N/d
$Q N_s$		169.3 kgTKN-N/d
$Q N_{ne}$		560.9 kgNO3-N/d

TOD balance		
TOD in (influent)		13053.82 kgTOD/d
TOD out		13054.12 kgTOD/d
$TOD_{effluent}$		619.43 kgTOD/d
TOD_{waste}		3315.62 kgTOD/d
TOD_{N_2-gas}		802.14 kgTOD/d
FO_t		8316.93 kgTOD/d

Flux of P in waste VSS	FP_s	42 kgP/d
Equiv conc in influent	P_s	2.72 mgP/l
Effluent Sol Unbiod Org P	P_{ouse}	0.00 mgP/l
Effluent TP	P_{te}	12.78 mgP/l
Effluent Ortho-P as P	P_{oe}	12.78 mgOP-P/l

Effluent Concentrations			General	Special	Unit	Effluent Concentrations			General	Special	Unit
Unbiod Sol COD	S_{use}	36.30	<75	<30	mgCOD	Unbiod Sol COD	S_{use}	36.30	<75	<30	mgCOD/l
Undiod Sol Org N	N_{ouse}	0.90	-	-	mgN/l	Undiod Sol Org N	N_{ouse}	0.90	-	-	mgN/l
FSA-N	N_{ae}	0.46	<6	<2	mgFSA	FSA-N	N_{ae}	0.36	<6	<2	mgFSA-N/l
TKN-N	N_{te}	1.36	-	-	mgTKN	TKN-N	N_{te}	1.26	-	-	mgTKN-N/l
Nitrate	N_{ne}	17.59	<15	<1.5	mgNO ₃	Nitrate	N_{ne}	18.03	<15	<1.5	mgNO ₃ -N/l
Undiod Sol Org P	P_{ouse}	0.60	-	-	mgP/l	Undiod Sol Org P	P_{ouse}	0.00	-	-	mgP/l
Ortho P as P	P_{oe}	11.99	<10	<2.5	mgOP-P	Ortho P as P	P_{oe}	12.78	<10	<2.5	mgOP-P/l
TP	P_{te}	12.59	-	-	mgP/l	TP	P_{te}	12.78	-	-	mgP/l

MLE Reactor @ 20 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	15.6 Ml/d
Sludge Age	SRT	20.0 days
Reactor TSS concentration	X _r	4179 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti 619	9627
BPO COD	Sbpi 479	7450
UPO COD	Supi 29	446
	fs'up	0.0464
VFA COD	Sbsi,a 0.0	0
FBSO COD	Sbsfi 75	1167
BSO COD	Sbsi 75	1167
USO COD	Susi 36.3	565
	fs'us	0.0587
BO COD	Sbi 554	8616
UO COD	Sui 65	1011
TSS	241	3745
ISS	51.4	800
VSS	189	2945
UPO VSS	19.4	302
BPO VSS	170	2643
TKN	Nti 48.2	750
Org N	Noi 13.8	215
FSA	Nai 34.4	535
BSO	Nobsi 2.90	45
USO	Nousi 0.90	14
BPO	Nobpi 8.70	135
UPO	Noupi 1.30	20
Total P	Pti 15.50	241
OP	Pai 12.80	199
Org P	Poi 2.70	42
BSO	Pobsi 0.70	11
USO	Pousi 0.60	9
BPO	Pobpi 0.78	12
UPO	Poupi 0.62	10

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,upo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,upo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,upo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{H20}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2141 /d
	μ _{Am20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.2829 /d
	b _{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0357 /d
	K _{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K _{HT}	0.6288 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	14683 kgVSS
Endogenous Residue VSS	MX _{EH}	12573 kgVSS
Unbiodegradeable Organic VSS	MX _{lv}	6033 kgVSS
Total VSS	MX _v	33289 kgVSS
ISS from influent		15994 kgISS
ISS of OHO's		2202 kgISS
ISS	MX _{IOI}	18196 kgISS
TSS	MX _t	51485 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{hn}	19.0 hr

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	15.6 Ml/d
Sludge Age	SRT	20.0 days
Reactor TSS concentration	X _T	3984 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti 618.9	9627
BPO COD	Sbpi 479	7450
UPO COD	Supi 29	446
	fs'up	0.04637
VFA COD	Sbsi,a 0	0
FBSO COD	Sbsfi 75	1167
BSO COD	Sbsi 75	1167
USO COD	Susi 36.3	565
	fs'us	0.05865
BO COD	Sbi 554	8616
UO COD	Sui 65	1011
TSS	240.72727	3745
ISS	51.4	800
VSS	189.31818	2945
UPO VSS	19.39	302
BPO VSS	170	2643
TKN	Nti 48.2	750
Org N	Noi 13.8	215
FSA	Nai 34.4	535
BSO	Nobsi 2.90	45.1
USO	Nousi 0.90	14.0
BPO	Nobpi 8.70	135
UPO	Noupi 1.30	20
Total P	Pti 15.5	241
OP	Pai 12.8	199
Org P	Poi 2.7	42.0
BSO	Pobsi 0.7	10.9
USO	Pousi	
BPO	Pobpi 0.78	12
UPO	Poupi 0.62	9.65

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,upo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,upo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,upo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{H20}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2691 /d
	μ _{Am20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.7157 /d
	b _{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0448 /d
	K _{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K _{HT}	1.5904 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	12152 kgVSS
Endogenous Residue VSS	MX _{EH}	13079 kgVSS
Unbiodegradeable Organic VSS	MX _{lv}	6033 kgVSS
Total VSS	MX _v	31264 kgVSS
ISS from influent		15994 kgISS
ISS of OHO's		1823 kgISS
ISS	MX _{IOI}	17817 kgISS
TSS	MX _t	49080 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{hn}	19.0 hr

MLE Reactor @ 20 Days SRT

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	1192 mgVSS/l
Endogenous Residue VSS	X_{EH}	1021 mgVSS/l
Unbiodegradable Organic VSS	X_i	490 mgVSS/l
Total VSS	X_v	2702 mgVSS/l
Influent Biodegradable ISS	X_{iOI}	1477 mgISS/l
TSS	X_t	4179 mgTSS/l

Active fraction of VSS	f_{av}	0.441 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.285 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.647 kgVSS/kgTSS

Waste Flow Rate	Q_w	616 m ³ /d
TSS wasted per day		2574 kgTSS/d
VSS wasted per day		1664 kgVSS/d

Flux of N in waste VSS	FN_s	166 kgN/d
Equiv conc in influent	N_s	10.70 mgN/l influent
Effluent Sol Unbiodegradable N	N_{ouse}	0.90 mgN/l

Factor of safety reducing $\mu_{A_{mT}}$	Sf	1.25
total unaerated mass fraction	fxt	0.148
Minimum sludge age for nitrification	SRT_m	4.87 days
SRT_m with Safety factor	$SRT_{m(SF)}$	6.09 Nitrifies!

If no nitrification		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	37.5 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	36.6 mgFSA-N/l

If complete nitrification		
Effluent NO ₃	N_{ne}	36.6 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ae}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	36.25 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	1.25 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.347 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.347 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	658.2 kgVSS

Denitrification	$K_{1(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	θ	1.2
	K_{1T}	0.3472 mgFSA/l
Denitrification	$K_{2(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	θ	1.08
	K_{2T}	0.0742 mgFSA/l

s-recycle ratio	s	1.00 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.621
Anoxic sludge mass fraction	f_{x1}	0.148 set = f_{xm} for balanced MLE
Min anoxic sludge mass fraction	f_{x1min}	0.027

Influent RBCOD fraction (Sbsi/Sbi)	$f_{sb's}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	10.40 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	19.14 mgNO ₃ -N/l influent

	A	0.6993
	B	18.8571
	C	1.336
Optimal a-recycle ratio	a_{opt}	0.07
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00 set = a_{opt} for balanced MLE
recycle limited		

Effluent Nitrate if recycle limited		18.13 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		17.46 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	18.13 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{te}$	19.37 mgN/l
N removal		59.8%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Carbonaceous Oxygen flux	FO_c	6598 kgO/d
Nitrogenous Oxygen flux	FO_N	2577 kgO/d
Oxygen demand recover by denitrification	FO_D	806 kgO/d
Total Oxygen Demand ($FO_c + FO_N - FO_D$)	FO_T	8369 kgO/d
Oxygen utilisation rate	O_T	33.2 mgO/l.h

Alkalinity consumed by nitrification		259 mg CaCO ₃
Alkalinity recovered by denitrification		65 mg CaCO ₃
Total Alkalinity consumption		194 mg CaCO ₃

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	986 mgVSS/l
Endogenous Residue VSS	X_{EH}	1062 mgVSS/l
Unbiodegradable Organic VSS	X_i	490 mgVSS/l
Total VSS	X_v	2538 mgVSS/l
Influent Biodegradable ISS	X_{iOI}	1446 mgISS/l
TSS	X_t	3984 mgTSS/l

Active fraction of VSS	f_{av}	0.389 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.248 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.637 kgVSS/kgTSS

Waste Flow Rate	Q_w	616 m ³ /d
TSS wasted per day		2454 kgTSS/d
VSS wasted per day		1563 kgVSS/d

Flux of N in waste VSS	FN_s	156 kgN/d
Equiv conc in influent	N_s	10.05 mgN/l influent
Effluent Sol Unbiodegradable N	N_{ouse}	0.90 mgN/l

Factor of safety reducing $\mu_{A_{mT}}$	Sf	1.25
total unaerated mass fraction	fxt	0.148
Minimum sludge age for nitrification	SRT_m	1.77 days
SRT_m with Safety factor	$SRT_{m(SF)}$	2.21 Nitrifies!

If no nitrification		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	38.2 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	37.3 mgFSA-N/l

If complete nitrification		
Effluent NO ₃	N_{ne}	37.3 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ae}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	36.96 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	1.19 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.293 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.293 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	606.1 kgVSS

Denitrification	$K_{1(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	θ	1.2
	K_{1T}	1.4930 mgFSA/l
Denitrification	$K_{2(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	θ	1.08
	K_{2T}	0.1374 mgFSA/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.834
Anoxic sludge mass fraction	f_{x1}	0.148
Min anoxic sludge mass fraction	f_{x1min}	0.007

Influent RBCOD fraction (Sbsi/Sbi)	$f_{sb's}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	15.93 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	24.67 mgNO ₃ -N/l influent

	A	0.6993
	B	14.0322
	C	11.691
Optimal a-recycle ratio	a_{opt}	0.80
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00
recycle limited		

Effluent Nitrate if recycle limited		18.48 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		12.63 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	18.48 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{te}$	19.67 mgN/l
N removal		59.2%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Carbonaceous Oxygen flux	FO_c	6748 kgO/d
Nitrogenous Oxygen flux	FO_N	2627 kgO/d
Oxygen demand recover by denitrification	FO_D	822 kgO/d
Total Oxygen Demand ($FO_c + FO_N - FO_D$)	FO_T	8553 kgO/d
Oxygen utilisation rate	O_T	34.0 mgO/l.h

Alkalinity consumed by nitrification		264 mg CaCO ₃
Alkalinity recovered by denitrification		66 mg CaCO ₃
Total Alkalinity consumption		198 mg CaCO ₃

MLE Reactor @ 20 Days SRT

COD mass balance	
COD in (influent)	9628 kgCOD/d
COD out	9628 kgCOD/d
$Q_e S_{Te} + Q_w S_{Te}$	565 kgCOD/d
$Q_w X_v f_{cv}$	2465 kgCOD/d
$V_p O_c$	6598 kgO/d

COD mass balance	
COD in (influent)	9628 kgCOD/d
COD out	9628 kgCOD/d
$Q_e S_{Te} + Q_w S_{Te}$	564.7 kgCOD/d
$Q_w X_v f_{cv}$	2315.1 kgCOD/d
$V_p O_c$	6747.9 kgO/d

MLE Reactor @ 20 Days SRT

N mass balance	
N in (influent)	749.8 kgTKN-N/d
N out	749.8 kgTKN-N/d
$Q_u N_{1e} + Q_w N_{1e}$	19.4 kgTKN-N/d
$Q N_s$	166.4 kgTKN-N/d
$Q N_{ne}$	563.9 kgNO3-N/d

TOD balance	
TOD in (influent)	13054 kgTOD/d
TOD out	13054 kgTOD/d
$TOD_{effluent}$	627 kgTOD/d
TOD_{waste}	3252 kgTOD/d
TOD_{N_2-gas}	806 kgTOD/d
FO_t	8369 kgTOD/d

Flux of P in waste VSS	FP_s	42 kgP/d
Equiv conc in influent	P_s	2.67 mgP/l
Effluent Sol Unbiod Org P	P_{ouse}	0.60 mgP/l
Effluent TP	P_{te}	12.83 mgP/l
Effluent Ortho-P as P	P_{oe}	12.23 mgOP-P/l

N mass balance	
N in (influent)	749.8 kgTKN-N/d
N out	749.8 kgTKN-N/d
$Q_u N_{1e} + Q_w N_{1e}$	18.6 kgTKN-N/d
$Q N_s$	156.3 kgTKN-N/d
$Q N_{ne}$	574.9 kgNO3-N/d

TOD balance	
TOD in (influent)	13054 kgTOD/d
TOD out	13054 kgTOD/d
$TOD_{effluent}$	624 kgTOD/d
TOD_{waste}	3055 kgTOD/d
TOD_{N_2-gas}	822 kgTOD/d
FO_t	8553 kgTOD/d

Flux of P in waste VSS	FP_s	39 kgP/d
Equiv conc in influent	P_s	2.51 mgP/l
Effluent Sol Unbiod Org P	P_{ouse}	0.00 mgP/l
Effluent TP	P_{te}	12.99 mgP/l
Effluent Ortho-P as P	P_{oe}	12.99 mgOP-P/l

Effluent Concentrations			General	Special	Unit	Effluent Concentrations			General	Special	Unit
Unbiod Sol COD	S_{use}	36.30	<75	<30	mgCOD	Unbiod Sol COD	S_{use}	36.30	<75	<30	mgCOD/l
Undiod Sol Org N	N_{ouse}	0.90	-	-	mgN/l	Undiod Sol Org N	N_{ouse}	0.90	-	-	mgN/l
FSA-N	N_{ae}	0.35	<6	<2	mgFSA	FSA-N	N_{ae}	0.29	<6	<2	mgFSA-N/l
TKN-N	N_{te}	1.25	-	-	mgTKN	TKN-N	N_{te}	1.19	-	-	mgTKN-N/l
Nitrate	N_{ne}	18.13	<15	<1.5	mgNO ₃	Nitrate	N_{ne}	18.48	<15	<1.5	mgNO ₃ -N/l
Undiod Sol Org P	P_{ouse}	0.60	-	-	mgP/l	Undiod Sol Org P	P_{ouse}	0.00	-	-	mgP/l
Ortho P as P	P_{oe}	12.23	<10	<2.5	mgOP-P	Ortho P as P	P_{oe}	12.99	<10	<2.5	mgOP-P/l
TP	P_{te}	12.83	-	-	mgP/l	TP	P_{te}	12.99	-	-	mgP/l

MLE Reactor @ 25 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	15.6 Ml/d
Sludge Age	SRT	25.0 days
Reactor TSS concentration	X _r	4985 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti 619	9627
BPO COD	Sbpi 479	7450
UPO COD	Supi 29	446
	fs'up	0.0464
VFA COD	Sbsi,a 0.0	0
FBSO COD	Sbsfi 75	1167
BSO COD	Sbsi 75	1167
USO COD	Susi 36.3	565
	fs'us	0.0587
BO COD	Sbi 554	8616
UO COD	Sui 65	1011
TSS	241	3745
ISS	51.4	800
VSS	189	2945
UPO VSS	19.4	302
BPO VSS	170	2643
TKN	Nti 48.2	750
Org N	Noi 13.8	215
FSA	Nai 34.4	535
BSO	Nobsi 2.90	45
USO	Nousi 0.90	14
BPO	Nobpi 8.70	135
UPO	Noupi 1.30	20
Total P	Pti 15.50	241
OP	Pai 12.80	199
Org P	Poi 2.70	42
BSO	Pobsi 0.70	11
USO	Pousi 0.60	9
BPO	Pobpi 0.78	12
UPO	Poupi 0.62	10

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,upo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,upo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,upo}	0.518 mgC/mgVSS

Temperature dependant coefficients

	T	16 °C
	b _{H20}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2141 /d
	μ _{Am20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.2829 /d
	b _{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0357 /d
	K _{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K _{HT}	0.6288 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	15261 kgVSS
Endogenous Residue VSS	MX _{EH}	16334 kgVSS
Unbiodegradeable Organic VSS	MX _{iv}	7541 kgVSS
Total VSS	MX _v	39137 kgVSS
ISS from influent		19992 kgISS
ISS of OHO's		2289 kgISS
ISS	MX _{IOI}	22282 kgISS
TSS	MX _t	61418 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{hn}	19.0 hr

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	15.6 Ml/d
Sludge Age	SRT	25.0 days
Reactor TSS concentration	X _T	4776 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti 618.9	9627
BPO COD	Sbpi 479	7450
UPO COD	Supi 29	446
	fs'up	0.04637
VFA COD	Sbsi,a 0	0
FBSO COD	Sbsfi 75	1167
BSO COD	Sbsi 75	1167
USO COD	Susi 36.3	565
	fs'us	0.05865
BO COD	Sbi 554	8616
UO COD	Sui 65	1011
TSS	240.72727	3745
ISS	51.4	800
VSS	189.31818	2945
UPO VSS	19.39	302
BPO VSS	170	2643
TKN	Nti 48.2	750
Org N	Noi 13.8	215
FSA	Nai 34.4	535
BSO	Nobsi 2.90	45.1
USO	Nousi 0.90	14.0
BPO	Nobpi 8.70	135
UPO	Noupi 1.30	20
Total P	Pti 15.5	241
OP	Pai 12.8	199
Org P	Poi 2.7	42.0
BSO	Pobsi 0.7	10.9
USO	Pousi	
BPO	Pobpi 0.78	12
UPO	Poupi 0.62	9.65

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,upo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,upo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,upo}	0.518 mgC/mgVSS

Temperature dependant coefficients

	T	24 °C
	b _{H20}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2691 /d
	μ _{Am20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.7157 /d
	b _{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0448 /d
	K _{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K _{HT}	1.5904 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	12545 kgVSS
Endogenous Residue VSS	MX _{EH}	16878 kgVSS
Unbiodegradeable Organic VSS	MX _{iv}	7541 kgVSS
Total VSS	MX _v	36964 kgVSS
ISS from influent		19992 kgISS
ISS of OHO's		1882 kgISS
ISS	MX _{IOI}	21874 kgISS
TSS	MX _t	58838 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{hn}	19.0 hr

MLE Reactor @ 25 Days SRT

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	1239 mgVSS/l
Endogenous Residue VSS	X_{EH}	1326 mgVSS/l
Unbiodegradable Organic VSS	X_I	612 mgVSS/l
Total VSS	X_V	3177 mgVSS/l
Influent Biodegradable ISS	X_{IOI}	1809 mgISS/l
TSS	X_t	4985 mgTSS/l

Active fraction of VSS	f_{av}	0.390 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.248 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.637 kgVSS/kgTSS

Waste Flow Rate	Q_w	493 m ³ /d
TSS wasted per day		2457 kgTSS/d
VSS wasted per day		1565 kgVSS/d

Flux of N in waste VSS	FN_s	157 kgN/d
Equiv conc in influent	N_s	10.06 mgN/l influent
Effluent Sol Unbiol Org N	N_{ouse}	0.90 mgN/l

Factor of safety reducing $\mu_{A_{MT}}$	Sf	1.25
total unaerated mass fraction	fxt	0.148
Minimum sludge age for nitrification	SRT_m	4.87 days
SRT_m with Safety factor	$SRT_{m(SF)}$	6.09 Nitrifies!

If no nitrification		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	38.1 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	37.2 mgFSA-N/l

If complete nitrification		
Effluent NO ₃	N_{ne}	37.2 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ae}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	36.95 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	1.19 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.288 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.288 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	759.5 kgVSS

Denitrification	$K_{1(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	Θ	1.2
	K_{1T}	0.3472 mgFSA/l
Denitrification	$K_{2(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	Θ	1.08
	K_{2T}	0.0742 mgFSA/l

s-recycle ratio	s	1.00 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.666
Anoxic sludge mass fraction	f_{x1}	0.148 set = f_{xm} for balanced MLE
Min anoxic sludge mass fraction	f_{x1min}	0.026

Influent RBCOD fraction (Sbsi/Sbi)	$f_{sb's}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	10.81 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	19.55 mgNO ₃ -N/l influent

	A	0.6993
	B	19.1432
	C	1.459
Optimal a-recycle ratio	a_{opt}	0.08
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00 set = a_{opt} for balanced MLE
recycle limited		

Effluent Nitrate if recycle limited		18.47 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		17.74 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	18.47 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{te}$	19.66 mgN/l
N removal		59.2%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Carbonaceous Oxygen flux	FO_c	6745 kgO/d
Nitrogenous Oxygen flux	FO_N	2627 kgO/d
Oxygen dmnd recover by denitrification	FO_D	822 kgO/d
Total Oxygen Demand ($FO_c + FO_N - FO_D$)	FO_T	8549 kgO/d
Oxygen utilisation rate	O_T	34.0 mgO/l.h

Alkalinity consumed by nitrification		264 mg CaCO ₃
Alkalinity recovered by denitrification		66 mg CaCO ₃
Total Alkalinity consumption		198 mg CaCO ₃

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	1018 mgVSS/l
Endogenous Residue VSS	X_{EH}	1370 mgVSS/l
Unbiodegradable Organic VSS	X_I	612 mgVSS/l
Total VSS	X_V	3000 mgVSS/l
Influent Biodegradable ISS	X_{IOI}	1775 mgISS/l
TSS	X_t	4776 mgTSS/l

Active fraction of VSS	f_{av}	0.339 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.213 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.628 kgVSS/kgTSS

Waste Flow Rate	Q_w	493 m ³ /d
TSS wasted per day		2354 kgTSS/d
VSS wasted per day		1479 kgVSS/d

Flux of N in waste VSS	FN_s	148 kgN/d
Equiv conc in influent	N_s	9.50 mgN/l influent
Effluent Sol Unbiol Org N	N_{ouse}	0.90 mgN/l

Factor of safety reducing $\mu_{A_{MT}}$	Sf	1.25
total unaerated mass fraction	fxt	0.148
Minimum sludge age for nitrification	SRT_m	1.77 days
SRT_m with Safety factor	$SRT_{m(SF)}$	2.21 Nitrifies!

If no nitrification		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	38.7 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	37.8 mgFSA-N/l

If complete nitrification		
Effluent NO ₃	N_{ne}	37.8 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ae}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	37.54 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	1.16 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.257 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.257 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	688.2 kgVSS

Denitrification	$K_{1(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	Θ	1.2
	K_{1T}	1.4930 mgFSA/l
Denitrification	$K_{2(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	Θ	1.08
	K_{2T}	0.1374 mgFSA/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.852
Anoxic sludge mass fraction	f_{x1}	0.148
Min anoxic sludge mass fraction	f_{x1min}	0.007

Influent RBCOD fraction (Sbsi/Sbi)	$f_{sb's}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	16.44 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	25.19 mgNO ₃ -N/l influent

	A	0.6993
	B	14.0969
	C	12.141
Optimal a-recycle ratio	a_{opt}	0.83
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00
recycle limited		

Effluent Nitrate if recycle limited		18.77 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		12.70 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	18.77 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{te}$	19.93 mgN/l
N removal		58.7%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Carbonaceous Oxygen flux	FO_c	6873 kgO/d
Nitrogenous Oxygen flux	FO_N	2669 kgO/d
Oxygen dmnd recover by denitrification	FO_D	835 kgO/d
Total Oxygen Demand ($FO_c + FO_N - FO_D$)	FO_T	8707 kgO/d
Oxygen utilisation rate	O_T	34.6 mgO/l.h

Alkalinity consumed by nitrification		268 mg CaCO ₃
Alkalinity recovered by denitrification		67 mg CaCO ₃
Total Alkalinity consumption		201 mg CaCO ₃

MLE Reactor @ 25 Days SRT

COD mass balance	
<i>COD in (influent)</i>	<i>9627.3 kgCOD/d</i>
<i>COD out</i>	<i>9627.6 kgCOD/d</i>
$Q_e S_{Te} + Q_w S_{Te}$	564.7 kgCOD/d
$Q_w X_v f_{cv}$	2318.4 kgCOD/d
$V_p O_c$	6744.5 kgO/d

COD mass balance	
<i>COD in (influent)</i>	<i>9627.3 kgCOD/d</i>
<i>COD out</i>	<i>9627.6 kgCOD/d</i>
$Q_e S_{Te} + Q_w S_{Te}$	564.7 kgCOD/d
$Q_w X_v f_{cv}$	2189.7 kgCOD/d
$V_p O_c$	6873.2 kgO/d

MLE Reactor @ 25 Days SRT

N mass balance	
N in (influent)	749.8 kgTKN-N/d
N out	749.8 kgTKN-N/d
$Q_u N_{le} + Q_w N_{le}$	18.5 kgTKN-N/d
$Q N_s$	156.5 kgTKN-N/d
$Q N_{ne}$	574.8 kgNO3-N/d

TOD balance	
TOD in (influent)	13053.82 kgTOD/d
TOD out	13054.12 kgTOD/d
$TOD_{effluent}$	628.55 kgTOD/d
TOD_{waste}	3054.43 kgTOD/d
TOD_{N_2-gas}	821.90 kgTOD/d
FO_t	8549.25 kgTOD/d

Flux of P in waste VSS	FP_s	39 kgP/d
Equiv conc in influent	P_s	2.52 mgP/l
Effluent Sol Unbiod Org P	P_{ouse}	0.60 mgP/l
Effluent TP	P_{te}	12.98 mgP/l
Effluent Ortho-P as P	P_{oe}	12.38 mgOP-P/l

N mass balance	
N in (influent)	749.8 kgTKN-N/d
N out	749.8 kgTKN-N/d
$Q_u N_{le} + Q_w N_{le}$	18.0 kgTKN-N/d
$Q N_s$	147.9 kgTKN-N/d
$Q N_{ne}$	583.9 kgNO3-N/d

TOD balance	
TOD in (influent)	13053.82 kgTOD/d
TOD out	13054.12 kgTOD/d
$TOD_{effluent}$	626.44 kgTOD/d
TOD_{waste}	2885.92 kgTOD/d
TOD_{N_2-gas}	835.01 kgTOD/d
FO_t	8706.76 kgTOD/d

Flux of P in waste VSS	FP_s	37 kgP/d
Equiv conc in influent	P_s	2.38 mgP/l
Effluent Sol Unbiod Org P	P_{ouse}	0.00 mgP/l
Effluent TP	P_{te}	13.12 mgP/l
Effluent Ortho-P as P	P_{oe}	13.12 mgOP-P/l

Effluent Concentrations			General	Special	Unit	Effluent Concentrations			General	Special	Unit
Unbiod Sol COD	S_{use}	36.30	<75	<30	mgCOD	Unbiod Sol COD	S_{use}	36.30	<75	<30	mgCOD/l
Undiod Sol Org N	N_{ouse}	0.90	-	-	mgN/l	Undiod Sol Org N	N_{ouse}	0.90	-	-	mgN/l
FSA-N	N_{ae}	0.29	<6	<2	mgFSA	FSA-N	N_{ae}	0.26	<6	<2	mgFSA-N/l
TKN-N	N_{te}	1.19	-	-	mgTKN	TKN-N	N_{te}	1.16	-	-	mgTKN-N/l
Nitrate	N_{ne}	18.47	<15	<1.5	mgNO ₃	Nitrate	N_{ne}	18.77	<15	<1.5	mgNO ₃ -N/l
Undiod Sol Org P	P_{ouse}	0.60	-	-	mgP/l	Undiod Sol Org P	P_{ouse}	0.00	-	-	mgP/l
Ortho P as P	P_{oe}	12.38	<10	<2.5	mgOP-P	Ortho P as P	P_{oe}	13.12	<10	<2.5	mgOP-P/l
TP	P_{te}	12.98	-	-	mgP/l	TP	P_{te}	13.12	-	-	mgP/l

MLE Reactor @ 30 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	15.6 Ml/d
Sludge Age	SRT	30.0 days
Reactor TSS concentration	X _r	5779 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti 619	9627
BPO COD	Sbpi 479	7450
UPO COD	Supi 29	446
	fs'up	0.0464
VFA COD	Sbsi,a 0.0	0
FBSO COD	Sbsfi 75	1167
BSO COD	Sbsi 75	1167
USO COD	Susi 36.3	565
	fs'us	0.0587
BO COD	Sbi 554	8616
UO COD	Sui 65	1011
TSS	241	3745
ISS	51.4	800
VSS	189	2945
UPO VSS	19.4	302
BPO VSS	170	2643
TKN	Nti 48.2	750
Org N	Noi 13.8	215
FSA	Nai 34.4	535
BSO	Nobsi 2.90	45
USO	Nousi 0.90	14
BPO	Nobpi 8.70	135
UPO	Noupi 1.30	20
Total P	Pti 15.50	241
OP	Pai 12.80	199
Org P	Poi 2.70	42
BSO	Pobsi 0.70	11
USO	Pousi 0.60	9
BPO	Pobpi 0.78	12
UPO	Poupi 0.62	10

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bsio}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,upo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,upo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,upo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{i20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2141 /d
	μ _{am20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{amT}	0.2829 /d
	b _{a20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0357 /d
	K _{i20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{NT}	0.6288 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	15672 kgVSS
Endogenous Residue VSS	MX _{EH}	20129 kgVSS
Unbiodegradeable Organic VSS	MX _{UV}	9050 kgVSS
Total VSS	MX _V	44851 kgVSS
ISS from influent		23991 kgISS
ISS of OHO's		2351 kgISS
ISS	MX _{IOI}	26342 kgISS
TSS	MX _T	71193 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{nh}	19.0 hr

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	15.6 Ml/d
Sludge Age	SRT	30.0 days
Reactor TSS concentration	X _T	5559 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti 618.9	9627
BPO COD	Sbpi 479	7450
UPO COD	Supi 29	446
	fs'up	0.04637
VFA COD	Sbsi,a 0	0
FBSO COD	Sbsfi 75	1167
BSO COD	Sbsi 75	1167
USO COD	Susi 36.3	565
	fs'us	0.05865
BO COD	Sbi 554	8616
UO COD	Sui 65	1011
TSS	240.72727	3745
ISS	51.4	800
VSS	189.31818	2945
UPO VSS	19.39	302
BPO VSS	170	2643
TKN	Nti 48.2	750
Org N	Noi 13.8	215
FSA	Nai 34.4	535
BSO	Nobsi 2.90	45.1
USO	Nousi 0.90	14.0
BPO	Nobpi 8.70	135
UPO	Noupi 1.30	20
Total P	Pti 15.5	241
OP	Pai 12.8	199
Org P	Poi 2.7	42.0
BSO	Pobsi 0.7	10.9
USO	Pousi	
BPO	Pobpi 0.78	12
UPO	Poupi 0.62	9.65

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bsio}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,upo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,upo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,upo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{i20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2691 /d
	μ _{am20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{amT}	0.7157 /d
	b _{a20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0448 /d
	K _{i20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{NT}	1.5904 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	12821 kgVSS
Endogenous Residue VSS	MX _{EH}	20700 kgVSS
Unbiodegradeable Organic VSS	MX _{UV}	9050 kgVSS
Total VSS	MX _V	42570 kgVSS
ISS from influent		23991 kgISS
ISS of OHO's		1923 kgISS
ISS	MX _{IOI}	25914 kgISS
TSS	MX _T	68485 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{nh}	19.0 hr

MLE Reactor @ 30 Days SRT

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	1272 mgVSS/l
Endogenous Residue VSS	X_{EH}	1634 mgVSS/l
Unbiodegradable Organic VSS	X_i	735 mgVSS/l
Total VSS	X_v	3641 mgVSS/l
Influent Biodegradable ISS	X_{i0i}	2138 mgISS/l
TSS	X_t	5779 mgTSS/l

Active fraction of VSS	f_{av}	0.349 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.220 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.630 kgVSS/kgTSS

Waste Flow Rate	Q_w	411 m ³ /d
TSS wasted per day		2373 kgTSS/d
VSS wasted per day		1495 kgVSS/d

Flux of N in waste VSS	FN_b	150 kgN/d
Equiv conc in influent	N_i	9.61 mgN/l influent
Effluent Sol Unbiol Org N	N_{ouse}	0.90 mgN/l

Factor of safety reducing μ_{aerT}	Sf	1.25
total unaerated mass fraction	fxt	0.148
Minimum sludge age for nitrification	SRT _m	4.87 days
SRT _m with Safety factor	SRT _{m (SF)}	6.09 Nitrifies!

<u>If no nitrification</u>		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{ie}	38.6 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	37.7 mgFSA-N/l

<u>If complete nitrification</u>		
Effluent NO ₃	N_{ne}	37.7 mgNO ₃ -N/l
Effluent TKN-N	N_{ie}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ae}	0.0 mgFSA-N/l

<u>Nitrification Results</u>		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	37.44 mgNO ₃ -N/l
Effluent TKN-N	N_{ie}	1.15 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.252 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.252 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	843.8 kgVSS

Denitrification	$K_{1(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	Θ	1.2
Denitrification	$K_{2(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	Θ	1.08
Denitrification	K_{1T}	0.3472 mgFSA/l
Half Saturation Coefficient	K_{2T}	0.0742 mgFSA/l

s-recycle ratio	s	1.00 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.695
Anoxic sludge mass fraction	f_{x1}	0.149 set = f_{xm} for balanced MLE
Min anoxic sludge mass fraction	f_{x1min}	0.025

Influent RBCOD fraction (Sbsi/Sbi)	$f_{sb/s}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	11.10 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	19.84 mgNO ₃ -N/l influent

A	0.6993	
B	19.3403	
C	1.553	
Optimal a-recycle ratio	a_{opt}	0.08
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00 set = a_{opt} for balanced MLE
recycle limited		

Effluent Nitrate if recycle limited		18.72 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		17.94 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	18.72 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{ie}$	19.87 mgN/l
N removal		58.8%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Carbonaceous Oxygen flux	FO_c	6849 kgO/d
Nitrogenous Oxygen flux	FO_n	2661 kgO/d
Oxygen dmnd recover by denitrification	FO_D	833 kgO/d
Total Oxygen Demand ($FO_c + FO_n - FO_D$)	FO_T	8677 kgO/d
Oxygen utilisation rate	O_T	34.5 mgO/l.h

Alkalinity consumed by nitrification		267 mg CaCO ₃
Alkalinity recovered by denitrification		67 mg CaCO ₃
Total Alkalinity consumption		200 mg CaCO ₃

COD mass balance		
COD in (influent)		9627.3 kgCOD/d
COD out		9627.6 kgCOD/d

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	1041 mgVSS/l
Endogenous Residue VSS	X_{EH}	1680 mgVSS/l
Unbiodegradable Organic VSS	X_i	735 mgVSS/l
Total VSS	X_v	3455 mgVSS/l
Influent Biodegradable ISS	X_{i0i}	2103 mgISS/l
TSS	X_t	5559 mgTSS/l

Active fraction of VSS	f_{av}	0.301 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.187 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.622 kgVSS/kgTSS

Waste Flow Rate	Q_w	411 m ³ /d
TSS wasted per day		2283 kgTSS/d
VSS wasted per day		1419 kgVSS/d

Flux of N in waste VSS	FN_b	142 kgN/d
Equiv conc in influent	N_i	9.12 mgN/l influent
Effluent Sol Unbiol Org N	N_{ouse}	0.90 mgN/l

Factor of safety reducing μ_{aerT}	Sf	1.25
total unaerated mass fraction	fxt	0.148
Minimum sludge age for nitrification	SRT _m	1.77 days
SRT _m with Safety factor	SRT _{m (SF)}	2.21 Nitrifies!

<u>If no nitrification</u>		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{ie}	39.1 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	38.2 mgFSA-N/l

<u>If complete nitrification</u>		
Effluent NO ₃	N_{ne}	38.2 mgNO ₃ -N/l
Effluent TKN-N	N_{ie}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ae}	0.0 mgFSA-N/l

<u>Nitrification Results</u>		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	37.94 mgNO ₃ -N/l
Effluent TKN-N	N_{ie}	1.13 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.234 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.234 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	755.0 kgVSS

Denitrification	$K_{1(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	Θ	1.2
Denitrification	$K_{2(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	Θ	1.08
Denitrification	K_{1T}	1.4930 mgFSA/l
Half Saturation Coefficient	K_{2T}	0.1374 mgFSA/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.863
Anoxic sludge mass fraction	f_{x1}	0.148
Min anoxic sludge mass fraction	f_{x1min}	0.007

Influent RBCOD fraction (Sbsi/Sbi)	$f_{sb/s}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	16.80 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	25.55 mgNO ₃ -N/l influent

A	0.6993	
B	14.1403	
C	12.460	
Optimal a-recycle ratio	a_{opt}	0.85
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00
recycle limited		

Effluent Nitrate if recycle limited		18.97 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		12.74 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	18.97 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{ie}$	20.11 mgN/l
N removal		58.3%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Carbonaceous Oxygen flux	FO_c	6961 kgO/d
Nitrogenous Oxygen flux	FO_n	2697 kgO/d
Oxygen dmnd recover by denitrification	FO_D	844 kgO/d
Total Oxygen Demand ($FO_c + FO_n - FO_D$)	FO_T	8815 kgO/d
Oxygen utilisation rate	O_T	35.0 mgO/l.h

Alkalinity consumed by nitrification		271 mg CaCO ₃
Alkalinity recovered by denitrification		68 mg CaCO ₃
Total Alkalinity consumption		203 mg CaCO ₃

COD mass balance		
COD in (influent)		9627.3 kgCOD/d
COD out		9627.6 kgCOD/d

MLE Reactor @ 30 Days SRT

$Q_a S_{1a} + Q_w S_{1a}$	564.7 kgCOD/d
$Q_w X_v f_{cv}$	2214.1 kgCOD/d
$V_p O_c$	6848.8 kgO/d

$Q_a S_{1a} + Q_w S_{1a}$	564.7 kgCOD/d
$Q_w X_v f_{cv}$	2101.6 kgCOD/d
$V_p O_c$	6961.4 kgO/d

MLE Reactor @ 30 Days SRT

N mass balance	
N in (influent)	749.8 kgTKN-N/d
N out	749.8 kgTKN-N/d
$Q_e N_{te} + Q_w N_{te}$	17.9 kgTKN-N/d
$Q_e N_s$	149.5 kgTKN-N/d
$Q_e N_{ne}$	582.3 kgNO3-N/d

TOD balance	
TOD in (influent)	13053.82 kgTOD/d
TOD out	13054.12 kgTOD/d
TOD _{effluent}	629.52 kgTOD/d
TOD _{waste}	2914.45 kgTOD/d
TOD _{N2-gas}	832.76 kgTOD/d
FO _i	8677.39 kgTOD/d

Flux of P in waste VSS	FP _s	37 kgP/d
Equiv conc in influent	P _s	2.40 mgP/l
Effluent Sol Unbiol Org P	P _{ouse}	0.60 mgP/l
Effluent TP	P _{te}	13.10 mgP/l
Effluent Ortho-P as P	P _{oe}	12.50 mgOP-P/l

N mass balance	
N in (influent)	749.8 kgTKN-N/d
N out	749.8 kgTKN-N/d
$Q_e N_{te} + Q_w N_{te}$	17.6 kgTKN-N/d
$Q_e N_s$	141.9 kgTKN-N/d
$Q_e N_{ne}$	590.2 kgNO3-N/d

TOD balance	
TOD in (influent)	13053.82 kgTOD/d
TOD out	13054.12 kgTOD/d
TOD _{effluent}	628.25 kgTOD/d
TOD _{waste}	2767.09 kgTOD/d
TOD _{N2-gas}	844.04 kgTOD/d
FO _i	8814.75 kgTOD/d

Flux of P in waste VSS	FP _s	35 kgP/d
Equiv conc in influent	P _s	2.28 mgP/l
Effluent Sol Unbiol Org P	P _{ouse}	0.00 mgP/l
Effluent TP	P _{te}	13.22 mgP/l
Effluent Ortho-P as P	P _{oe}	13.22 mgOP-P/l

Effluent Concentrations			General	Special	Unit	Effluent Concentrations			General	Special	Unit
Unbiol Sol COD	S _{use}	36.30	<75	<30	mgCOD/l	Unbiol Sol COD	S _{use}	36.30	<75	<30	mgCOD/l
Unbiol Sol Org N	N _{ouse}	0.90	-	-	mgN/l	Unbiol Sol Org N	N _{ouse}	0.90	-	-	mgN/l
FSA-N	N _{ae}	0.25	<6	<2	mgFSA-N/l	FSA-N	N _{ae}	0.23	<6	<2	mgFSA-N/l
TKN-N	N _{te}	1.15	-	-	mgTKN-N/l	TKN-N	N _{te}	1.13	-	-	mgTKN-N/l
Nitrate	N _{ne}	18.72	<15	<1.5	mgNO ₃ -N/l	Nitrate	N _{ne}	18.97	<15	<1.5	mgNO ₃ -N/l
Unbiol Sol Org P	P _{ouse}	0.60	-	-	mgP/l	Unbiol Sol Org P	P _{ouse}	0.00	-	-	mgP/l
Ortho P as P	P _{oe}	12.50	<10	<2.5	mgOP-P/l	Ortho P as P	P _{oe}	13.22	<10	<2.5	mgOP-P/l
TP	P _{te}	13.10	-	-	mgP/l	TP	P _{te}	13.22	-	-	mgP/l

UCT Reactor @ 10 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	19.44 Ml/d
Sludge Age	SRT	10.0 days
Reactor TSS concentration	X _T	3662.35 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	619	12034
BPO COD	Sbpi	479	9312
UPO COD	Supi	29	558
	fS'up		0.046
VFA COD	Sbsi,a	0.0	0
FBSO COD	Sbsfi	75	1458
BSO COD	Sbsi	75	1458
USO COD	Susi	36.3	706
	fS'us		0.059
BO COD	Sbi	554	10770
UO COD	Sui	65	1264
TSS		241	4681
ISS		51.4	1000
VSS		189	3681
UPO VSS		19.4	377
BPO VSS		170	3304
TKN	Nti	48.2	937
Org N	Noi	13.8	268
FSA	Nai	34.4	669
BSO	Nobsi	2.90	56
USO	Nousi	0.90	18
BPO	Nobpi	8.70	169
UPO	Noupi	1.30	25
Total P	Pti	15.50	301
OP	Pai	12.80	249
Org P	Poi	2.70	53
BSO	Pobsi	0.70	14
USO	Pousi	0.60	12
BPO	Pobpi	0.78	15
UPO	Poupi	0.62	12

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _{oh}	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{ohv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{coHO}	0.15
Yield coefficient of ANO's	Y _a	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,fbs}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,u}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,u}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,u}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{hT}	0.2141 /d
	μ _{h,m20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{amT}	0.2829 /d
	b _{h20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{aT}	0.0357 /d
	K _{s20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{sT}	0.6288 mgFSA/l
	K _{s(pH)}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{sT}	0.3472
Denitrification	K _{s(pH)}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{sT}	0.0742
Denitrification	K ⁺ _{s(pH)}	0.255
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K ⁺ _{sT}	0.1874

Factor of safety reducing μ _{amT}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _m	6.76 days
SRT _m (with safety factor)	SRT _m	8.45 Nitrifies!

Max unaerated sludge mass fraction	f _{sm}	0.40
Total unaerated sludge mass fraction	f _{st}	0.35
Anoxic mass fraction primary anox 2	f _{z,prim anox 2}	0.27
Anaerobic mass fraction	f _{anaer}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments 2

r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N _{re}	3.9 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{o2,s}	0.0 mgO/l

influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	1.000 :1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi) f_{BSi} 0.135

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	19.44 Ml/d
Sludge Age	SRT	10.0 days
Reactor TSS concentration	X _T	3464 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	619	12034
BPO COD	Sbpi	479	9312
UPO COD	Supi	29	558
	fS'up		0.046
VFA COD	Sbsi,a	0	0
FBSO COD	Sbsfi	75	1458
BSO COD	Sbsi	75	1458
USO COD	Susi	36	706
	fS'us		0.059
BO COD	Sbi	554	10770
UO COD	Sui	65	1264
TSS		241	4681
ISS		51	1000
VSS		189	3681
UPO VSS		19	377
BPO VSS		170	3304
TKN	Nti	48	937
Org N	Noi	14	268
FSA	Nai	34	669
BSO	Nobsi	2.90	56
USO	Nousi	0.90	18
BPO	Nobpi	8.70	169
UPO	Noupi	1.30	25
Total P	Pti	15.50	301
OP	Pai	12.80	249
Org P	Poi	2.70	53
BSO	Pobsi	0.70	14
USO	Pousi	0.60	12
BPO	Pobpi	0.78	15
UPO	Poupi	0.62	12

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _{oh}	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{ohv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{coHO}	0.15
Yield coefficient of ANO's	Y _a	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,fbs}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,u}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,u}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,u}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate OHO	b _{hT}	0.2691 /d
	μ _{h,m20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{amT}	0.7157 /d
	b _{h20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{aT}	0.0448 /d
	K _{s20}	1.0
Nitrification	θ	1.123
Half Saturation Coefficient	K _{sT}	1.5904
	K _{s(pH)}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{sT}	1.4930
Denitrification	K _{s(pH)}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{sT}	0.1374
Denitrification	K ⁺ _{s(pH)}	0.255
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K ⁺ _{sT}	0.3469

Factor of safety reducing μ _{amT}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _m	2.38 days
SRT _m (with safety factor)	SRT _m	2.98 Nitrifies!

Max unaerated sludge mass fraction	f _{sm}	0.75
Total unaerated sludge mass fraction	f _{st}	0.35
Anoxic mass fraction primary anox 2	f _{z,prim anox 2}	0.27
Anaerobic mass fraction	f _{anaer}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments 2

r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N _{re}	3.9 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{o2,s}	0.0 mgO/l

influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi) f_{BSi} 0.135

UCT Reactor @ 10 Days SRT

Influent TKN	N_0	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_L	267 kgN/d
Equiv conc in influent	N_i	13.72 mgN/l
Effluent Sol Unbiode Org N	N_{unb}	0.90 mgN/l
Effluent ammonia	N_{NH}	1.78 mgFSA-N/l
TKN in effluent	N_{eff}	2.68 mgTKN-N/l
Nitrification capacity	N_c	31.79 mgN/l influent

Denitrification potential BSO (K1)	D_{BPO}	1.5 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BPO}	38.11 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{d1}	39.57 mgNO ₂ -N/l influent

	A	0.6993
	B	-6.0320
	C	46.654
Optimal a-recycle ratio	a_{opt}	13.55
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00 set = a_{opt} for balanced UCT
		recycle limited

Effluent Nitrate if recycle limited		3.97 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-3.23 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{NH}	3.97 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₂)	$N_{NH} + N_{NH}$	6.66 mgN/l
N removal		86.2%

Alkalinity consumed by nitrification		227 mg CaCO ₃
Alkalinity recovered by denitrification		99 mg CaCO ₃
Total Alkalinity consumption		128 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{BVL,A}$	0 mgCOD/l
FBSO COD	S_{BVL}	75 mgCOD/l
BSO COD	S_{BVL}	75 mgCOD/l
BO COD	S_{BVL}	554 mgCOD/l

S_{F1} reduction due to O ₂ & NO ₃		33.54 mgCOD/l
Reduced FBSO concentration	$S_{F1,COMP}$	41.46 mgCOD/l

	k_{F120}	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	k_{F1T}	0.0535 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

Trial 1	S_{BVLN}	0.00	MX_{BVL}/Q_L	734	S_{BVLN}	6.42
Trial 2		6.42		753		6.28
Trial 3		6.28		752		6.29
Trial 4		6.29		752		6.29

Flux BO COD obtained by OHO's	95%	10209 kgCOD/d
Flux BO COD obtained by PAO's	5%	562 kgCOD/d
Check total BO COD		10770 kgCOD/d

correct
10770

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{d20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{dT}	0.0357 /d

Activated Sludge Masses

OHO VSS		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	14627 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	6262 kgVSS

PAO VSS		
Polyphosphate Acc Organisms VSS	MX_{PAO}	1863 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	166 kgVSS

Unbiodegradable Organic VSS	MX_{UO}	3768 kgVSS
Total VSS	MX_V	26687 kgVSS

ISS from influent		9996 kgISS
ISS of OHO's		2194 kgISS
ISS of PAO's		2453 kgISS
ISS	MX_{DO}	14643 kgISS
TSS	MX_T	41330 kgTSS
VSS/TSS ratio		0.646 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.380 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	3.40 mgP/l
biomass P-content	ΔP_{OHO}	3.43 mgP/l
Potential P-removal		6.83 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	3.40 mgP/l
biomass P-content	ΔP_{OHO}	3.43 mgP/l
Total Actual P-removal		6.83 mgP/l

TP effluent P_{le} 8.67 mgP/l

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	7115 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	261 kgO/d
Carbonaceous Oxygen flux	FO_L	7376 kgO/d
Nitrogenous Oxygen flux	FO_N	2825 kgO/d
Oxygen dmdnd recover by denitrification	FO_D	1547 kgO/d
Total Oxygen Demand (FO _L + FO _N - FO _D)	FO_T	8654 kgO/d
Oxygen utilisation rate	O_T	49.3 mgO/L/h

Influent TKN	N_0	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_L	249 kgN/d
Equiv conc in influent	N_i	12.79 mgN/l
Effluent Sol Unbiode Org N	N_{unb}	0.90 mgN/l
Effluent ammonia	N_{NH}	0.72 mgFSA-N/l
TKN in effluent	N_{eff}	1.62 mgTKN-N/l
Nitrification capacity	N_c	33.78 mgN/l influent

Denitrification potential BSO (K1)	D_{BPO}	1.4 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BPO}	59.94 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{d1}	61.32 mgNO ₂ -N/l influent

	A	0.6993
	B	-25.7836
	C	88.149
Optimal a-recycle ratio	a_{opt}	40.02
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00
		recycle limited

Effluent Nitrate if recycle limited		4.22 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-22.99 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{NH}	4.22 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₂)	$N_{NH} + N_{NH}$	5.84 mgN/l
N removal		87.9%

Alkalinity consumed by nitrification		241 mg CaCO ₃
Alkalinity recovered by denitrification		106 mg CaCO ₃
Total Alkalinity consumption		136 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{BVL,A}$	0 mgCOD/l
FBSO COD	S_{BVL}	75 mgCOD/l
BSO COD	S_{BVL}	75 mgCOD/l
BO COD	S_{BVL}	554 mgCOD/l

S_{F1} reduction due to O ₂ & NO ₃		33.54 mgCOD/l
Reduced FBSO concentration	$S_{F1,COMP}$	41.46 mgCOD/l

	k_{F120}	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	k_{F1T}	0.0673 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

Trial 1	S_{BVLN}	0.00	MX_{BVL}/Q_L	625	S_{BVLN}	6.04
Trial 2		6.04		640		5.92
Trial 3		5.92		639		5.92
Trial 4		5.92		639		5.92

Flux BO COD obtained by OHO's	95%	10194 kgCOD/d
Flux BO COD obtained by PAO's	5%	576 kgCOD/d
Check total BO COD		10770 kgCOD/d

correct

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{d20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{dT}	0.0448 /d

Activated Sludge Masses

OHO VSS		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	12429 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	6689 kgVSS

PAO VSS		
Polyphosphate Acc Organisms VSS	MX_{PAO}	1790 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	201 kgVSS

Unbiodegradable Organic VSS	MX_{UO}	3768 kgVSS
Total VSS	MX_V	24877 kgVSS

ISS from influent		9996 kgISS
ISS of OHO's		1864 kgISS
ISS of PAO's		2356 kgISS
ISS	MX_{DO}	14217 kgISS
TSS	MX_T	39093 kgTSS
VSS/TSS ratio		0.636 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.38 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	3.27 mgP/l
biomass P-content	ΔP_{OHO}	3.20 mgP/l
Potential P-removal		6.47 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	3.27 mgP/l
biomass P-content	ΔP_{OHO}	3.20 mgP/l
Total Actual P-removal		6.47 mgP/l

TP effluent P_{le} 9.03 mgP/l

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	7363 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	281 kgO/d
Carbonaceous Oxygen flux	FO_L	7644 kgO/d
Nitrogenous Oxygen flux	FO_N	3002 kgO/d
Oxygen dmdnd recover by denitrification	FO_D	1644 kgO/d
Total Oxygen Demand (FO _L + FO _N - FO _D)	FO_T	9002 kgO/d
Oxygen utilisation rate	O_T	51.2 mgO/L/h

UCT Reactor @ 10 Days SRT

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Check	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	3351	11170	26808	41330
Concentration TSS (kgTSS/m ³)	1.83	3.66	3.66	3.388
Volume (m ³)	1830	3050	7320	12200
Volume fraction	15%	25%	60%	100%
Concentration VSS (kgVSS/m ³)	1.18	2.36	2.36	2.19
UPO VSS Concentration (kgUPOVSS/m ³)	0.167	0.334	0.334	0.309

Mass TSS wasted per day 4133.0 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 1128.5 m³/d

COD mass balance	
COD in (influent)	12034 kgCOD/d
COD out	12034 kgCOD/d
$Q_e S_{10} + Q_w S_{10}$	706 kgCOD/d
$Q_e X_e f_{cv}$ or $f_{cv} MX_e/Rs$	3952 kgCOD/d
FO_L	7376 kgO/d

N Mass balance	
TKN in (influent)	937 kgN/d
TKN out	937 kgN/d
N_{10}	122 kgN/d
N_{waste}	274 kgN/d
$N_{denitrified}$	541 kgN/d

TOD balance	
TOD in (influent)	16317 kgTOD/d
TOD out	16317 kgTOD/d
$TOD_{effluent}$	889 kgTOD/d
TOD_{waste}	5227 kgTOD/d
TOD_{N_2-gas}	1547 kgTOD/d
FO_L	8654 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S_{10e}	36.30	75	30 mgCOD/l
Undioid Sol Org N	N_{10e}	0.90	-	- mgN/l
FSA-N	N_{10}	1.78	6	2 mgFSA-N/l
TKN-N	N_{10}	2.68	-	- mgTKN-N/l
Nitrate	N_{10}	3.97	15	1.5 mgNO ₃ -N/l
Undioid Sol Org P	P_{10e}	0.60	-	- mgP/l
Ortho P as P	P_{10}	8.67	10	2.5 mgP/l
TP	P_{10}	9.27	-	- mgP/l

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	3170	10566	25358	39093
Concentration TSS (kgTSS/m ³)	1.73	3.46	3.46	3.204
Volume (m ³)	1830	3050	7320	12200
	3170			
Concentration VSS (kgVSS/m ³)	1.10	2.20	2.20	2.04
UPO VSS Concentration (kgUPOVSS/m ³)	0.167	0.334	0.334	0.309

Mass TSS wasted per day 3909.3 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 1128.5 m³/d

COD mass balance	
COD in (influent)	12034.2 kgCOD/d
COD out	12034.2 kgCOD/d
$Q_e S_{10} + Q_w S_{10}$	705.8 kgCOD/d
$Q_e X_e f_{cv}$ or $f_{cv} MX_e/Rs$	3684.2 kgCOD/d
FO_L	7644.1 kgO/d

N Mass balance	
TKN in (influent)	937.22 kgN/d
TKN out	937.22 kgN/d
N_{10}	107.05 kgN/d
N_{waste}	255.4 kgN/d
$N_{denitrified}$	574.8 kgN/d

TOD balance	
TOD in (influent)	16317.27 kgTOD/d
TOD out	16317.27 kgTOD/d
$TOD_{effluent}$	800.58 kgTOD/d
TOD_{waste}	4870.44 kgTOD/d
TOD_{N_2-gas}	1643.97 kgTOD/d
FO_L	9002.29 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S_{10e}	36.30	75	30 mgCOD/l
Undioid Sol Org N	N_{10e}	0.90	-	- mgN/l
FSA-N	N_{10}	0.72	6	2 mgFSA-N/l
TKN-N	N_{10}	1.62	-	- mgTKN-N/l
Nitrate	N_{10}	4.22	15	1.5 mgNO ₃ -N/l
Undioid Sol Org P	P_{10e}	0.60	-	- mgP/l
Ortho P as P	P_{10}	9.03	10	2.5 mgP/l
TP	P_{10}	9.63	-	- mgP/l

UCT Reactor @ 15 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	19.44 Ml/d
Sludge Age	SRT	15.0 days
Reactor TSS concentration	X _T	4951.96 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti	619 12034
BPO COD	Sbpi	479 9312
UPO COD	Supi	29 558
	fS'up	0.046
VFA COD	Sbsi,a	0 0
FBSO COD	Sbsfi	75 1458
BSO COD	Sbsi	75 1458
USO COD	Susi	36.3 706
	fS'us	0.059
BO COD	Sbi	554 10770
UO COD	Sui	65 1264
TSS		241 4681
ISS		51.4 1000
VSS		189 3681
UPO VSS		19.4 377
BPO VSS		170 3304
TKN	Nti	48.2 937
Org N	Noi	13.8 268
FSA	Nai	34.4 669
BSO	Nobsi	2.90 56
USO	Nousi	0.90 18
BPO	Nobpi	8.70 169
UPO	Noupi	1.30 25
Total P	Pti	15.50 301
OP	Pai	12.80 249
Org P	Poi	2.70 53
BSO	Pobsi	0.70 14
USO	Pousi	0.60 12
BPO	Pobpi	0.78 15
UPO	Poupi	0.62 12

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _{oh}	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{ohv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{coHO}	0.15
Yield coefficient of ANO's	Y _a	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,fbs}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,u}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,u}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,u}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{hT}	0.2141 /d
	μ _{h,20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{ant}	0.2829 /d
	b _{n20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{aT}	0.0357 /d
	K _{s,20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{sT}	0.6288 mgFSA/l
	K _{s,20}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{sT}	0.3472
	K _{s,20}	0.101
Denitrification	θ	1.08
for ND system	K _{sT}	0.0742
Half Saturation Coefficient	K _{sT}	0.255
Denitrification	K _{s,20}	0.108
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K _{s,20}	0.1874

Factor of safety reducing μ _{ant}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _m	6.76 days
SRT _m (with safety factor)	SRT _m	8.45 Nitrifies!

Max unaerated sludge mass fraction	f _{un}	0.55
Total unaerated sludge mass fraction	f _{xt}	0.35
Anoxic mass fraction primary anox 2	f _{z,prim anox 2}	0.27
Anaerobic mass fraction	f _{anaer}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments 2

r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N _{nr}	4.3 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{o2,s}	0.0 mgO/l

influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	1.000 :1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)	f _{Sb/s}	0.135

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	19.44 Ml/d
Sludge Age	SRT	15.0 days
Reactor TSS concentration	X _T	4696 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti	619 12034
BPO COD	Sbpi	479 9312
UPO COD	Supi	29 558
	fS'up	0.046
VFA COD	Sbsi,a	0 0
FBSO COD	Sbsfi	75 1458
BSO COD	Sbsi	75 1458
USO COD	Susi	36 706
	fS'us	0.059
BO COD	Sbi	554 10770
UO COD	Sui	65 1264
TSS		241 4681
ISS		51 1000
VSS		189 3681
UPO VSS		19 377
BPO VSS		170 3304
TKN	Nti	48 937
Org N	Noi	14 268
FSA	Nai	34 669
BSO	Nobsi	2.90 56
USO	Nousi	0.90 18
BPO	Nobpi	8.70 169
UPO	Noupi	1.30 25
Total P	Pti	15.50 301
OP	Pai	12.80 249
Org P	Poi	2.70 53
BSO	Pobsi	0.70 14
USO	Pousi	0.60 12
BPO	Pobpi	0.78 15
UPO	Poupi	0.62 12

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _{oh}	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{ohv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{coHO}	0.15
Yield coefficient of ANO's	Y _a	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,fbs}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,u}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,u}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,u}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate OHO	b _{hT}	0.2691 /d
	μ _{h,20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{ant}	0.7157 /d
	b _{n20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{aT}	0.0448 /d
	K _{s,20}	1.0
Nitrification	θ	1.123
Half Saturation Coefficient	K _{sT}	1.5904
	K _{s,20}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{sT}	1.4930
	K _{s,20}	0.101
Denitrification	θ	1.08
for ND system	K _{sT}	0.1374
Half Saturation Coefficient	K _{sT}	0.255
Denitrification	K _{s,20}	0.108
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K _{s,20}	0.3469

Factor of safety reducing μ _{ant}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _m	2.38 days
SRT _m (with safety factor)	SRT _m	2.98 Nitrifies!

Max unaerated sludge mass fraction	f _{un}	0.81
Total unaerated sludge mass fraction	f _{xt}	0.35
Anoxic mass fraction primary anox 2	f _{z,prim anox 2}	0.27
Anaerobic mass fraction	f _{anaer}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments 2

r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N _{nr}	4.3 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{o2,s}	0.0 mgO/l

influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)	f _{Sb/s}	0.135

UCT Reactor @ 15 Days SRT

Influent TKN	N_0	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_L	235 kgN/d
Equiv conc in influent	N_i	12.10 mgN/l
Effluent Sol Unbiode Org N	N_{unb}	0.90 mgN/l
Effluent ammonia	N_{NH}	0.79 mgFSA-N/l
TKN in effluent	N_{eff}	1.69 mgTKN-N/l
Nitrification capacity	N_c	34.41 mgN/l influent

Denitrification potential BSO (K1)	D_{BBSO}	1.2 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BBSO}	42.71 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{d1}	43.93 mgNO ₂ -N/l influent

	A	0.6993
	B	-7.7715
	C	52.751
Optimal a-recycle ratio	a_{opt}	15.87
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00
	set = a_{opt} for balanced UCT	
	recycle limited	

Effluent Nitrate if recycle limited		4.30 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-4.97 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{NH}	4.30 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₂)	$N_{NH} + N_{NH}$	5.99 mgN/l
N removal		87.6%

Alkalinity consumed by nitrification		246 mg CaCO ₃
Alkalinity recovered by denitrification		107 mg CaCO ₃
Total Alkalinity consumption		138 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{BVL,A}$	0 mgCOD/l
FBSO COD	S_{BVL}	75 mgCOD/l
BSO COD	S_{BVL}	75 mgCOD/l
BO COD	S_{BVL}	554 mgCOD/l

S_{F1} reduction due to O ₂ & NO ₃		36.55 mgCOD/l
Reduced FBSO concentration	$S_{F1,COMP}$	38.45 mgCOD/l

	k_{F120}	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	k_{F1T}	0.0535 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

Trial 1	S_{BVLN}	MX _{BVL} /Q _L	S_{BVLN}	5.35
Trial 2	5.35	826	843	5.24
Trial 3	5.24	843	843	5.24
Trial 4	5.24	843	843	5.24

Flux BO COD obtained by OHO's	95%	10227 kgCOD/d
Flux BO COD obtained by PAO's	5%	544 kgCOD/d
Check total BO COD		10770 kgCOD/d

correct
10770

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{d20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{dT}	0.0357 /d

Activated Sludge Masses

OHO VSS		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	16393 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	10527 kgVSS

PAO VSS		
Polyphosphate Acc Organisms VSS	MX_{PAO}	2390 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	320 kgVSS

Unbiodegradable Organic VSS	MX_{UO}	5652 kgVSS
Total VSS	MX_V	35283 kgVSS

ISS from influent		14994 kgISS
ISS of OHO's		2459 kgISS
ISS of PAO's		3147 kgISS
ISS	MX_{DO}	20600 kgISS
TSS	MX_T	55883 kgTSS
VSS/TSS ratio		0.631 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.380 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.91 mgP/l
biomass P-content	ΔP_{OHO}	3.02 mgP/l
Potential P-removal		5.93 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.91 mgP/l
biomass P-content	ΔP_{OHO}	3.02 mgP/l
Total Actual P-removal		5.93 mgP/l

TP effluent P_{Le} 9.57 mgP/l

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	7569 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	276 kgO/d
Carbonaceous Oxygen flux	FO_L	7845 kgO/d
Nitrogenous Oxygen flux	FO_N	3058 kgO/d
Oxygen dmdnd recover by denitrification	FO_D	1674 kgO/d
Total Oxygen Demand (FO _L + FO _N - FO _D)	FO_T	9228 kgO/d
Oxygen utilisation rate	O_T	52.5 mgO/L/h

Influent TKN	N_0	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_L	220 kgN/d
Equiv conc in influent	N_i	11.32 mgN/l
Effluent Sol Unbiode Org N	N_{unb}	0.90 mgN/l
Effluent ammonia	N_{NH}	0.50 mgFSA-N/l
TKN in effluent	N_{eff}	1.40 mgTKN-N/l
Nitrification capacity	N_c	35.48 mgN/l influent

Denitrification potential BSO (K1)	D_{BBSO}	1.2 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BBSO}	66.04 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{d1}	67.20 mgNO ₂ -N/l influent

	A	0.6993
	B	-29.9740
	C	98.225
Optimal a-recycle ratio	a_{opt}	45.92
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00
	recycle limited	

Effluent Nitrate if recycle limited		4.44 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-27.18 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{NH}	4.44 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₂)	$N_{NH} + N_{NH}$	5.84 mgN/l
N removal		87.9%

Alkalinity consumed by nitrification		253 mg CaCO ₃
Alkalinity recovered by denitrification		111 mg CaCO ₃
Total Alkalinity consumption		142 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{BVL,A}$	0 mgCOD/l
FBSO COD	S_{BVL}	75 mgCOD/l
BSO COD	S_{BVL}	75 mgCOD/l
BO COD	S_{BVL}	554 mgCOD/l

S_{F1} reduction due to O ₂ & NO ₃		36.55 mgCOD/l
Reduced FBSO concentration	$S_{F1,COMP}$	38.45 mgCOD/l

	k_{F120}	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	k_{F1T}	0.0673 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

Trial 1	S_{BVLN}	MX _{BVL} /Q _L	S_{BVLN}	5.10
Trial 2	5.10	691	705	5.00
Trial 3	5.00	704	704	5.00
Trial 4	5.00	704	704	5.00

Flux BO COD obtained by OHO's	95%	10217 kgCOD/d
Flux BO COD obtained by PAO's	5%	553 kgCOD/d
Check total BO COD		10770 kgCOD/d

correct

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{d20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{dT}	0.0448 /d

Activated Sludge Masses

OHO VSS		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	13694 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	11054 kgVSS

PAO VSS		
Polyphosphate Acc Organisms VSS	MX_{PAO}	2232 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	375 kgVSS

Unbiodegradable Organic VSS	MX_{UO}	5652 kgVSS
Total VSS	MX_V	33008 kgVSS

ISS from influent		14994 kgISS
ISS of OHO's		2054 kgISS
ISS of PAO's		2938 kgISS
ISS	MX_{DO}	19987 kgISS
TSS	MX_T	52995 kgTSS
VSS/TSS ratio		0.623 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.38 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.72 mgP/l
biomass P-content	ΔP_{OHO}	2.83 mgP/l
Potential P-removal		5.55 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.72 mgP/l
biomass P-content	ΔP_{OHO}	2.83 mgP/l
Total Actual P-removal		5.55 mgP/l

TP effluent P_{Le} 9.95 mgP/l

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	7774 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	296 kgO/d
Carbonaceous Oxygen flux	FO_L	8069 kgO/d
Nitrogenous Oxygen flux	FO_N	3153 kgO/d
Oxygen dmdnd recover by denitrification	FO_D	1726 kgO/d
Total Oxygen Demand (FO _L + FO _N - FO _D)	FO_T	9496 kgO/d
Oxygen utilisation rate	O_T	54.1 mgO/L/h

UCT Reactor @ 15 Days SRT

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Check	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	4531	15103	36248	55883
Concentration TSS (kgTSS/m ³)	2.48	4.95	4.95	4.581
Volume (m ³)	1830	3050	7320	12200
Volume fraction	15%	25%	60%	100%
Concentration VSS (kgVSS/m ³)	1.56	3.13	3.13	2.89
UPO VSS Concentration (kgUPOVSS/m ³)	0.250	0.501	0.501	0.463

Mass TSS wasted per day 3725.5 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 752.3 m³/d

COD mass balance	
COD in (influent)	12034.2 kgCOD/d
COD out	12034.2 kgCOD/d
$Q_s S_{in} + Q_w S_{iw}$	705.8 kgCOD/d
$Q_w X_{f_{cv}} \text{ or } f_{cv} MX_{w}/Rs$	3483.6 kgCOD/d
FO_L	7844.8 kgO/d

N Mass balance	
TKN in (influent)	937.22 kgN/d
TKN out	937.22 kgN/d
N_{D_2}	112.04 kgN/d
N_{waste}	239.7 kgN/d
$N_{denitrified}$	585.5 kgN/d

TOD balance	
TOD in (influent)	16317.27 kgTOD/d
TOD out	16317.27 kgTOD/d
$TOD_{effluent}$	823.11 kgTOD/d
TOD_{waste}	4591.63 kgTOD/d
TOD_{N_2-gas}	1674.41 kgTOD/d
FO_L	9228.12 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S_{use}	36.30	75	30 mgCOD/l
Undiol Sol Org N	$N_{D_{use}}$	0.90	-	- mgN/l
FSA-N	N_{se}	0.79	6	2 mgFSA-N/l
TKN-N	N_{D_2}	1.69	-	- mgTKN-N/l
Nitrate	N_{NB}	4.30	15	1.5 mgNO ₃ -N/l
Undiol Sol Org P	$P_{D_{use}}$	0.60	-	- mgP/l
Ortho P as P	P_{se}	9.57	10	2.5 mgP/l
TP	P_{D_2}	10.17	-	- mgP/l

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	4297	14323	34375	52995
Concentration TSS (kgTSS/m ³)	2.35	4.70	4.70	4.344
Volume (m ³)	1830	3050	7320	12200
	4297			
Concentration VSS (kgVSS/m ³)	1.46	2.92	2.92	2.71
UPO VSS Concentration (kgUPOVSS/m ³)	0.250	0.501	0.501	0.463

Mass TSS wasted per day 3533.0 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 752.3 m³/d

COD mass balance	
COD in (influent)	12034.2 kgCOD/d
COD out	12034.2 kgCOD/d
$Q_s S_{in} + Q_w S_{iw}$	705.8 kgCOD/d
$Q_w X_{f_{cv}} \text{ or } f_{cv} MX_{w}/Rs$	3259.0 kgCOD/d
FO_L	8069.3 kgO/d

N Mass balance	
TKN in (influent)	937.22 kgN/d
TKN out	937.22 kgN/d
N_{D_2}	109.12 kgN/d
N_{waste}	224.4 kgN/d
$N_{denitrified}$	603.7 kgN/d

TOD balance	
TOD in (influent)	16317.27 kgTOD/d
TOD out	16317.27 kgTOD/d
$TOD_{effluent}$	798.36 kgTOD/d
TOD_{waste}	4296.78 kgTOD/d
TOD_{N_2-gas}	1726.45 kgTOD/d
FO_L	9495.69 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S_{use}	36.30	75	30 mgCOD/l
Undiol Sol Org N	$N_{D_{use}}$	0.90	-	- mgN/l
FSA-N	N_{se}	0.50	6	2 mgFSA-N/l
TKN-N	N_{D_2}	1.40	-	- mgTKN-N/l
Nitrate	N_{NB}	4.44	15	1.5 mgNO ₃ -N/l
Undiol Sol Org P	$P_{D_{use}}$	0.60	-	- mgP/l
Ortho P as P	P_{se}	9.95	10	2.5 mgP/l
TP	P_{D_2}	10.55	-	- mgP/l

UCT Reactor @ 20 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	19.44 Ml/d
Sludge Age	SRT	20.0 days
Reactor TSS concentration	X _T	6163.16 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti	619 12034
BPO COD	Sbpi	479 9312
UPO COD	Supi	29 558
	fS'up	0.046
VFA COD	Sbsi,a	0 0
FBSO COD	Sbsfi	75 1458
BSO COD	Sbsi	75 1458
USO COD	Susi	36.3 706
	fS'us	0.059
BO COD	Sbi	554 10770
UO COD	Sui	65 1264
TSS		241 4681
ISS		51.4 1000
VSS		189 3681
UPO VSS		19.4 377
BPO VSS		170 3304
TKN	Nti	48.2 937
Org N	Noi	13.8 268
FSA	Nai	34.4 669
BSO	Nobsi	2.90 56
USO	Nousi	0.90 18
BPO	Nobpi	8.70 169
UPO	Noupi	1.30 25
Total P	Pti	15.50 301
OP	Pai	12.80 249
Org P	Poi	2.70 53
BSO	Pobsi	0.70 14
USO	Pousi	0.60 12
BPO	Pobpi	0.78 15
UPO	Poupi	0.62 12

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _{oh}	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{ohv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{coHO}	0.15
Yield coefficient of ANO's	Y _a	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,fbs}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,u}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,u}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,u}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{hT}	0.2141 /d
	μ _{h,20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{ant}	0.2829 /d
	b _{n20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{aT}	0.0357 /d
	K _{s,20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{sT}	0.6288 mgFSA/l
	K _{s,20}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{sT}	0.3472
	K _{s,20}	0.101
Denitrification	θ	1.08
for ND system	K _{sT}	0.0742
Half Saturation Coefficient	K _{sT}	0.255
Denitrification	K _{s,20}	0.108
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K _{sT}	0.1874

Factor of safety reducing μ _{ant}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _m	6.76 days
SRT _m (with safety factor)	SRT _m	8.45 Nitrifies!

Max unaerated sludge mass fraction	f _{un}	0.62
Total unaerated sludge mass fraction	f _{xt}	0.35
Anoxic mass fraction primary anox 2	f _{prim anox 2}	0.27
Anaerobic mass fraction	f _{anaer}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments 2

r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N _{nr}	4.4 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{o2,s}	0.0 mgO/l

influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	1.1 :1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)	f _{Sb,i}	0.135

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	19.44 Ml/d
Sludge Age	SRT	20.0 days
Reactor TSS concentration	X _T	5866 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti	619 12034
BPO COD	Sbpi	479 9312
UPO COD	Supi	29 558
	fS'up	0.046
VFA COD	Sbsi,a	0 0
FBSO COD	Sbsfi	75 1458
BSO COD	Sbsi	75 1458
USO COD	Susi	36 706
	fS'us	0.059
BO COD	Sbi	554 10770
UO COD	Sui	65 1264
TSS		241 4681
ISS		51 1000
VSS		189 3681
UPO VSS		19 377
BPO VSS		170 3304
TKN	Nti	48 937
Org N	Noi	14 268
FSA	Nai	34 669
BSO	Nobsi	2.90 56
USO	Nousi	0.90 18
BPO	Nobpi	8.70 169
UPO	Noupi	1.30 25
Total P	Pti	15.50 301
OP	Pai	12.80 249
Org P	Poi	2.70 53
BSO	Pobsi	0.70 14
USO	Pousi	0.60 12
BPO	Pobpi	0.78 15
UPO	Poupi	0.62 12

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _{oh}	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{ohv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{coHO}	0.15
Yield coefficient of ANO's	Y _a	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,fbs}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,u}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,u}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,u}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate OHO	b _{hT}	0.2691 /d
	μ _{h,20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{ant}	0.7157 /d
	b _{n20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{aT}	0.0448 /d
	K _{s,20}	1.0
Nitrification	θ	1.123
Half Saturation Coefficient	K _{sT}	1.5904
	K _{s,20}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{sT}	1.4930
	K _{s,20}	0.101
Denitrification	θ	1.08
for ND system	K _{sT}	0.1374
Half Saturation Coefficient	K _{sT}	0.255
Denitrification	K _{s,20}	0.108
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K _{sT}	0.3469

Factor of safety reducing μ _{ant}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _m	2.38 days
SRT _m (with safety factor)	SRT _m	2.98 Nitrifies!

Max unaerated sludge mass fraction	f _{un}	0.83
Total unaerated sludge mass fraction	f _{xt}	0.35
Anoxic mass fraction primary anox 2	f _{prim anox 2}	0.27
Anaerobic mass fraction	f _{anaer}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments 2

r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N _{nr}	4.4 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{o2,s}	0.0 mgO/l

influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	1.1 :1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)	f _{Sb,i}	0.135

UCT Reactor @ 20 Days SRT

Influent TKN	N_0	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_L	216 kgN/d
Equiv conc in influent	N_i	11.12 mgN/l
Effluent Sol Unbiode Org N	N_{unb}	0.90 mgN/l
Effluent ammonia	N_{NH}	0.55 mgFSA-N/l
TKN in effluent	N_{eff}	1.45 mgTKN-N/l
Nitrification capacity	N_c	35.63 mgN/l influent

Denitrification potential BSO (K1)	D_{BBSO}	1.1 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BBSO}	45.43 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{d1}	46.55 mgNO ₂ -N/l influent

	A	0.6993
	B	-9.0373
	C	57.949
Optimal a-recycle ratio	a_{opt}	17.62
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00
	set = a_{opt} for balanced UCT	
	recycle limited	

Effluent Nitrate if recycle limited		4.39 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-6.32 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{NH}	4.39 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₂)	$N_{NH} + N_{NH}$	5.84 mgN/l
N removal		87.9%

Alkalinity consumed by nitrification		254 mg CaCO ₃
Alkalinity recovered by denitrification		112 mg CaCO ₃
Total Alkalinity consumption		143 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{BVL,A}$	0 mgCOD/l
FBSO COD	S_{BVL}	75 mgCOD/l
BSO COD	S_{BVL}	75 mgCOD/l
BO COD	S_{BVL}	554 mgCOD/l

S_{F1} reduction due to O ₂ & NO ₃		37.84 mgCOD/l
Reduced FBSO concentration	$S_{F1,COMP}$	37.16 mgCOD/l

	k_{F120}	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	k_{F1T}	0.0535 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

Trial 1	S_{BVLN}	0.00	MX_{BVL}/Q_L	881	S_{BVLN}	4.86
Trial 2		4.86		897		4.77
Trial 3		4.77		897		4.77
Trial 4		4.77		897		4.77

Flux BO COD obtained by OHO's	95%	10233 kgCOD/d
Flux BO COD obtained by PAO's	5%	537 kgCOD/d
Check total BO COD		10770 kgCOD/d

correct
10770

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{d20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{dT}	0.0357 /d

Activated Sludge Masses

<u>OHO VSS</u>		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	17439 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	14932 kgVSS
<u>PAO VSS</u>		
Polyphosphate Acc Organisms VSS	MX_{PAO}	2820 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	503 kgVSS
Unbiodegradable Organic VSS	MX_{UO}	7536 kgVSS
Total VSS	MX_V	43230 kgVSS
ISS from influent		19992 kgISS
ISS of OHO's		2616 kgISS
ISS of PAO's		3713 kgISS
ISS	MX_{DO}	26321 kgISS
TSS	MX_T	69551 kgTSS
VSS/TSS ratio		0.622 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.380 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.57 mgP/l
biomass P-content	ΔP_{OHO}	2.78 mgP/l
Potential P-removal		5.35 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.57 mgP/l
biomass P-content	ΔP_{OHO}	2.78 mgP/l
Total Actual P-removal		5.35 mgP/l

TP effluent P_{le} 10.15 mgP/l

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	7836 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	291 kgO/d
Carbonaceous Oxygen flux	FO_L	8127 kgO/d
Nitrogenous Oxygen flux	FO_N	3166 kgO/d
Oxygen dmdnd recover by denitrification	FO_D	1738 kgO/d
Total Oxygen Demand (FO _C + FO _N - FO _D)	FO_T	9556 kgO/d
Oxygen utilisation rate	O_T	54.4 mgO/L/h

Influent TKN	N_0	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_L	203 kgN/d
Equiv conc in influent	N_i	10.45 mgN/l
Effluent Sol Unbiode Org N	N_{unb}	0.90 mgN/l
Effluent ammonia	N_{NH}	0.41 mgFSA-N/l
TKN in effluent	N_{eff}	1.31 mgTKN-N/l
Nitrification capacity	N_c	36.44 mgN/l influent

Denitrification potential BSO (K1)	D_{BBSO}	1.1 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BBSO}	69.55 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{d1}	70.62 mgNO ₂ -N/l influent

	A	0.6993
	B	-32.3017
	C	108.104
Optimal a-recycle ratio	a_{opt}	49.33
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00
	recycle limited	

Effluent Nitrate if recycle limited		4.49 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-29.59 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{NH}	4.49 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₂)	$N_{NH} + N_{NH}$	5.80 mgN/l
N removal		88.0%

Alkalinity consumed by nitrification		260 mg CaCO ₃
Alkalinity recovered by denitrification		114 mg CaCO ₃
Total Alkalinity consumption		146 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{BVL,A}$	0 mgCOD/l
FBSO COD	S_{BVL}	75 mgCOD/l
BSO COD	S_{BVL}	75 mgCOD/l
BO COD	S_{BVL}	554 mgCOD/l

S_{F1} reduction due to O ₂ & NO ₃		37.84 mgCOD/l
Reduced FBSO concentration	$S_{F1,COMP}$	37.16 mgCOD/l

	k_{F120}	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	k_{F1T}	0.0673 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

Trial 1	S_{BVLN}	0.00	MX_{BVL}/Q_L	729	S_{BVLN}	4.67
Trial 2		4.67		742		4.59
Trial 3		4.59		742		4.59
Trial 4		4.59		742		4.59

Flux BO COD obtained by OHO's	95%	10226 kgCOD/d
Flux BO COD obtained by PAO's	5%	544 kgCOD/d
Check total BO COD		10770 kgCOD/d

correct

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{d20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{dT}	0.0448 /d

Activated Sludge Masses

<u>OHO VSS</u>		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	14422 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	15523 kgVSS
<u>PAO VSS</u>		
Polyphosphate Acc Organisms VSS	MX_{PAO}	2581 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	579 kgVSS
Unbiodegradable Organic VSS	MX_{UO}	7536 kgVSS
Total VSS	MX_V	40641 kgVSS
ISS from influent		19992 kgISS
ISS of OHO's		2163 kgISS
ISS of PAO's		3398 kgISS
ISS	MX_{DO}	25554 kgISS
TSS	MX_T	66195 kgTSS
VSS/TSS ratio		0.614 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.38 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.36 mgP/l
biomass P-content	ΔP_{OHO}	2.61 mgP/l
Potential P-removal		4.97 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.36 mgP/l
biomass P-content	ΔP_{OHO}	2.61 mgP/l
Total Actual P-removal		4.97 mgP/l

TP effluent P_{le} 10.53 mgP/l

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	8009 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	310 kgO/d
Carbonaceous Oxygen flux	FO_L	8319 kgO/d
Nitrogenous Oxygen flux	FO_N	3238 kgO/d
Oxygen dmdnd recover by denitrification	FO_D	1777 kgO/d
Total Oxygen Demand (FO _C + FO _N - FO _D)	FO_T	9780 kgO/d
Oxygen utilisation rate	O_T	55.7 mgO/L/h

UCT Reactor @ 20 Days SRT

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Check	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	5639	18798	45114	69551
Concentration TSS (kgTSS/m ³)	3.08	6.16	6.16	5.701
Volume (m ³)	1830	3050	7320	12200
Volume fraction	15%	25%	60%	100%
Concentration VSS (kgVSS/m ³)	1.92	3.83	3.83	3.54
UPO VSS Concentration (kgUPOVSS/m ³)	0.334	0.668	0.668	0.618

Mass TSS wasted per day 3477.6 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 564.3 m³/d

COD mass balance	
COD in (influent)	12034.2 kgCOD/d
COD out	12034.2 kgCOD/d
$Q_s S_{10} + Q_w S_{10}$	705.8 kgCOD/d
$Q_w X_{f_{10}}$ or $f_{10} MX_w/Rs$	3201.2 kgCOD/d
FO_L	8127.1 kgO/d

N Mass balance	
TKN in (influent)	937.22 kgN/d
TKN out	937.22 kgN/d
N_{10}	110.23 kgN/d
N_{waste}	219.4 kgN/d
$N_{denitrified}$	607.5 kgN/d

TOD balance	
TOD in (influent)	16317.27 kgTOD/d
TOD out	16317.27 kgTOD/d
$TOD_{effluent}$	810.51 kgTOD/d
TOD_{waste}	4213.25 kgTOD/d
TOD_{N_2-gas}	1737.59 kgTOD/d
FO_L	9555.93 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S_{10e}	36.30	75	30 mgCOD/l
Unbiol Sol Org N	N_{10e}	0.90	-	- mgN/l
FSA-N	N_{10}	0.55	6	2 mgFSA-N/l
TKN-N	N_{10}	1.45	-	- mgTKN-N/l
Nitrate	N_{10}	4.39	15	1.5 mgNO ₃ -N/l
Unbiol Sol Org P	P_{10e}	0.60	-	- mgP/l
Ortho P as P	P_{10}	10.15	10	2.5 mgP/l
TP	P_{10}	10.75	-	- mgP/l

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	5367	17890	42937	66195
Concentration TSS (kgTSS/m ³)	2.93	5.87	5.87	5.426
Volume (m ³)	1830	3050	7320	12200
	5367			
Concentration VSS (kgVSS/m ³)	1.80	3.60	3.60	3.33
UPO VSS Concentration (kgUPOVSS/m ³)	0.334	0.668	0.668	0.618

Mass TSS wasted per day 3309.7 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 564.3 m³/d

COD mass balance	
COD in (influent)	12034.2 kgCOD/d
COD out	12034.2 kgCOD/d
$Q_s S_{10} + Q_w S_{10}$	705.8 kgCOD/d
$Q_w X_{f_{10}}$ or $f_{10} MX_w/Rs$	3009.5 kgCOD/d
FO_L	8318.9 kgO/d

N Mass balance	
TKN in (influent)	937.22 kgN/d
TKN out	937.22 kgN/d
N_{10}	109.42 kgN/d
N_{waste}	206.5 kgN/d
$N_{denitrified}$	621.3 kgN/d

TOD balance	
TOD in (influent)	16317.27 kgTOD/d
TOD out	16317.27 kgTOD/d
$TOD_{effluent}$	798.24 kgTOD/d
TOD_{waste}	3961.98 kgTOD/d
TOD_{N_2-gas}	1776.99 kgTOD/d
FO_L	9780.06 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S_{10e}	36.30	75	30 mgCOD/l
Unbiol Sol Org N	N_{10e}	0.90	-	- mgN/l
FSA-N	N_{10}	0.41	6	2 mgFSA-N/l
TKN-N	N_{10}	1.31	-	- mgTKN-N/l
Nitrate	N_{10}	4.49	15	1.5 mgNO ₃ -N/l
Unbiol Sol Org P	P_{10e}	0.60	-	- mgP/l
Ortho P as P	P_{10}	10.53	10	2.5 mgP/l
TP	P_{10}	11.13	-	- mgP/l

UCT Reactor @ 25 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	19.44 Ml/d
Sludge Age	SRT	25.0 days
Reactor TSS concentration	X _T	7328.42 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	619	12034
BPO COD	Sbpi	479	9312
UPO COD	Supi	29	558
	fS'up		0.046
VFA COD	Sbsi,a	0.0	0
FBSO COD	Sbsfi	75	1458
BSO COD	Sbsi	75	1458
USO COD	Susi	36.3	706
	fS'us		0.059
BO COD	Sbi	554	10770
UO COD	Sui	65	1264
TSS		241	4681
ISS		51.4	1000
VSS		189	3681
UPO VSS		19.4	377
BPO VSS		170	3304
TKN	Nti	48.2	937
Org N	Noi	13.8	268
FSA	Nai	34.4	669
BSO	Nobsi	2.90	56
USO	Nousi	0.90	18
BPO	Nobpi	8.70	169
UPO	Noupi	1.30	25
Total P	Pti	15.50	301
OP	Pai	12.80	249
Org P	Poi	2.70	53
BSO	Pobsi	0.70	14
USO	Pousi	0.60	12
BPO	Pobpi	0.78	15
UPO	Poupi	0.62	12

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _o	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{ov}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _o	0.2
ISS content of OHO's	f _{coHO}	0.15
Yield coefficient of ANO's	Y _a	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,fbs}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,u}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,u}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,u}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{hT}	0.2141 /d
	μ _{h,20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{ant}	0.2829 /d
	b _{n20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{aT}	0.0357 /d
	K _{s20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{sT}	0.6288 mgFSA/l
	K _{s(20)}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{sT}	0.3472
	K _{s(20)}	0.101
Denitrification	θ	1.08
for ND system	K _{sT}	0.0742
Half Saturation Coefficient	K _{sT}	0.255
Denitrification	K _{s(20)}	1.08
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K _{sT}	0.1874

Factor of safety reducing μ _{ant}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _m	6.76 days
SRT _m (with safety factor)	SRT _m	8.45 Nitrifies!

Max unaerated sludge mass fraction	f _{un}	0.67
Total unaerated sludge mass fraction	f _{xt}	0.35
Anoxic mass fraction primary anox 2	f _{z,prim anox 2}	0.27
Anaerobic mass fraction	f _{anaer}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments 2

r-recyle ratio	r	1.0 :1
r-recyle NO ₂ concentration	N _{nr}	4.5 mgNO ₂ -N/l
r-recyle O ₂ concentration	S _{o2,s}	0.0 mgO/l

influent NO ₂ concentration	S _{NO2,i}	0.0 mgNO ₂ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recyle ratio	s	1.692 :1
s-recyle DO concentration	O _s	1.0 mgO/l

a-recyle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)	f _{Sb/s}	0.135

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	19.44 Ml/d
Sludge Age	SRT	25.0 days
Reactor TSS concentration	X _T	6999 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	619	12034
BPO COD	Sbpi	479	9312
UPO COD	Supi	29	558
	fS'up		0.046
VFA COD	Sbsi,a	0	0
FBSO COD	Sbsfi	75	1458
BSO COD	Sbsi	75	1458
USO COD	Susi	36	706
	fS'us		0.059
BO COD	Sbi	554	10770
UO COD	Sui	65	1264
TSS		241	4681
ISS		51	1000
VSS		189	3681
UPO VSS		19	377
BPO VSS		170	3304
TKN	Nti	48	937
Org N	Noi	14	268
FSA	Nai	34	669
BSO	Nobsi	2.90	56
USO	Nousi	0.90	18
BPO	Nobpi	8.70	169
UPO	Noupi	1.30	25
Total P	Pti	15.50	301
OP	Pai	12.80	249
Org P	Poi	2.70	53
BSO	Pobsi	0.70	14
USO	Pousi	0.60	12
BPO	Pobpi	0.78	15
UPO	Poupi	0.62	12

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _o	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{ov}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _o	0.2
ISS content of OHO's	f _{coHO}	0.15
Yield coefficient of ANO's	Y _a	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,fbs}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,u}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,u}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,u}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate OHO	b _{hT}	0.2691 /d
	μ _{h,20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{ant}	0.7157 /d
	b _{n20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{aT}	0.0448 /d
	K _{s20}	1.0
Nitrification	θ	1.123
Half Saturation Coefficient	K _{sT}	1.5904
	K _{s(20)}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{sT}	1.4930
	K _{s(20)}	0.101
Denitrification	θ	1.08
for ND system	K _{sT}	0.1374
Half Saturation Coefficient	K _{sT}	0.255
Denitrification	K _{s(20)}	1.08
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K _{sT}	0.3469

Factor of safety reducing μ _{ant}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _m	2.38 days
SRT _m (with safety factor)	SRT _m	2.98 Nitrifies!

Max unaerated sludge mass fraction	f _{un}	0.85
Total unaerated sludge mass fraction	f _{xt}	0.35
Anoxic mass fraction primary anox 2	f _{z,prim anox 2}	0.27
Anaerobic mass fraction	f _{anaer}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments 2

r-recyle ratio	r	1.0 :1
r-recyle NO ₂ concentration	N _{nr}	4.5 mgNO ₂ -N/l
r-recyle O ₂ concentration	S _{o2,s}	0.0 mgO/l

influent NO ₂ concentration	S _{NO2,i}	0.0 mgNO ₂ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recyle ratio	s	1.7 :1
s-recyle DO concentration	O _s	1.0 mgO/l

a-recyle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)	f _{Sb/s}	0.135

UCT Reactor @ 25 Days SRT

Influent TKN	N_0	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_L	203 kgN/d
Equiv conc in influent	N_i	10.46 mgN/l
Effluent Sol Unbiode Org N	N_{unb}	0.90 mgN/l
Effluent ammonia	N_{NH}	0.44 mgFSA-N/l
TKN in effluent	N_{eff}	1.34 mgTKN-N/l
Nitrification capacity	N_c	36.40 mgN/l influent

Denitrification potential BSO (K1)	D_{BBSO}	1.0 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BBSO}	47.25 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{d1}	48.29 mgNO ₂ -N/l influent

	A	0.6993
	B	-9.4157
	C	66.813
Optimal a-recycle ratio	a_{opt}	18.60
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00 set = a_{opt} for balanced UCT
		recycle limited

Effluent Nitrate if recycle limited		4.19 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-7.10 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{NH}	4.19 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₂)	$N_{NH} + N_{NH}$	5.53 mgN/l
N removal		88.5%

Alkalinity consumed by nitrification		260 mg CaCO ₃
Alkalinity recovered by denitrification		115 mg CaCO ₃
Total Alkalinity consumption		145 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{BVL,A}$	0 mgCOD/l
FBSO COD	S_{BVL}	75 mgCOD/l
BSO COD	S_{BVL}	75 mgCOD/l
BO COD	S_{BVL}	554 mgCOD/l

S_{F1} reduction due to O ₂ & NO ₃		38.7 mgCOD/l
Reduced FBSO concentration	$S_{F1,COMP}$	36.3 mgCOD/l

	k_{F120}	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	k_{F1T}	0.0535 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	S_{BVLN}	MX_{BVL}/Q_L	S_{BVLN}	
Trial 1	0.00	917		4.56
Trial 2	4.56	933		4.48
Trial 3	4.48	933		4.48
Trial 4	4.48	933		4.48

Flux BO COD obtained by OHO's	95%	10239 kgCOD/d
Flux BO COD obtained by PAO's	5%	531 kgCOD/d
Check total BO COD		10770 kgCOD/d

correct
10770

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{G20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{GT}	0.0357 /d

Activated Sludge Masses

<u>OHO VSS</u>			
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	18135 kgVSS	
Endogenous Residue VSS OHO	$MX_{E,OHO}$	19410 kgVSS	
<u>PAO VSS</u>			
Polyphosphate Acc Organisms VSS	MX_{PAO}	3160 kgVSS	
Endogenous Residue VSS PAO	$MX_{E,PAO}$	705 kgVSS	
Unbiodegradable Organic VSS	MX_{UO}	9420 kgVSS	
Total VSS	MX_V	50830 kgVSS	
ISS from influent		24991 kgISS	
ISS of OHO's		2720 kgISS	
ISS of PAO's		4160 kgISS	
ISS	MX_{DO}	31871 kgISS	
TSS	MX_T	82701 kgTSS	
VSS/TSS ratio		0.615 kgVSS/kgTSS	

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.380 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.31 mgP/l
biomass P-content	ΔP_{OHO}	2.61 mgP/l
Potential P-removal		4.92 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.31 mgP/l
biomass P-content	ΔP_{OHO}	2.61 mgP/l
Total Actual P-removal		4.92 mgP/l

TP effluent

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	8015 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	302 kgO/d
Carbonaceous Oxygen flux	FO_L	8317 kgO/d
Nitrogenous Oxygen flux	FO_N	3235 kgO/d
Oxygen dnmnd recover by denitrification	FO_D	1791 kgO/d
Total Oxygen Demand (FO _C + FO _N - FO _D)	FO_T	9760 kgO/d
Oxygen utilisation rate	O_T	55.6 mgO/L/h

Influent TKN	N_0	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_L	192 kgN/d
Equiv conc in influent	N_i	9.88 mgN/l
Effluent Sol Unbiode Org N	N_{unb}	0.90 mgN/l
Effluent ammonia	N_{NH}	0.36 mgFSA-N/l
TKN in effluent	N_{eff}	1.26 mgTKN-N/l
Nitrification capacity	N_c	37.07 mgN/l influent

Denitrification potential BSO (K1)	D_{BBSO}	1.0 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BBSO}	71.85 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{d1}	72.86 mgNO ₂ -N/l influent

	A	0.6993
	B	-33.3166
	C	131.813
Optimal a-recycle ratio	a_{opt}	51.32
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00
		recycle limited

Effluent Nitrate if recycle limited		4.26 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-31.00 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{NH}	4.26 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₂)	$N_{NH} + N_{NH}$	5.52 mgN/l
N removal		88.5%

Alkalinity consumed by nitrification		265 mg CaCO ₃
Alkalinity recovered by denitrification		117 mg CaCO ₃
Total Alkalinity consumption		148 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{BVL,A}$	0 mgCOD/l
FBSO COD	S_{BVL}	75 mgCOD/l
BSO COD	S_{BVL}	75 mgCOD/l
BO COD	S_{BVL}	554 mgCOD/l

S_{F1} reduction due to O ₂ & NO ₃		38.7 mgCOD/l
Reduced FBSO concentration	$S_{F1,COMP}$	36.3 mgCOD/l

	k_{F120}	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	k_{F1T}	0.0673 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	S_{BVLN}	MX_{BVL}/Q_L	S_{BVLN}	
Trial 1	0.00	754		4.41
Trial 2	4.41	766		4.34
Trial 3	4.34	766		4.34
Trial 4	4.34	766		4.34

Flux BO COD obtained by OHO's	95%	10233 kgCOD/d
Flux BO COD obtained by PAO's	5%	537 kgCOD/d
Check total BO COD		10770 kgCOD/d

correct

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{G20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{GT}	0.0448 /d

Activated Sludge Masses

<u>OHO VSS</u>			
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	14899 kgVSS	
Endogenous Residue VSS OHO	$MX_{E,OHO}$	20045 kgVSS	
<u>PAO VSS</u>			
Polyphosphate Acc Organisms VSS	MX_{PAO}	2848 kgVSS	
Endogenous Residue VSS PAO	$MX_{E,PAO}$	798 kgVSS	
Unbiodegradable Organic VSS	MX_{UO}	9420 kgVSS	
Total VSS	MX_V	48011 kgVSS	
ISS from influent		24991 kgISS	
ISS of OHO's		2235 kgISS	
ISS of PAO's		3750 kgISS	
ISS	MX_{DO}	30975 kgISS	
TSS	MX_T	78886 kgTSS	
VSS/TSS ratio		0.608 kgVSS/kgTSS	

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.38 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.08 mgP/l
biomass P-content	ΔP_{OHO}	2.47 mgP/l
Potential P-removal		4.55 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.08 mgP/l
biomass P-content	ΔP_{OHO}	2.47 mgP/l
Total Actual P-removal		4.55 mgP/l

TP effluent

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	8163 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	321 kgO/d
Carbonaceous Oxygen flux	FO_L	8484 kgO/d
Nitrogenous Oxygen flux	FO_N	3294 kgO/d
Oxygen dnmnd recover by denitrification	FO_D	1824 kgO/d
Total Oxygen Demand (FO _C + FO _N - FO _D)	FO_T	9954 kgO/d
Oxygen utilisation rate	O_T	56.7 mgO/L/h

UCT Reactor @ 25 Days SRT

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Check	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	6706	22352	53644	82701
Concentration TSS (kgTSS/m ³)	3.66	7.33	7.33	6.779
Volume (m ³)	1830	3050	7320	12200
Volume fraction	15%	25%	60%	100%
Concentration VSS (kgVSS/m ³)	2.25	4.50	4.50	4.17
UPO VSS Concentration (kgUPOVSS/m ³)	0.417	0.835	0.835	0.772

Mass TSS wasted per day 3308.1 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 451.4 m³/d

COD mass balance	
COD in (influent)	12034.2 kgCOD/d
COD out	12034.2 kgCOD/d
$Q_s S_{10} + Q_w S_{10}$	705.8 kgCOD/d
$Q_w X_{10} f_{10}$ or $f_{10} MX_{10}/Rs$	3011.2 kgCOD/d
FO_L	8317.1 kgO/d

N Mass balance	
TKN in (influent)	937.22 kgN/d
TKN out	937.22 kgN/d
N_{10}	105.02 kgN/d
N_{waste}	205.8 kgN/d
$N_{denitrified}$	626.4 kgN/d

TOD balance	
TOD in (influent)	16317.27 kgTOD/d
TOD out	16317.27 kgTOD/d
$TOD_{effluent}$	805.86 kgTOD/d
TOD_{waste}	3959.51 kgTOD/d
TOD_{N2-gas}	1791.46 kgTOD/d
FO_L	9760.43 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S_{10e}	36.30	75	30 mgCOD/l
Unbiol Sol Org N	N_{10e}	0.90	-	- mgN/l
FSA-N	N_{10}	0.44	6	2 mgFSA-N/l
TKN-N	N_{10}	1.34	-	- mgTKN-N/l
Nitrate	N_{10}	4.19	15	1.5 mgNO ₃ -N/l
Unbiol Sol Org P	P_{10e}	0.60	-	- mgP/l
Ortho P as P	P_{10}	10.58	10	2.5 mgP/l
TP	P_{10}	11.18	-	- mgP/l

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	6404	21348	51234	78986
Concentration TSS (kgTSS/m ³)	3.50	7.00	7.00	6.474
Volume (m ³)	1830	3050	7320	12200
	6404			
Concentration VSS (kgVSS/m ³)	2.13	4.25	4.25	3.94
UPO VSS Concentration (kgUPOVSS/m ³)	0.417	0.835	0.835	0.772

Mass TSS wasted per day 3159.4 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 451.4 m³/d

COD mass balance	
COD in (influent)	12034.2 kgCOD/d
COD out	12034.2 kgCOD/d
$Q_s S_{10} + Q_w S_{10}$	705.8 kgCOD/d
$Q_w X_{10} f_{10}$ or $f_{10} MX_{10}/Rs$	2844.2 kgCOD/d
FO_L	8484.2 kgO/d

N Mass balance	
TKN in (influent)	937.22 kgN/d
TKN out	937.22 kgN/d
N_{10}	104.85 kgN/d
N_{waste}	194.5 kgN/d
$N_{denitrified}$	637.8 kgN/d

TOD balance	
TOD in (influent)	16317.27 kgTOD/d
TOD out	16317.27 kgTOD/d
$TOD_{effluent}$	798.44 kgTOD/d
TOD_{waste}	3740.79 kgTOD/d
TOD_{N2-gas}	1824.21 kgTOD/d
FO_L	9953.83 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S_{10e}	36.30	75	30 mgCOD/l
Unbiol Sol Org N	N_{10e}	0.90	-	- mgN/l
FSA-N	N_{10}	0.36	6	2 mgFSA-N/l
TKN-N	N_{10}	1.26	-	- mgTKN-N/l
Nitrate	N_{10}	4.26	15	1.5 mgNO ₃ -N/l
Unbiol Sol Org P	P_{10e}	0.60	-	- mgP/l
Ortho P as P	P_{10}	10.95	10	2.5 mgP/l
TP	P_{10}	11.55	-	- mgP/l

UCT Reactor @ 30 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	19.44 Ml/d
Sludge Age	SRT	30.0 days
Reactor TSS concentration	X _T	8458.87 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	619	12034
BPO COD	Sbpi	479	9312
UPO COD	Supi	29	558
	fs'up		0.046
VFA COD	Sbsi,a	0.0	0
FBSO COD	Sbsfi	75	1458
BSO COD	Sbsi	75	1458
USO COD	Susi	36.3	706
	fs'us		0.059
BO COD	Sbi	554	10770
UO COD	Sui	65	1264
TSS		241	4681
ISS		51.4	1000
VSS		189	3681
UPO VSS		19.4	377
BPO VSS		170	3304
TKN	Nti	48.2	937
Org N	Noi	13.8	268
FSA	Nai	34.4	669
BSO	Nobsi	2.90	56
USO	Nousi	0.90	18
BPO	Nobpi	8.70	169
UPO	Noupi	1.30	25
Total P	Pti	15.50	301
OP	Pai	12.80	249
Org P	Poi	2.70	53
BSO	Pobsi	0.70	14
USO	Pousi	0.60	12
BPO	Pobpi	0.78	15
UPO	Poupi	0.62	12

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _o	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{ov}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,fbs}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,u}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,u}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,u}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2141 /d
	μ _{h,n20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{amT}	0.2829 /d
	b _{h20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0357 /d
	K _{h20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{HT}	0.6288 mgFSA/l
	K _{HT(20)}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{LT}	0.3472
	K _{HT(20)}	0.101
Denitrification	θ	1.08
for ND system	K _{LT}	0.0742
Half Saturation Coefficient	K _{LT}	0.0742
Denitrification	K ¹⁰ _{LT(20)}	0.255
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K ¹⁰ _{LT}	0.1874

Factor of safety reducing μ _{amT}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _m	6.76 days
SRT _m (with safety factor)	SRT _m	8.45 Nitrifies!

Max unaerated sludge mass fraction	f _{xm}	0.70
Total unaerated sludge mass fraction	f _{xt}	0.35
Anoxic mass fraction primary anox 2	f _{x prim anox 2}	0.27
Anaerobic mass fraction	f _{anox}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments 2

r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N _{br}	4.6 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{O2,L}	0.0 mgO/l

influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	2.642 :1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)	f _{Sb/s}	0.135

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	19.44 Ml/d
Sludge Age	SRT	30.0 days
Reactor TSS concentration	X _T	8105 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	619	12034
BPO COD	Sbpi	479	9312
UPO COD	Supi	29	558
	fs'up		0.046
VFA COD	Sbsi,a	0	0
FBSO COD	Sbsfi	75	1458
BSO COD	Sbsi	75	1458
USO COD	Susi	36	706
	fs'us		0.059
BO COD	Sbi	554	10770
UO COD	Sui	65	1264
TSS		241	4681
ISS		51	1000
VSS		189	3681
UPO VSS		19	377
BPO VSS		170	3304
TKN	Nti	48	937
Org N	Noi	14	268
FSA	Nai	34	669
BSO	Nobsi	2.90	56
USO	Nousi	0.90	18
BPO	Nobpi	8.70	169
UPO	Noupi	1.30	25
Total P	Pti	15.50	301
OP	Pai	12.80	249
Org P	Poi	2.70	53
BSO	Pobsi	0.70	14
USO	Pousi	0.60	12
BPO	Pobpi	0.78	15
UPO	Poupi	0.62	12

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _o	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{ov}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,fbs}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,u}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,u}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,u}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate OHO	b _{HT}	0.2691 /d
	μ _{h,n20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{amT}	0.7157 /d
	b _{h20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0448 /d
	K _{h20}	1.0
Nitrification	θ	1.123
Half Saturation Coefficient	K _{HT}	1.5904
	K _{HT(20)}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{LT}	1.4930
	K _{HT(20)}	0.101
Denitrification	θ	1.08
for ND system	K _{LT}	0.1374
Half Saturation Coefficient	K _{LT}	0.1374
Denitrification	K ¹⁰ _{LT(20)}	0.255
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K ¹⁰ _{LT}	0.3469

Factor of safety reducing μ _{amT}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _m	2.38 days
SRT _m (with safety factor)	SRT _m	2.98 Nitrifies!

Max unaerated sludge mass fraction	f _{xm}	0.86
Total unaerated sludge mass fraction	f _{xt}	0.35
Anoxic mass fraction primary anox 2	f _{x prim anox 2}	0.27
Anaerobic mass fraction	f _{anox}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments 2

r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N _{br}	4.6 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{O2,L}	0.0 mgO/l

influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	2.6 :1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)	f _{Sb/s}	0.135

UCT Reactor @ 30 Days SRT

Influent TKN	N_0	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_L	194 kgN/d
Equiv conc in influent	N_i	9.98 mgN/l
Effluent Sol Unbiode Org N	N_{unb}	0.90 mgN/l
Effluent ammonia	N_{NH}	0.38 mgFSA-N/l
TKN in effluent	N_{de}	1.28 mgTKN-N/l
Nitrification capacity	N_L	36.94 mgN/l influent

Denitrification potential BSO (K1)	D_{BBSO}	1.0 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BPO}	48.57 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{d1}	49.56 mgNO ₂ -N/l influent

	A	0.6993
	B	-9.1411
	C	79.514
Optimal a-recycle ratio	a_{opt}	19.04
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00
set = a_{opt} for balanced UCT		
recycle limited		

Effluent Nitrate if recycle limited		3.83 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-7.49 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{NH}	3.83 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₂)	$N_{NH} + N_{de}$	5.11 mgN/l
N removal		89.4%

Alkalinity consumed by nitrification		264 mg CaCO ₃
Alkalinity recovered by denitrification		118 mg CaCO ₃
Total Alkalinity consumption		146 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{bH,a}$	0 mgCOD/l
FBSO COD	S_{bH}	75 mgCOD/l
BSO COD	S_{bH}	75 mgCOD/l
BO COD	S_{bH}	554 mgCOD/l

$S_{F,i}$ reduction due to O ₂ & NO ₃		39.71498628 mgCOD/l
Reduced FBSO concentration	$S_{F,i,conv}$	35.28501372 mgCOD/l

	$k_{r,120}$	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	$k_{r,T}$	0.0535 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

Trial 1	$S_{bH/N}$	0.00	MX _{BPO} /Q _i	943	$S_{bH/N}$	4.31
Trial 2		4.31		959		4.24
Trial 3		4.24		959		4.24
Trial 4		4.24		959		4.24

Flux BO COD obtained by OHO's	95%	10249 kgCOD/d
Flux BO COD obtained by PAO's	5%	521 kgCOD/d
Check total BO COD		10770 kgCOD/d

correct
10770

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{G20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{GT}	0.0357 /d

Activated Sludge Masses

<u>OHO VSS</u>		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	18642 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	23944 kgVSS

<u>PAO VSS</u>		
Polyphosphate Acc Organisms VSS	MX_{PAO}	3399 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	909 kgVSS

Unbiodegradable Organic VSS	MX_{iu}	11304 kgVSS
Total VSS	MX_v	58199 kgVSS

ISS from influent		29989 kgTSS
ISS of OHO's		2796 kgTSS
ISS of PAO's		4475 kgTSS
ISS	MX_{DO}	37260 kgTSS
TSS	MX_t	95458 kgTSS
VSS/TSS ratio		0.610 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.380 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.07 mgP/l
biomass P-content	ΔP_{OHO}	2.49 mgP/l
Potential P-removal		4.56 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.07 mgP/l
biomass P-content	ΔP_{OHO}	2.49 mgP/l
Total Actual P-removal		4.56 mgP/l

TP effluent P_{le} 10.94 mgP/l

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	8147 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	309 kgO/d
Carbonaceous Oxygen flux	FO_c	8455 kgO/d
Nitrogenous Oxygen flux	FO_N	3283 kgO/d
Oxygen dmdnd recover by denitrification	FO_d	1841 kgO/d
Total Oxygen Demand (FO _c + FO _N + FO _d)	FO_T	9897 kgO/d
Oxygen utilisation rate	O_r	56.3 mgO/l/h

Influent TKN	N_0	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_L	184 kgN/d
Equiv conc in influent	N_i	9.46 mgN/l
Effluent Sol Unbiode Org N	N_{unb}	0.90 mgN/l
Effluent ammonia	N_{NH}	0.32 mgFSA-N/l
TKN in effluent	N_{de}	1.22 mgTKN-N/l
Nitrification capacity	N_L	37.51 mgN/l influent

Denitrification potential BSO (K1)	D_{BBSO}	1.0 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BPO}	73.51 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{d1}	74.47 mgNO ₂ -N/l influent

	A	0.6993
	B	-33.4861
	C	168.752
Optimal a-recycle ratio	a_{opt}	52.48
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00
recycle limited		

Effluent Nitrate if recycle limited		3.89 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-31.84 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{NH}	3.89 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₂)	$N_{NH} + N_{de}$	5.11 mgN/l
N removal		89.4%

Alkalinity consumed by nitrification		268 mg CaCO ₃
Alkalinity recovered by denitrification		120 mg CaCO ₃
Total Alkalinity consumption		148 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{bH,a}$	0 mgCOD/l
FBSO COD	S_{bH}	75 mgCOD/l
BSO COD	S_{bH}	75 mgCOD/l
BO COD	S_{bH}	554 mgCOD/l

$S_{F,i}$ reduction due to O ₂ & NO ₃		39.71498628 mgCOD/l
Reduced FBSO concentration	$S_{F,i,conv}$	35.28501372 mgCOD/l

	$k_{r,120}$	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	$k_{r,T}$	0.0673 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

Trial 1	$S_{bH/N}$	0.00	MX _{BPO} /Q _i	772	$S_{bH/N}$	4.19
Trial 2		4.19		784		4.12
Trial 3		4.12		784		4.12
Trial 4		4.12		784		4.12

Flux BO COD obtained by OHO's	95%	10244 kgCOD/d
Flux BO COD obtained by PAO's	5%	526 kgCOD/d
Check total BO COD		10770 kgCOD/d

correct

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{G20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{GT}	0.0448 /d

Activated Sludge Masses

<u>OHO VSS</u>		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	15244 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	24611 kgVSS

<u>PAO VSS</u>		
Polyphosphate Acc Organisms VSS	MX_{PAO}	3027 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	1018 kgVSS

Unbiodegradable Organic VSS	MX_{iu}	11304 kgVSS
Total VSS	MX_v	55204 kgVSS

ISS from influent		29989 kgTSS
ISS of OHO's		2287 kgTSS
ISS of PAO's		3985 kgTSS
ISS	MX_{DO}	36260 kgTSS
TSS	MX_t	91464 kgTSS
VSS/TSS ratio		0.604 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.38 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	1.84 mgP/l
biomass P-content	ΔP_{OHO}	2.37 mgP/l
Potential P-removal		4.21 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	1.84 mgP/l
biomass P-content	ΔP_{OHO}	2.37 mgP/l
Total Actual P-removal		4.21 mgP/l

TP effluent P_{le} 11.29 mgP/l

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	8277 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	326 kgO/d
Carbonaceous Oxygen flux	FO_c	8603 kgO/d
Nitrogenous Oxygen flux	FO_N	3334 kgO/d
Oxygen dmdnd recover by denitrification	FO_d	1870 kgO/d
Total Oxygen Demand (FO _c + FO _N + FO _d)	FO_T	10067 kgO/d
Oxygen utilisation rate	O_r	57.3 mgO/l/h

UCT Reactor @ 30 Days SRT

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Check	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	7740	25800	61919	95458
Concentration TSS (kgTSS/m ³)	4.23	8.46	8.46	7.824
Volume (m ³)	1830	3050	7320	12200
Volume fraction	15%	25%	60%	100%
Concentration VSS (kgVSS/m ³)	2.58	5.16	5.16	4.77
UPO VSS Concentration (kgUPOVSS/m ³)	0.501	1.002	1.002	0.927

Mass TSS wasted per day 3181.9 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 376.2 m³/d

COD mass balance	
COD in (influent)	12034.2 kgCOD/d
COD out	12034.2 kgCOD/d
$Q_w S_{iw} + Q_w S_{wo}$	705.8 kgCOD/d
$Q_w X_w f_{cv}$ or $f_{cv} MX_w/Rs$	2873.1 kgCOD/d
FO_L	8455.3 kgO/d

N Mass balance	
TKN in (influent)	937.22 kgN/d
TKN out	937.22 kgN/d
N_{D_2}	97.45 kgN/d
N_{waste}	195.9 kgN/d
$N_{denitrified}$	643.9 kgN/d

TOD balance	
TOD in (influent)	16317.27 kgTOD/d
TOD out	16317.27 kgTOD/d
$TOD_{effluent}$	803.62 kgTOD/d
TOD_{waste}	3775.49 kgTOD/d
TOD_{N_2-gas}	1841.43 kgTOD/d
FO_L	9896.73 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S_{UOE}	36.30	75	30 mgCOD/l
Unbiol Sol Org N	N_{OUOE}	0.90	-	mgN/l
FSA-N	N_{NS}	0.38	6	2 mgFSA-N/l
TKN-N	N_{NS}	1.28	-	mgTKN-N/l
Nitrate	N_{NS}	3.83	15	1.5 mgNO ₃ -N/l
Unbiol Sol Org P	P_{OUOE}	0.60	-	mgP/l
Ortho P as P	P_{OE}	10.94	10	2.5 mgP/l
TP	P_{OE}	11.54	-	mgP/l

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	7416	24720	59328	91464
Concentration TSS (kgTSS/m ³)	4.05	8.10	8.10	7.497
Volume (m ³)	1830	3050	7320	12200
	7416			
Concentration VSS (kgVSS/m ³)	2.45	4.89	4.89	4.52
UPO VSS Concentration (kgUPOVSS/m ³)	0.501	1.002	1.002	0.927

Mass TSS wasted per day 3048.8 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 376.2 m³/d

COD mass balance	
COD in (influent)	12034.2 kgCOD/d
COD out	12034.2 kgCOD/d
$Q_w S_{iw} + Q_w S_{wo}$	705.8 kgCOD/d
$Q_w X_w f_{cv}$ or $f_{cv} MX_w/Rs$	2725.3 kgCOD/d
FO_L	8603.1 kgO/d

N Mass balance	
TKN in (influent)	937.22 kgN/d
TKN out	937.22 kgN/d
N_{D_2}	97.49 kgN/d
N_{waste}	185.9 kgN/d
$N_{denitrified}$	653.8 kgN/d

TOD balance	
TOD in (influent)	16317.27 kgTOD/d
TOD out	16317.27 kgTOD/d
$TOD_{effluent}$	798.67 kgTOD/d
TOD_{waste}	3581.96 kgTOD/d
TOD_{N_2-gas}	1869.85 kgTOD/d
FO_L	10066.79 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S_{UOE}	36.30	75	30 mgCOD/l
Unbiol Sol Org N	N_{OUOE}	0.90	-	mgN/l
FSA-N	N_{NS}	0.32	6	2 mgFSA-N/l
TKN-N	N_{NS}	1.22	-	mgTKN-N/l
Nitrate	N_{NS}	3.89	15	1.5 mgNO ₃ -N/l
Unbiol Sol Org P	P_{OUOE}	0.60	-	mgP/l
Ortho P as P	P_{OE}	11.29	10	2.5 mgP/l
TP	P_{OE}	11.89	-	mgP/l

**Annexure A5 – Detailed Reactor Model for Influent
Flow of 40 ML/d**

MLE Reactor @ 10 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	17.8 Ml/d
Sludge Age	SRT	10.0 days
Reactor TSS concentration	X _r	2829 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti 619	11003
BPO COD	Sbpi 479	8514
UPO COD	Supi 29	510
	fs'up 0.0464	
VFA COD	Sbsi,a 0.0	0
FBSD COD	Sbsfi 75	1333
BSO COD	Sbsi 75	1333
USO COD	Susi 36.3	645
	fs'us 0.0587	
BO COD	Sbi 554	9847
UO COD	Sui 65	1156
TSS	241	4280
ISS	51.4	914
VSS	189	3366
UPO VSS	19.4	345
BPO VSS	170	3021
TKN	Nti 48.2	857
Org N	Noi 13.8	245
FSA	Nai 34.4	612
BSO	Nobsi 2.90	52
USO	Nousi 0.90	16
BPO	Nobpi 8.70	155
UPO	Noupi 1.30	23
Total P	Pti 15.50	276
OP	Pai 12.80	228
Org P	Poi 2.70	48
BSO	Pobsi 0.70	12
USO	Pousi 0.60	11
BPO	Pobpi 0.78	14
UPO	Poupi 0.62	11

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSD	f _{cm,bsd}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,upo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,upo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,upo}	0.518 mgC/mgVSS

Temperature dependant coefficients

	T	16 °C
	b _{H20}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2141 /d
	μ _{Am20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.2829 /d
	b _{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0357 /d
	K _{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K _{HT}	0.6288 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	14109 kgVSS
Endogenous Residue VSS	MX _{EH}	6041 kgVSS
Unbiodegradeable Organic VSS	MX _{iv}	3447 kgVSS
Total VSS	MX _v	23597 kgVSS
ISS from influent		9139 kgISS
ISS of OHO's		2116 kgISS
ISS	MX _{IOI}	11256 kgISS
TSS	MX _t	34853 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{hn}	16.6 hr

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	17.8 Ml/d
Sludge Age	SRT	10.0 days
Reactor TSS concentration	X _T	2667 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti 618.9	11003
BPO COD	Sbpi 479	8514
UPO COD	Supi 29	510
	fs'up 0.04637	
VFA COD	Sbsi,a 0	0
FBSD COD	Sbsfi 75	1333
BSO COD	Sbsi 75	1333
USO COD	Susi 36.3	645
	fs'us 0.05865	
BO COD	Sbi 554	9847
UO COD	Sui 65	1156
TSS	240.72727	4280
ISS	51.4	914
VSS	189.31818	3366
UPO VSS	19.39	345
BPO VSS	170	3021
TKN	Nti 48.2	857
Org N	Noi 13.8	245
FSA	Nai 34.4	612
BSO	Nobsi 2.90	51.6
USO	Nousi 0.90	16.0
BPO	Nobpi 8.70	155
UPO	Noupi 1.30	23
Total P	Pti 15.5	276
OP	Pai 12.8	228
Org P	Poi 2.7	48.0
BSO	Pobsi 0.7	12.4
USO	Pousi 0.6	11
BPO	Pobpi 0.78	14
UPO	Poupi 0.62	11.03

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSD	f _{cm,bsd}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,upo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,upo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,upo}	0.518 mgC/mgVSS

Temperature dependant coefficients

	T	24 °C
	b _{H20}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2691 /d
	μ _{Am20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.7157 /d
	b _{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0448 /d
	K _{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K _{HT}	1.5904 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	12006 kgVSS
Endogenous Residue VSS	MX _{EH}	6461 kgVSS
Unbiodegradeable Organic VSS	MX _{iv}	3447 kgVSS
Total VSS	MX _v	21915 kgVSS
ISS from influent		9139 kgISS
ISS of OHO's		1801 kgISS
ISS	MX _{IOI}	10940 kgISS
TSS	MX _t	32855 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{hn}	16.6 hr

MLE Reactor @ 10 Days SRT

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X _{BH}	1145 mgVSS/l
Endogenous Residue VSS	X _{EH}	490 mgVSS/l
Unbiodegradable Organic VSS	X _I	280 mgVSS/l
Total VSS	X _V	1915 mgVSS/l
Influent Biodegradable ISS	X _{IOI}	914 mgISS/l
TSS	X _t	2829 mgTSS/l

Active fraction of VSS	f _{av}	0.598 kgVSS/kgVSS
Active fraction of TSS	f _{at}	0.405 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.677 kgVSS/kgTSS

Waste Flow Rate	Q _w	1232 m ³ /d
TSS wasted per day		3485 kgTSS/d
VSS wasted per day		2360 kgVSS/d

Flux of N in waste VSS	FN _s	236 kgN/d
Equiv conc in influent	N _s	13.27 mgN/l influent
Effluent Sol Unbiol Org N	N _{ouse}	0.90 mgN/l

Factor of safety reducing μ _{AMT}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.148
Minimum sludge age for nitrification	SRT _m	4.87 days
SRT _m with Safety factor	SRT _{m (Sf)}	6.09 Nitrifies!

<u>If no nitrification</u>		
Effluent NO ₃	N _{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	34.9 mgTKN-N/l
Effluent FSA-N	N _{ae} = N _{an}	34.0 mgFSA-N/l

<u>If complete nitrification</u>		
Effluent NO ₃	N _{ne}	34.0 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	0.9 mgTKN-N/l
Effluent FSA-N	N _{ae}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	N _{ne} = N _c	33.22 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	1.71 mgTKN-N/l
(calculated N _{ae})	(N _{ae})	0.810 mgFSA-N/l
Effluent FSA-N	N _{ae}	0.810 mgFSA-N/l
Nitrifier sludge mass	MX _{BA}	435.2 kgVSS

Denitrification	K ₁₍₂₀₎	0.72 mgFSA/l
Half Saturation Coefficient	Θ	1.2
	K _{1T}	0.3472 mgFSA/l
Denitrification	K ₂₍₂₀₎	0.101 mgFSA/l
Half Saturation Coefficient	Θ	1.08
	K _{2T}	0.0742 mgFSA/l

s-recycle ratio	s	1.00 :1
s-recycle DO concentration	O _s	1.0 mgO/l
a-recycle DO concentration	O _a	2.0 mgO/l

Max unaerated sludge mass fraction	f _{xm}	0.401
Anoxic sludge mass fraction	f _{x1}	0.148 set = f_{xm} for balanced MLE
Min anoxic sludge mass fraction	f _{x1min}	0.032

Influent RBCOD fraction (Sbsi/Sbi)	f _{sb's}	0.135

Denitrification potential BSO (K1)	D _{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D _{pBPO}	8.74 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D _{p1}	17.49 mgNO ₃ -N/l influent

	A	0.6993
	B	17.4756
	C	1.062
Optimal a-recycle ratio	a _{opt}	0.06
Maximum practical a-recycle ratio	a _{max}	6
chosen a-recycle ratio	a	0.00 set = a_{opt} for balanced MLE
recycle limited		

Effluent Nitrate if recycle limited		16.61 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		16.08 mgNO ₃ -N/l
Actual Effluent Nitrate	N _{ne}	16.61 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	N _{ne} + N _{te}	18.32 mgN/l
N removal		62.0%

Volume of Primary Anoxic Tank	V _{anox}	1828 m ³
Volume of Aerobic Tank	V _{aer}	10492 m ³

Carbonaceous Oxygen flux	FO _C	6863 kgO/d
Nitrogenous Oxygen flux	FO _N	2699 kgO/d
Oxygen dmnd recover by denitrification	FO _D	844 kgO/d
Total Oxygen Demand (FO _C + FO _N - FO _D)	FO _T	8717 kgO/d
Oxygen utilisation rate	O _T	34.6 mgO/l.h

Alkalinity consumed by nitrification		237 mg CaCO ₃
Alkalinity recovered by denitrification		59 mg CaCO ₃
Total Alkalinity consumption		178 mg CaCO ₃

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X _{BH}	975 mgVSS/l
Endogenous Residue VSS	X _{EH}	524 mgVSS/l
Unbiodegradable Organic VSS	X _I	280 mgVSS/l
Total VSS	X _V	1779 mgVSS/l
Influent Biodegradable ISS	X _{IOI}	888 mgISS/l
TSS	X _t	2667 mgTSS/l

Active fraction of VSS	f _{av}	0.548 kgVSS/kgVSS
Active fraction of TSS	f _{at}	0.365 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.667 kgVSS/kgTSS

Waste Flow Rate	Q _w	1232 m ³ /d
TSS wasted per day		3286 kgTSS/d
VSS wasted per day		2191 kgVSS/d

Flux of N in waste VSS	FN _s	219 kgN/d
Equiv conc in influent	N _s	12.33 mgN/l influent
Effluent Sol Unbiol Org N	N _{ouse}	0.90 mgN/l

Factor of safety reducing μ _{AMT}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.148
Minimum sludge age for nitrification	SRT _m	1.77 days
SRT _m with Safety factor	SRT _{m (Sf)}	2.21 Nitrifies!

<u>If no nitrification</u>		
Effluent NO ₃	N _{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	35.9 mgTKN-N/l
Effluent FSA-N	N _{ae} = N _{an}	35.0 mgFSA-N/l

<u>If complete nitrification</u>		
Effluent NO ₃	N _{ne}	35.0 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	0.9 mgTKN-N/l
Effluent FSA-N	N _{ae}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	N _{ne} = N _c	34.48 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	1.40 mgTKN-N/l
(calculated N _{ae})	(N _{ae})	0.496 mgFSA-N/l
Effluent FSA-N	N _{ae}	0.496 mgFSA-N/l
Nitrifier sludge mass	MX _{BA}	423.2 kgVSS

Denitrification	K ₁₍₂₀₎	0.72 mgFSA/l
Half Saturation Coefficient	Θ	1.2
	K _{1T}	1.4930 mgFSA/l
Denitrification	K ₂₍₂₀₎	0.101 mgFSA/l
Half Saturation Coefficient	Θ	1.08
	K _{2T}	0.1374 mgFSA/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O _s	1.0 mgO/l
a-recycle DO concentration	O _a	2.0 mgO/l

Max unaerated sludge mass fraction	f _{xm}	0.747
Anoxic sludge mass fraction	f _{x1}	0.148
Min anoxic sludge mass fraction	f _{x1min}	0.009

Influent RBCOD fraction (Sbsi/Sbi)	f _{sb's}	0.135

Denitrification potential BSO (K1)	D _{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D _{pBPO}	13.77 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D _{p1}	22.52 mgNO ₃ -N/l influent

	A	0.6993
	B	13.7091
	C	9.856
Optimal a-recycle ratio	a _{opt}	0.69
Maximum practical a-recycle ratio	a _{max}	6
chosen a-recycle ratio	a	0.00
recycle limited		

Effluent Nitrate if recycle limited		17.24 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		12.31 mgNO ₃ -N/l
Actual Effluent Nitrate	N _{ne}	17.24 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	N _{ne} + N _{te}	18.63 mgN/l
N removal		61.3%

Volume of Primary Anoxic Tank	V _{anox}	1828 m ³
Volume of Aerobic Tank	V _{aer}	10492 m ³

Carbonaceous Oxygen flux	FO _C	7112 kgO/d
Nitrogenous Oxygen flux	FO _N	2801 kgO/d
Oxygen dmnd recover by denitrification	FO _D	876 kgO/d
Total Oxygen Demand (FO _C + FO _N - FO _D)	FO _T	9037 kgO/d
Oxygen utilisation rate	O _T	35.9 mgO/l.h

Alkalinity consumed by nitrification		246 mg CaCO ₃
Alkalinity recovered by denitrification		62 mg CaCO ₃
Total Alkalinity consumption		185 mg CaCO ₃

MLE Reactor @ 10 Days SRT

COD mass balance	
COD in (influent)	11002.7 kgCOD/d
COD out	11003.0 kgCOD/d
$Q_e S_{Te} + Q_w S_{Te}$	645.3 kgCOD/d
$Q_w X_v f_{cv}$	3494.7 kgCOD/d
$V_p O_c$	6862.9 kgO/d

COD mass balance	
COD in (influent)	11002.7 kgCOD/d
COD out	11003.0 kgCOD/d
$Q_e S_{Te} + Q_w S_{Te}$	645.3 kgCOD/d
$Q_w X_v f_{cv}$	3245.6 kgCOD/d
$V_p O_c$	7112.1 kgO/d

MLE Reactor @ 10 Days SRT

N mass balance		
N in (influent)		856.9 kgTKN-N/d
N out		856.9 kgTKN-N/d
$Q_e N_{te} + Q_w N_{te}$		30.4 kgTKN-N/d
$Q N_s$		236.0 kgTKN-N/d
$Q N_{ne}$		590.5 kgNO3-N/d

TOD balance		
TOD in (influent)		14918.65 kgTOD/d
TOD out		14918.99 kgTOD/d
$TOD_{effluent}$		729.93 kgTOD/d
TOD_{waste}		4627.47 kgTOD/d
TOD_{N_2-gas}		844.43 kgTOD/d
FO_t		8717.15 kgTOD/d

Flux of P in waste VSS	FP_s	59 kgP/d
Equiv conc in influent	P_s	3.32 mgP/l
Effluent Sol Unbiod Org P	P_{ouse}	0.60 mgP/l
Effluent TP	P_{te}	12.18 mgP/l
Effluent Ortho-P as P	P_{oe}	11.58 mgOP-P/l

N mass balance		
N in (influent)		856.9 kgTKN-N/d
N out		856.9 kgTKN-N/d
$Q_e N_{te} + Q_w N_{te}$		24.8 kgTKN-N/d
$Q N_s$		219.1 kgTKN-N/d
$Q N_{ne}$		612.9 kgNO3-N/d

TOD balance		
TOD in (influent)		14918.65 kgTOD/d
TOD out		14918.99 kgTOD/d
$TOD_{effluent}$		706.15 kgTOD/d
TOD_{waste}		4299.68 kgTOD/d
TOD_{N_2-gas}		876.49 kgTOD/d
FO_t		9036.68 kgTOD/d

Flux of P in waste VSS	FP_s	55 kgP/d
Equiv conc in influent	P_s	3.08 mgP/l
Effluent Sol Unbiod Org P	P_{ouse}	0.00 mgP/l
Effluent TP	P_{te}	12.42 mgP/l
Effluent Ortho-P as P	P_{oe}	12.42 mgOP-P/l

Effluent Concentrations			General	Special	Unit	Effluent Concentrations			General	Special	Unit
Unbiod Sol COD	S_{use}	36.30	<75	<30	mgCOD	Unbiod Sol COD	S_{use}	36.30	<75	<30	mgCOD/l
Undiod Sol Org N	N_{ouse}	0.90	-	-	mgN/l	Undiod Sol Org N	N_{ouse}	0.90	-	-	mgN/l
FSA-N	N_{ae}	0.81	<6	<2	mgFSA	FSA-N	N_{ae}	0.50	<6	<2	mgFSA-N/l
TKN-N	N_{te}	1.71	-	-	mgTKN	TKN-N	N_{te}	1.40	-	-	mgTKN-N/l
Nitrate	N_{ne}	16.61	<15	<1.5	mgNO ₃	Nitrate	N_{ne}	17.24	<15	<1.5	mgNO ₃ -N/l
Undiod Sol Org P	P_{ouse}	0.60	-	-	mgP/l	Undiod Sol Org P	P_{ouse}	0.00	-	-	mgP/l
Ortho P as P	P_{oe}	11.58	<10	<2.5	mgOP-P	Ortho P as P	P_{oe}	12.42	<10	<2.5	mgOP-P/l
TP	P_{te}	12.18	-	-	mgP/l	TP	P_{te}	12.42	-	-	mgP/l

MLE Reactor @ 15 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	17.8 MI/d
Sludge Age	SRT	15.0 days
Reactor TSS concentration	X _r	3829 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti 619	11003
BPO COD	Sbpi 479	8514
UPO COD	Supi 29	510
	fs'up 0.0464	
VFA COD	Sbsi,a 0.0	0
FBSO COD	Sbsfi 75	1333
BSO COD	Sbsi 75	1333
USO COD	Susi 36.3	645
	fs'us 0.0587	
BO COD	Sbi 554	9847
UO COD	Sui 65	1156
TSS	241	4280
ISS	51.4	914
VSS	189	3366
UPO VSS	19.4	345
BPO VSS	170	3021
TKN	Nti 48.2	857
Org N	Noi 13.8	245
FSA	Nai 34.4	612
BSO	Nobsi 2.90	52
USO	Nousi 0.90	16
BPO	Nobpi 8.70	155
UPO	Noupi 1.30	23
Total P	Pti 15.50	276
OP	Pai 12.80	228
Org P	Poi 2.70	48
BSO	Pobsi 0.70	12
USO	Pousi 0.60	11
BPO	Pobpi 0.78	14
UPO	Poupi 0.62	11

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,upo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,upo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,upo}	0.518 mgC/mgVSS

Temperature dependant coefficients

	T	16 °C
	b _{H20}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2141 /d
	μ _{Am20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.2829 /d
	b _{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0357 /d
	K _{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K _{HT}	0.6288 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	15784 kgVSS
Endogenous Residue VSS	MX _{EH}	10137 kgVSS
Unbiodegradeable Organic VSS	MX _{lv}	5171 kgVSS
Total VSS	MX _v	31092 kgVSS
ISS from influent		13709 kgISS
ISS of OHO's		2368 kgISS
ISS	MX _{IOI}	16077 kgISS
TSS	MX _t	47169 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{hn}	16.6 hr

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	17.8 MI/d
Sludge Age	SRT	15.0 days
Reactor TSS concentration	X _T	3629 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti 618.9	11003
BPO COD	Sbpi 479	8514
UPO COD	Supi 29	510
	fs'up 0.04637	
VFA COD	Sbsi,a 0	0
FBSO COD	Sbsfi 75	1333
BSO COD	Sbsi 75	1333
USO COD	Susi 36.3	645
	fs'us 0.05865	
BO COD	Sbi 554	9847
UO COD	Sui 65	1156
TSS	240.72727	4280
ISS	51.4	914
VSS	189.31818	3366
UPO VSS	19.39	345
BPO VSS	170	3021
TKN	Nti 48.2	857
Org N	Noi 13.8	245
FSA	Nai 34.4	612
BSO	Nobsi 2.90	51.6
USO	Nousi 0.90	16.0
BPO	Nobpi 8.70	155
UPO	Noupi 1.30	23
Total P	Pti 15.5	276
OP	Pai 12.8	228
Org P	Poi 2.7	48.0
BSO	Pobsi 0.7	12.4
USO	Pousi 0.6	11
BPO	Pobpi 0.78	14
UPO	Poupi 0.62	11.03

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,upo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,upo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,upo}	0.518 mgC/mgVSS

Temperature dependant coefficients

	T	24 °C
	b _{H20}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2691 /d
	μ _{Am20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.7157 /d
	b _{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0448 /d
	K _{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K _{HT}	1.5904 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	13198 kgVSS
Endogenous Residue VSS	MX _{EH}	10654 kgVSS
Unbiodegradeable Organic VSS	MX _{lv}	5171 kgVSS
Total VSS	MX _v	29023 kgVSS
ISS from influent		13709 kgISS
ISS of OHO's		1980 kgISS
ISS	MX _{IOI}	15689 kgISS
TSS	MX _t	44712 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{hn}	16.6 hr

MLE Reactor @ 15 Days SRT

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X _{BH}	1281 mgVSS/l
Endogenous Residue VSS	X _{EH}	823 mgVSS/l
Unbiodegradable Organic VSS	X _I	420 mgVSS/l
Total VSS	X _V	2524 mgVSS/l
Influent Biodegradable ISS	X _{IOI}	1305 mgISS/l
TSS	X _t	3829 mgTSS/l

Active fraction of VSS	f _{av}	0.508 kgVSS/kgVSS
Active fraction of TSS	f _{at}	0.335 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.659 kgVSS/kgTSS

Waste Flow Rate	Q _w	821 m ³ /d
TSS wasted per day		3145 kgTSS/d
VSS wasted per day		2073 kgVSS/d

Flux of N in waste VSS	FN _s	207 kgN/d
Equiv conc in influent	N _s	11.66 mgN/l influent
Effluent Sol Unbiodeg Org N	N _{ouse}	0.90 mgN/l

Factor of safety reducing μ _{AMT}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.148
Minimum sludge age for nitrification	SRT _m	4.87 days
SRT _m with Safety factor	SRT _{m (Sf)}	6.09 Nitrifies!

<u>If no nitrification</u>		
Effluent NO ₃	N _{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	36.5 mgTKN-N/l
Effluent FSA-N	N _{ae} = N _{an}	35.6 mgFSA-N/l

<u>If complete nitrification</u>		
Effluent NO ₃	N _{ne}	35.6 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	0.9 mgTKN-N/l
Effluent FSA-N	N _{ae}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	N _{ne} = N _c	35.18 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	1.36 mgTKN-N/l
(calculated N _{ae})	(N _{ae})	0.464 mgFSA-N/l
Effluent FSA-N	N _{ae}	0.464 mgFSA-N/l
Nitrifier sludge mass	MX _{BA}	611.0 kgVSS

Denitrification	K ₁₍₂₀₎	0.72 mgFSA/l
Half Saturation Coefficient	Θ	1.2
	K _{1T}	0.3472 mgFSA/l
Denitrification	K ₂₍₂₀₎	0.101 mgFSA/l
Half Saturation Coefficient	Θ	1.08
	K _{2T}	0.0742 mgFSA/l

s-recycle ratio	s	1.00 :1
s-recycle DO concentration	O _s	1.0 mgO/l
a-recycle DO concentration	O _a	2.0 mgO/l

Max unaerated sludge mass fraction	f _{xm}	0.548
Anoxic sludge mass fraction	f _{x1}	0.148 set = f_{xm} for balanced MLE
Min anoxic sludge mass fraction	f _{x1min}	0.028

Influent RBCOD fraction (Sbsi/Sbi)	f _{sb's}	0.135

Denitrification potential BSO (K1)	D _{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D _{pBPO}	9.78 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D _{p1}	18.53 mgNO ₃ -N/l influent

	A	0.6993
	B	18.3974
	C	1.179
Optimal a-recycle ratio	a _{opt}	0.06
Maximum practical a-recycle ratio	a _{max}	6
chosen a-recycle ratio	a	0.00 set = a_{opt} for balanced MLE
recycle limited		

Effluent Nitrate if recycle limited		17.59 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		17.00 mgNO ₃ -N/l
Actual Effluent Nitrate	N _{ne}	17.59 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	N _{ne} + N _{te}	18.95 mgN/l
N removal		60.7%

Volume of Primary Anoxic Tank	V _{anox}	1828 m ³
Volume of Aerobic Tank	V _{aer}	10492 m ³

Carbonaceous Oxygen flux	FO _C	7288 kgO/d
Nitrogenous Oxygen flux	FO _N	2858 kgO/d
Oxygen dmnd recover by denitrification	FO _D	894 kgO/d
Total Oxygen Demand (FO _C + FO _N - FO _D)	FO _T	9251 kgO/d
Oxygen utilisation rate	O _T	36.7 mgO/l.h

Alkalinity consumed by nitrification		251 mg CaCO ₃
Alkalinity recovered by denitrification		63 mg CaCO ₃
Total Alkalinity consumption		188 mg CaCO ₃

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X _{BH}	1071 mgVSS/l
Endogenous Residue VSS	X _{EH}	865 mgVSS/l
Unbiodegradable Organic VSS	X _I	420 mgVSS/l
Total VSS	X _V	2356 mgVSS/l
Influent Biodegradable ISS	X _{IOI}	1273 mgISS/l
TSS	X _t	3629 mgTSS/l

Active fraction of VSS	f _{av}	0.455 kgVSS/kgVSS
Active fraction of TSS	f _{at}	0.295 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.649 kgVSS/kgTSS

Waste Flow Rate	Q _w	821 m ³ /d
TSS wasted per day		2981 kgTSS/d
VSS wasted per day		1935 kgVSS/d

Flux of N in waste VSS	FN _s	193 kgN/d
Equiv conc in influent	N _s	10.88 mgN/l influent
Effluent Sol Unbiodeg Org N	N _{ouse}	0.90 mgN/l

Factor of safety reducing μ _{AMT}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.148
Minimum sludge age for nitrification	SRT _m	1.77 days
SRT _m with Safety factor	SRT _{m (Sf)}	2.21 Nitrifies!

<u>If no nitrification</u>		
Effluent NO ₃	N _{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	37.3 mgTKN-N/l
Effluent FSA-N	N _{ae} = N _{an}	36.4 mgFSA-N/l

<u>If complete nitrification</u>		
Effluent NO ₃	N _{ne}	36.4 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	0.9 mgTKN-N/l
Effluent FSA-N	N _{ae}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	N _{ne} = N _c	36.06 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	1.26 mgTKN-N/l
(calculated N _{ae})	(N _{ae})	0.356 mgFSA-N/l
Effluent FSA-N	N _{ae}	0.356 mgFSA-N/l
Nitrifier sludge mass	MX _{BA}	574.9 kgVSS

Denitrification	K ₁₍₂₀₎	0.72 mgFSA/l
Half Saturation Coefficient	Θ	1.2
	K _{1T}	1.4930 mgFSA/l
Denitrification	K ₂₍₂₀₎	0.101 mgFSA/l
Half Saturation Coefficient	Θ	1.08
	K _{2T}	0.1374 mgFSA/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O _s	1.0 mgO/l
a-recycle DO concentration	O _a	2.0 mgO/l

Max unaerated sludge mass fraction	f _{xm}	0.805
Anoxic sludge mass fraction	f _{x1}	0.148
Min anoxic sludge mass fraction	f _{x1min}	0.008

Influent RBCOD fraction (Sbsi/Sbi)	f _{sb's}	0.135

Denitrification potential BSO (K1)	D _{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D _{pBPO}	15.14 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D _{p1}	23.88 mgNO ₃ -N/l influent

	A	0.6993
	B	13.9251
	C	11.007
Optimal a-recycle ratio	a _{opt}	0.76
Maximum practical a-recycle ratio	a _{max}	6
chosen a-recycle ratio	a	0.00
recycle limited		

Effluent Nitrate if recycle limited		18.03 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		12.53 mgNO ₃ -N/l
Actual Effluent Nitrate	N _{ne}	18.03 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	N _{ne} + N _{te}	19.29 mgN/l
N removal		60.0%

Volume of Primary Anoxic Tank	V _{anox}	1828 m ³
Volume of Aerobic Tank	V _{aer}	10492 m ³

Carbonaceous Oxygen flux	FO _C	7492 kgO/d
Nitrogenous Oxygen flux	FO _N	2930 kgO/d
Oxygen dmnd recover by denitrification	FO _D	917 kgO/d
Total Oxygen Demand (FO _C + FO _N - FO _D)	FO _T	9505 kgO/d
Oxygen utilisation rate	O _T	37.7 mgO/l.h

Alkalinity consumed by nitrification		257 mg CaCO ₃
Alkalinity recovered by denitrification		64 mg CaCO ₃
Total Alkalinity consumption		193 mg CaCO ₃

MLE Reactor @ 15 Days SRT

COD mass balance	
COD in (influent)	11002.7 kgCOD/d
COD out	11003.0 kgCOD/d
$Q_e S_{Te} + Q_w S_{Te}$	645.3 kgCOD/d
$Q_w X_v f_{cv}$	3069.8 kgCOD/d
$V_p O_c$	7287.8 kgO/d

COD mass balance	
COD in (influent)	11002.7 kgCOD/d
COD out	11003.0 kgCOD/d
$Q_e S_{Te} + Q_w S_{Te}$	645.3 kgCOD/d
$Q_w X_v f_{cv}$	2865.6 kgCOD/d
$V_p O_c$	7492.1 kgO/d

MLE Reactor @ 15 Days SRT

N mass balance		
N in (influent)		856.9 kgTKN-N/d
N out		856.9 kgTKN-N/d
$Q_u N_{ie} + Q_w N_{te}$		24.3 kgTKN-N/d
$Q N_s$		207.3 kgTKN-N/d
$Q N_{ne}$		625.4 kgNO3-N/d

TOD balance		
TOD in (influent)		14918.65 kgTOD/d
TOD out		14918.99 kgTOD/d
$TOD_{effluent}$		721.24 kgTOD/d
TOD_{waste}		4052.05 kgTOD/d
TOD_{N_2-gas}		894.26 kgTOD/d
FO_t		9251.45 kgTOD/d

Flux of P in waste VSS	FP_s	52 kgP/d
Equiv conc in influent	P_s	2.91 mgP/l
Effluent Sol Unbiod Org P	P_{ouse}	0.60 mgP/l
Effluent TP	P_{te}	12.59 mgP/l
Effluent Ortho-P as P	P_{oe}	11.99 mgOP-P/l

N mass balance		
N in (influent)		856.9 kgTKN-N/d
N out		856.9 kgTKN-N/d
$Q_u N_{ie} + Q_w N_{te}$		22.3 kgTKN-N/d
$Q N_s$		193.5 kgTKN-N/d
$Q N_{ne}$		641.1 kgNO3-N/d

TOD balance		
TOD in (influent)		14918.65 kgTOD/d
TOD out		14918.99 kgTOD/d
$TOD_{effluent}$		712.86 kgTOD/d
TOD_{waste}		3784.35 kgTOD/d
TOD_{N_2-gas}		916.73 kgTOD/d
FO_t		9505.06 kgTOD/d

Flux of P in waste VSS	FP_s	48 kgP/d
Equiv conc in influent	P_s	2.72 mgP/l
Effluent Sol Unbiod Org P	P_{ouse}	0.00 mgP/l
Effluent TP	P_{te}	12.78 mgP/l
Effluent Ortho-P as P	P_{oe}	12.78 mgOP-P/l

Effluent Concentrations			General	Special	Unit	Effluent Concentrations			General	Special	Unit
Unbiod Sol COD	S_{use}	36.30	<75	<30	mgCOD	Unbiod Sol COD	S_{use}	36.30	<75	<30	mgCOD/l
Undiod Sol Org N	N_{ouse}	0.90	-	-	mgN/l	Undiod Sol Org N	N_{ouse}	0.90	-	-	mgN/l
FSA-N	N_{ae}	0.46	<6	<2	mgFSA	FSA-N	N_{ae}	0.36	<6	<2	mgFSA-N/l
TKN-N	N_{te}	1.36	-	-	mgTKN	TKN-N	N_{te}	1.26	-	-	mgTKN-N/l
Nitrate	N_{ne}	17.59	<15	<1.5	mgNO ₃	Nitrate	N_{ne}	18.03	<15	<1.5	mgNO ₃ -N/l
Undiod Sol Org P	P_{ouse}	0.60	-	-	mgP/l	Undiod Sol Org P	P_{ouse}	0.00	-	-	mgP/l
Ortho P as P	P_{oe}	11.99	<10	<2.5	mgOP-P	Ortho P as P	P_{oe}	12.78	<10	<2.5	mgOP-P/l
TP	P_{te}	12.59	-	-	mgP/l	TP	P_{te}	12.78	-	-	mgP/l

MLE Reactor @ 20 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	17.8 MI/d
Sludge Age	SRT	20.0 days
Reactor TSS concentration	X _r	4776 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti 619	11003
BPO COD	Sbpi 479	8514
UPO COD	Supi 29	510
	fs'up 0.0464	
VFA COD	Sbsi,a 0.0	0
FBSO COD	Sbsfi 75	1333
BSO COD	Sbsi 75	1333
USO COD	Susi 36.3	645
	fs'us 0.0587	
BO COD	Sbi 554	9847
UO COD	Sui 65	1156
TSS	241	4280
ISS	51.4	914
VSS	189	3366
UPO VSS	19.4	345
BPO VSS	170	3021
TKN	Nti 48.2	857
Org N	Noi 13.8	245
FSA	Nai 34.4	612
BSO	Nobsi 2.90	52
USO	Nousi 0.90	16
BPO	Nobpi 8.70	155
UPO	Noupi 1.30	23
Total P	Pti 15.50	276
OP	Pai 12.80	228
Org P	Poi 2.70	48
BSO	Pobsi 0.70	12
USO	Pousi 0.60	11
BPO	Pobpi 0.78	14
UPO	Poupi 0.62	11

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,upo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,upo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,upo}	0.518 mgC/mgVSS

Temperature dependant coefficients

	T	16 °C
	b _{H20}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2141 /d
	μ _{Am20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.2829 /d
	b _{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0357 /d
	K _{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K _{HT}	0.6288 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	16781 kgVSS
Endogenous Residue VSS	MX _{EH}	14369 kgVSS
Unbiodegradable Organic VSS	MX _{iv}	6895 kgVSS
Total VSS	MX _v	38044 kgVSS
ISS from influent		18279 kgISS
ISS of OHO's		2517 kgISS
ISS	MX _{IOI}	20796 kgISS
TSS	MX _t	58840 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{hn}	16.6 hr

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	17.8 MI/d
Sludge Age	SRT	20.0 days
Reactor TSS concentration	X _T	4553 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti 618.9	11003
BPO COD	Sbpi 479	8514
UPO COD	Supi 29	510
	fs'up 0.04637	
VFA COD	Sbsi,a 0	0
FBSO COD	Sbsfi 75	1333
BSO COD	Sbsi 75	1333
USO COD	Susi 36.3	645
	fs'us 0.05865	
BO COD	Sbi 554	9847
UO COD	Sui 65	1156
TSS	240.72727	4280
ISS	51.4	914
VSS	189.31818	3366
UPO VSS	19.39	345
BPO VSS	170	3021
TKN	Nti 48.2	857
Org N	Noi 13.8	245
FSA	Nai 34.4	612
BSO	Nobsi 2.90	51.6
USO	Nousi 0.90	16.0
BPO	Nobpi 8.70	155
UPO	Noupi 1.30	23
Total P	Pti 15.5	276
OP	Pai 12.8	228
Org P	Poi 2.7	48.0
BSO	Pobsi 0.7	12.4
USO	Pousi 0.60	11
BPO	Pobpi 0.78	14
UPO	Poupi 0.62	11.03

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,upo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,upo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,upo}	0.518 mgC/mgVSS

Temperature dependant coefficients

	T	24 °C
	b _{H20}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2691 /d
	μ _{Am20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.7157 /d
	b _{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0448 /d
	K _{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K _{HT}	1.5904 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	13888 kgVSS
Endogenous Residue VSS	MX _{EH}	14947 kgVSS
Unbiodegradable Organic VSS	MX _{iv}	6895 kgVSS
Total VSS	MX _v	35730 kgVSS
ISS from influent		18279 kgISS
ISS of OHO's		2083 kgISS
ISS	MX _{IOI}	20362 kgISS
TSS	MX _t	56092 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{hn}	16.6 hr

MLE Reactor @ 20 Days SRT

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X _{BH}	1362 mgVSS/l
Endogenous Residue VSS	X _{EH}	1166 mgVSS/l
Unbiodegradable Organic VSS	X _I	560 mgVSS/l
Total VSS	X _V	3088 mgVSS/l
Influent Biodegradable ISS	X _{IOI}	1688 mgISS/l
TSS	X _t	4776 mgTSS/l

Active fraction of VSS	f _{av}	0.441 kgVSS/kgVSS
Active fraction of TSS	f _{at}	0.285 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.647 kgVSS/kgTSS

Waste Flow Rate	Q _w	616 m ³ /d
TSS wasted per day		2942 kgTSS/d
VSS wasted per day		1902 kgVSS/d

Flux of N in waste VSS	FN _s	190 kgN/d
Equiv conc in influent	N _s	10.70 mgN/l influent
Effluent Sol Unbiodeg Org N	N _{ouse}	0.90 mgN/l

Factor of safety reducing μ _{AMT}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.148
Minimum sludge age for nitrification	SRT _m	4.87 days
SRT _m with Safety factor	SRT _{m (Sf)}	6.09 Nitrifies!

<u>If no nitrification</u>		
Effluent NO ₃	N _{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	37.5 mgTKN-N/l
Effluent FSA-N	N _{ae} = N _{an}	36.6 mgFSA-N/l

<u>If complete nitrification</u>		
Effluent NO ₃	N _{ne}	36.6 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	0.9 mgTKN-N/l
Effluent FSA-N	N _{ae}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	N _{ne} = N _c	36.25 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	1.25 mgTKN-N/l
(calculated N _{ae})	(N _{ae})	0.347 mgFSA-N/l
Effluent FSA-N	N _{ae}	0.347 mgFSA-N/l
Nitrifier sludge mass	MX _{BA}	752.2 kgVSS

Denitrification	K ₁₍₂₀₎	0.72 mgFSA/l
Half Saturation Coefficient	Θ	1.2
	K _{1T}	0.3472 mgFSA/l
	K ₂₍₂₀₎	0.101 mgFSA/l
Denitrification	Θ	1.08
Half Saturation Coefficient	K _{2T}	0.0742 mgFSA/l

s-recycle ratio	s	1.00 :1
s-recycle DO concentration	O _s	1.0 mgO/l
a-recycle DO concentration	O _a	2.0 mgO/l

Max unaerated sludge mass fraction	f _{xm}	0.621
Anoxic sludge mass fraction	f _{x1}	0.148 set = f_{xm} for balanced MLE
Min anoxic sludge mass fraction	f _{x1min}	0.027

Influent RBCOD fraction (Sbsi/Sbi)	f _{sb's}	0.135

Denitrification potential BSO (K1)	D _{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D _{pBPO}	10.40 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D _{p1}	19.14 mgNO ₃ -N/l influent

	A	0.6993
	B	18.8571
	C	1.336
Optimal a-recycle ratio	a _{opt}	0.07
Maximum practical a-recycle ratio	a _{max}	6
chosen a-recycle ratio	a	0.00 set = a_{opt} for balanced MLE
recycle limited		

Effluent Nitrate if recycle limited		18.13 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		17.46 mgNO ₃ -N/l
Actual Effluent Nitrate	N _{ne}	18.13 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	N _{ne} + N _{te}	19.37 mgN/l
N removal		59.8%

Volume of Primary Anoxic Tank	V _{anox}	1828 m ³
Volume of Aerobic Tank	V _{aer}	10492 m ³

Carbonaceous Oxygen flux	FO _c	7541 kgO/d
Nitrogenous Oxygen flux	FO _N	2945 kgO/d
Oxygen dmnd recover by denitrification	FO _D	922 kgO/d
Total Oxygen Demand (FO _c + FO _N - FO _D)	FO _T	9564 kgO/d
Oxygen utilisation rate	O _T	38.0 mgO/l.h

Alkalinity consumed by nitrification		259 mg CaCO ₃
Alkalinity recovered by denitrification		65 mg CaCO ₃
Total Alkalinity consumption		194 mg CaCO ₃

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X _{BH}	1127 mgVSS/l
Endogenous Residue VSS	X _{EH}	1213 mgVSS/l
Unbiodegradable Organic VSS	X _I	560 mgVSS/l
Total VSS	X _V	2900 mgVSS/l
Influent Biodegradable ISS	X _{IOI}	1653 mgISS/l
TSS	X _t	4553 mgTSS/l

Active fraction of VSS	f _{av}	0.389 kgVSS/kgVSS
Active fraction of TSS	f _{at}	0.248 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.637 kgVSS/kgTSS

Waste Flow Rate	Q _w	616 m ³ /d
TSS wasted per day		2805 kgTSS/d
VSS wasted per day		1786 kgVSS/d

Flux of N in waste VSS	FN _s	179 kgN/d
Equiv conc in influent	N _s	10.05 mgN/l influent
Effluent Sol Unbiodeg Org N	N _{ouse}	0.90 mgN/l

Factor of safety reducing μ _{AMT}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.148
Minimum sludge age for nitrification	SRT _m	1.77 days
SRT _m with Safety factor	SRT _{m (Sf)}	2.21 Nitrifies!

<u>If no nitrification</u>		
Effluent NO ₃	N _{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	38.2 mgTKN-N/l
Effluent FSA-N	N _{ae} = N _{an}	37.3 mgFSA-N/l

<u>If complete nitrification</u>		
Effluent NO ₃	N _{ne}	37.3 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	0.9 mgTKN-N/l
Effluent FSA-N	N _{ae}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	N _{ne} = N _c	36.96 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	1.19 mgTKN-N/l
(calculated N _{ae})	(N _{ae})	0.293 mgFSA-N/l
Effluent FSA-N	N _{ae}	0.293 mgFSA-N/l
Nitrifier sludge mass	MX _{BA}	692.7 kgVSS

Denitrification	K ₁₍₂₀₎	0.72 mgFSA/l
Half Saturation Coefficient	Θ	1.2
	K _{1T}	1.4930 mgFSA/l
	K ₂₍₂₀₎	0.101 mgFSA/l
Denitrification	Θ	1.08
Half Saturation Coefficient	K _{2T}	0.1374 mgFSA/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O _s	1.0 mgO/l
a-recycle DO concentration	O _a	2.0 mgO/l

Max unaerated sludge mass fraction	f _{xm}	0.834
Anoxic sludge mass fraction	f _{x1}	0.148
Min anoxic sludge mass fraction	f _{x1min}	0.007

Influent RBCOD fraction (Sbsi/Sbi)	f _{sb's}	0.135

Denitrification potential BSO (K1)	D _{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D _{pBPO}	15.93 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D _{p1}	24.67 mgNO ₃ -N/l influent

	A	0.6993
	B	14.0322
	C	11.691
Optimal a-recycle ratio	a _{opt}	0.80
Maximum practical a-recycle ratio	a _{max}	6
chosen a-recycle ratio	a	0.00
recycle limited		

Effluent Nitrate if recycle limited		18.48 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		12.63 mgNO ₃ -N/l
Actual Effluent Nitrate	N _{ne}	18.48 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	N _{ne} + N _{te}	19.67 mgN/l
N removal		59.2%

Volume of Primary Anoxic Tank	V _{anox}	1828 m ³
Volume of Aerobic Tank	V _{aer}	10492 m ³

Carbonaceous Oxygen flux	FO _c	7712 kgO/d
Nitrogenous Oxygen flux	FO _N	3003 kgO/d
Oxygen dmnd recover by denitrification	FO _D	940 kgO/d
Total Oxygen Demand (FO _c + FO _N - FO _D)	FO _T	9775 kgO/d
Oxygen utilisation rate	O _T	38.8 mgO/l.h

Alkalinity consumed by nitrification		264 mg CaCO ₃
Alkalinity recovered by denitrification		66 mg CaCO ₃
Total Alkalinity consumption		198 mg CaCO ₃

MLE Reactor @ 20 Days SRT

COD mass balance	
COD in (influent)	11003 kgCOD/d
COD out	11003 kgCOD/d
$Q_e S_{Te} + Q_w S_{Te}$	645 kgCOD/d
$Q_w X_v f_{cv}$	2817 kgCOD/d
$V_p O_c$	7541 kgO/d

COD mass balance	
COD in (influent)	11003 kgCOD/d
COD out	11003 kgCOD/d
$Q_e S_{Te} + Q_w S_{Te}$	645.3 kgCOD/d
$Q_w X_v f_{cv}$	2645.8 kgCOD/d
$V_p O_c$	7711.9 kgO/d

MLE Reactor @ 20 Days SRT

N mass balance	
N in (influent)	856.9 kgTKN-N/d
N out	856.9 kgTKN-N/d
$Q_u N_{te} + Q_w N_{te}$	22.2 kgTKN-N/d
$Q N_s$	190.2 kgTKN-N/d
$Q N_{ne}$	644.5 kgNO3-N/d

TOD balance	
TOD in (influent)	14919 kgTOD/d
TOD out	14919 kgTOD/d
$TOD_{effluent}$	721 kgTOD/d
TOD_{waste}	3712 kgTOD/d
TOD_{N_2-gas}	922 kgTOD/d
FO_t	9564 kgTOD/d

Flux of P in waste VSS	FP_s	48 kgP/d
Equiv conc in influent	P_s	2.67 mgP/l
Effluent Sol Unbiod Org P	P_{ouse}	0.60 mgP/l
Effluent TP	P_{te}	12.83 mgP/l
Effluent Ortho-P as P	P_{oe}	12.23 mgOP-P/l

N mass balance	
N in (influent)	856.9 kgTKN-N/d
N out	856.9 kgTKN-N/d
$Q_u N_{te} + Q_w N_{te}$	21.2 kgTKN-N/d
$Q N_s$	178.6 kgTKN-N/d
$Q N_{ne}$	657.0 kgNO3-N/d

TOD balance	
TOD in (influent)	14919 kgTOD/d
TOD out	14919 kgTOD/d
$TOD_{effluent}$	717 kgTOD/d
TOD_{waste}	3488 kgTOD/d
TOD_{N_2-gas}	940 kgTOD/d
FO_t	9775 kgTOD/d

Flux of P in waste VSS	FP_s	45 kgP/d
Equiv conc in influent	P_s	2.51 mgP/l
Effluent Sol Unbiod Org P	P_{ouse}	0.00 mgP/l
Effluent TP	P_{te}	12.99 mgP/l
Effluent Ortho-P as P	P_{oe}	12.99 mgOP-P/l

Effluent Concentrations			General	Special	Unit	Effluent Concentrations			General	Special	Unit
Unbiod Sol COD	S_{use}	36.30	<75	<30	mgCOD	Unbiod Sol COD	S_{use}	36.30	<75	<30	mgCOD/l
Undiod Sol Org N	N_{ouse}	0.90	-	-	mgN/l	Undiod Sol Org N	N_{ouse}	0.90	-	-	mgN/l
FSA-N	N_{ae}	0.35	<6	<2	mgFSA	FSA-N	N_{ae}	0.29	<6	<2	mgFSA-N/l
TKN-N	N_{te}	1.25	-	-	mgTKN	TKN-N	N_{te}	1.19	-	-	mgTKN-N/l
Nitrate	N_{ne}	18.13	<15	<1.5	mgNO ₃	Nitrate	N_{ne}	18.48	<15	<1.5	mgNO ₃ -N/l
Undiod Sol Org P	P_{ouse}	0.60	-	-	mgP/l	Undiod Sol Org P	P_{ouse}	0.00	-	-	mgP/l
Ortho P as P	P_{oe}	12.23	<10	<2.5	mgOP-P	Ortho P as P	P_{oe}	12.99	<10	<2.5	mgOP-P/l
TP	P_{te}	12.83	-	-	mgP/l	TP	P_{te}	12.99	-	-	mgP/l

MLE Reactor @ 25 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	17.8 MI/d
Sludge Age	SRT	25.0 days
Reactor TSS concentration	X _r	5697 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti 619	11003
BPO COD	Sbpi 479	8514
UPO COD	Supi 29	510
	fs'up 0.0464	
VFA COD	Sbsi,a 0.0	0
FBSO COD	Sbsfi 75	1333
BSO COD	Sbsi 75	1333
USO COD	Susi 36.3	645
	fs'us 0.0587	
BO COD	Sbi 554	9847
UO COD	Sui 65	1156
TSS	241	4280
ISS	51.4	914
VSS	189	3366
UPO VSS	19.4	345
BPO VSS	170	3021
TKN	Nti 48.2	857
Org N	Noi 13.8	245
FSA	Nai 34.4	612
BSO	Nobsi 2.90	52
USO	Nousi 0.90	16
BPO	Nobpi 8.70	155
UPO	Noupi 1.30	23
Total P	Pti 15.50	276
OP	Pai 12.80	228
Org P	Poi 2.70	48
BSO	Pobsi 0.70	12
USO	Pousi 0.60	11
BPO	Pobpi 0.78	14
UPO	Poupi 0.62	11

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,upo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,upo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,upo}	0.518 mgC/mgVSS

Temperature dependant coefficients

	T	16 °C
	b _{H20}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2141 /d
	μ _{Am20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.2829 /d
	b _{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0357 /d
	K _{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K _{HT}	0.6288 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	17441 kgVSS
Endogenous Residue VSS	MX _{EH}	18668 kgVSS
Unbiodegradeable Organic VSS	MX _{iv}	8619 kgVSS
Total VSS	MX _v	44727 kgVSS
ISS from influent		22848 kgISS
ISS of OHO's		2616 kgISS
ISS	MX _{IOI}	25465 kgISS
TSS	MX _t	70192 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{hn}	16.6 hr

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	17.8 MI/d
Sludge Age	SRT	25.0 days
Reactor TSS concentration	X _T	5458 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti 618.9	11003
BPO COD	Sbpi 479	8514
UPO COD	Supi 29	510
	fs'up 0.04637	
VFA COD	Sbsi,a 0	0
FBSO COD	Sbsfi 75	1333
BSO COD	Sbsi 75	1333
USO COD	Susi 36.3	645
	fs'us 0.05865	
BO COD	Sbi 554	9847
UO COD	Sui 65	1156
TSS	240.72727	4280
ISS	51.4	914
VSS	189.31818	3366
UPO VSS	19.39	345
BPO VSS	170	3021
TKN	Nti 48.2	857
Org N	Noi 13.8	245
FSA	Nai 34.4	612
BSO	Nobsi 2.90	51.6
USO	Nousi 0.90	16.0
BPO	Nobpi 8.70	155
UPO	Noupi 1.30	23
Total P	Pti 15.5	276
OP	Pai 12.8	228
Org P	Poi 2.7	48.0
BSO	Pobsi 0.7	12.4
USO	Pousi 0.6	11
BPO	Pobpi 0.78	14
UPO	Poupi 0.62	11.03

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,upo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,upo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,upo}	0.518 mgC/mgVSS

Temperature dependant coefficients

	T	24 °C
	b _{H20}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2691 /d
	μ _{Am20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.7157 /d
	b _{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0448 /d
	K _{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K _{HT}	1.5904 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	14337 kgVSS
Endogenous Residue VSS	MX _{EH}	19289 kgVSS
Unbiodegradeable Organic VSS	MX _{iv}	8619 kgVSS
Total VSS	MX _v	42244 kgVSS
ISS from influent		22848 kgISS
ISS of OHO's		2151 kgISS
ISS	MX _{IOI}	24999 kgISS
TSS	MX _t	67243 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{hn}	16.6 hr

MLE Reactor @ 25 Days SRT

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	1416 mgVSS/l
Endogenous Residue VSS	X_{EH}	1515 mgVSS/l
Unbiodegradable Organic VSS	X_I	700 mgVSS/l
Total VSS	X_V	3630 mgVSS/l
Influent Biodegradable ISS	X_{IOI}	2067 mgISS/l
TSS	X_t	5697 mgTSS/l

Active fraction of VSS	f_{av}	0.390 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.248 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.637 kgVSS/kgTSS

Waste Flow Rate	Q_w	493 m ³ /d
TSS wasted per day		2808 kgTSS/d
VSS wasted per day		1789 kgVSS/d

Flux of N in waste VSS	FN_s	179 kgN/d
Equiv conc in influent	N_s	10.06 mgN/l influent
Effluent Sol Unbiodegradable N	N_{ouse}	0.90 mgN/l

Factor of safety reducing $\mu_{A_{mT}}$	Sf	1.25
total unaerated mass fraction	fxt	0.148
Minimum sludge age for nitrification	SRT_m	4.87 days
SRT_m with Safety factor	$SRT_{m(SF)}$	6.09 Nitrifies!

If no nitrification		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	38.1 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	37.2 mgFSA-N/l

If complete nitrification		
Effluent NO ₃	N_{ne}	37.2 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ae}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	36.95 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	1.19 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.288 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.288 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	868.0 kgVSS

Denitrification	$K_{1(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	θ	1.2
	K_{1T}	0.3472 mgFSA/l
Denitrification	$K_{2(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	θ	1.08
	K_{2T}	0.0742 mgFSA/l

s-recycle ratio	s	1.00 : 1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.666
Anoxic sludge mass fraction	f_{x1}	0.148 set = f_{xm} for balanced MLE
Min anoxic sludge mass fraction	f_{x1min}	0.026

Influent RBCOD fraction (Sbsi/Sbi)	$f_{sb's}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	10.81 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	19.55 mgNO ₃ -N/l influent

	A	0.6993
	B	19.1432
	C	1.459
Optimal a-recycle ratio	a_{opt}	0.08
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00 set = a_{opt} for balanced MLE
recycle limited		

Effluent Nitrate if recycle limited		18.47 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		17.74 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	18.47 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{te}$	19.66 mgN/l
N removal		59.2%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Carbonaceous Oxygen flux	FO_c	7708 kgO/d
Nitrogenous Oxygen flux	FO_N	3002 kgO/d
Oxygen demand recover by denitrification	FO_D	939 kgO/d
Total Oxygen Demand ($FO_c + FO_N - FO_D$)	FO_T	9771 kgO/d
Oxygen utilisation rate	O_T	38.8 mgO/l.h

Alkalinity consumed by nitrification		264 mg CaCO ₃
Alkalinity recovered by denitrification		66 mg CaCO ₃
Total Alkalinity consumption		198 mg CaCO ₃

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	1164 mgVSS/l
Endogenous Residue VSS	X_{EH}	1566 mgVSS/l
Unbiodegradable Organic VSS	X_I	700 mgVSS/l
Total VSS	X_V	3429 mgVSS/l
Influent Biodegradable ISS	X_{IOI}	2029 mgISS/l
TSS	X_t	5458 mgTSS/l

Active fraction of VSS	f_{av}	0.339 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.213 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.628 kgVSS/kgTSS

Waste Flow Rate	Q_w	493 m ³ /d
TSS wasted per day		2690 kgTSS/d
VSS wasted per day		1690 kgVSS/d

Flux of N in waste VSS	FN_s	169 kgN/d
Equiv conc in influent	N_s	9.50 mgN/l influent
Effluent Sol Unbiodegradable N	N_{ouse}	0.90 mgN/l

Factor of safety reducing $\mu_{A_{mT}}$	Sf	1.25
total unaerated mass fraction	fxt	0.148
Minimum sludge age for nitrification	SRT_m	1.77 days
SRT_m with Safety factor	$SRT_{m(SF)}$	2.21 Nitrifies!

If no nitrification		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	38.7 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	37.8 mgFSA-N/l

If complete nitrification		
Effluent NO ₃	N_{ne}	37.8 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ae}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	37.54 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	1.16 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.257 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.257 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	786.5 kgVSS

Denitrification	$K_{1(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	θ	1.2
	K_{1T}	1.4930 mgFSA/l
Denitrification	$K_{2(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	θ	1.08
	K_{2T}	0.1374 mgFSA/l

s-recycle ratio	s	1.0 : 1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.852
Anoxic sludge mass fraction	f_{x1}	0.148
Min anoxic sludge mass fraction	f_{x1min}	0.007

Influent RBCOD fraction (Sbsi/Sbi)	$f_{sb's}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	16.44 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	25.19 mgNO ₃ -N/l influent

	A	0.6993
	B	14.0969
	C	12.141
Optimal a-recycle ratio	a_{opt}	0.83
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00
recycle limited		

Effluent Nitrate if recycle limited		18.77 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		12.70 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	18.77 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{te}$	19.93 mgN/l
N removal		58.7%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Carbonaceous Oxygen flux	FO_c	7855 kgO/d
Nitrogenous Oxygen flux	FO_N	3050 kgO/d
Oxygen demand recover by denitrification	FO_D	954 kgO/d
Total Oxygen Demand ($FO_c + FO_N - FO_D$)	FO_T	9951 kgO/d
Oxygen utilisation rate	O_T	39.5 mgO/l.h

Alkalinity consumed by nitrification		268 mg CaCO ₃
Alkalinity recovered by denitrification		67 mg CaCO ₃
Total Alkalinity consumption		201 mg CaCO ₃

MLE Reactor @ 25 Days SRT

COD mass balance	
COD in (influent)	11002.7 kgCOD/d
COD out	11003.0 kgCOD/d
$Q_e S_{Te} + Q_w S_{Te}$	645.3 kgCOD/d
$Q_w X_v f_{cv}$	2649.7 kgCOD/d
$V_p O_c$	7708.0 kgO/d

COD mass balance	
COD in (influent)	11002.7 kgCOD/d
COD out	11003.0 kgCOD/d
$Q_e S_{Te} + Q_w S_{Te}$	645.3 kgCOD/d
$Q_w X_v f_{cv}$	2502.5 kgCOD/d
$V_p O_c$	7855.1 kgO/d

MLE Reactor @ 25 Days SRT

N mass balance		
N in (influent)		856.9 kgTKN-N/d
N out		856.9 kgTKN-N/d
$Q_e N_{te} + Q_w N_{te}$		21.1 kgTKN-N/d
$Q N_s$		178.9 kgTKN-N/d
$Q N_{ne}$		656.9 kgNO3-N/d

TOD balance		
TOD in (influent)		14918.65 kgTOD/d
TOD out		14918.99 kgTOD/d
$TOD_{effluent}$		721.28 kgTOD/d
TOD_{waste}		3487.84 kgTOD/d
TOD_{N_2-gas}		939.31 kgTOD/d
FO_t		9770.57 kgTOD/d

Flux of P in waste VSS	FP_s	45 kgP/d
Equiv conc in influent	P_s	2.52 mgP/l
Effluent Sol Unbiod Org P	P_{ouse}	0.60 mgP/l
Effluent TP	P_{te}	12.98 mgP/l
Effluent Ortho-P as P	P_{oe}	12.38 mgOP-P/l

N mass balance		
N in (influent)		856.9 kgTKN-N/d
N out		856.9 kgTKN-N/d
$Q_e N_{te} + Q_w N_{te}$		20.6 kgTKN-N/d
$Q N_s$		169.0 kgTKN-N/d
$Q N_{ne}$		667.3 kgNO3-N/d

TOD balance		
TOD in (influent)		14918.65 kgTOD/d
TOD out		14918.99 kgTOD/d
$TOD_{effluent}$		718.85 kgTOD/d
TOD_{waste}		3295.27 kgTOD/d
TOD_{N_2-gas}		954.30 kgTOD/d
FO_t		9950.58 kgTOD/d

Flux of P in waste VSS	FP_s	42 kgP/d
Equiv conc in influent	P_s	2.38 mgP/l
Effluent Sol Unbiod Org P	P_{ouse}	0.00 mgP/l
Effluent TP	P_{te}	13.12 mgP/l
Effluent Ortho-P as P	P_{oe}	13.12 mgOP-P/l

Effluent Concentrations			General	Special	Unit	Effluent Concentrations			General	Special	Unit
Unbiod Sol COD	S_{use}	36.30	<75	<30	mgCOD	Unbiod Sol COD	S_{use}	36.30	<75	<30	mgCOD/l
Undiod Sol Org N	N_{ouse}	0.90	-	-	mgN/l	Undiod Sol Org N	N_{ouse}	0.90	-	-	mgN/l
FSA-N	N_{ae}	0.29	<6	<2	mgFSA	FSA-N	N_{ae}	0.26	<6	<2	mgFSA-N/l
TKN-N	N_{te}	1.19	-	-	mgTKN	TKN-N	N_{te}	1.16	-	-	mgTKN-N/l
Nitrate	N_{ne}	18.47	<15	<1.5	mgNO ₃	Nitrate	N_{ne}	18.77	<15	<1.5	mgNO ₃ -N/l
Undiod Sol Org P	P_{ouse}	0.60	-	-	mgP/l	Undiod Sol Org P	P_{ouse}	0.00	-	-	mgP/l
Ortho P as P	P_{oe}	12.38	<10	<2.5	mgOP-P	Ortho P as P	P_{oe}	13.12	<10	<2.5	mgOP-P/l
TP	P_{te}	12.98	-	-	mgP/l	TP	P_{te}	13.12	-	-	mgP/l

MLE Reactor @ 30 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	17.8 Ml/d
Sludge Age	SRT	30.0 days
Reactor TSS concentration	X _r	6604 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	619	11003
BPO COD	Sbpi	479	8514
UPO COD	Supi	29	510
	fs'up		0.0464
VFA COD	Sbsi,a	0.0	0
FBSO COD	Sbsfi	75	1333
BSO COD	Sbsi	75	1333
USO COD	Susi	36.3	645
	fs'us		0.0587
BO COD	Sbi	554	9847
UO COD	Sui	65	1156
TSS		241	4280
ISS		51.4	914
VSS		189	3366
UPO VSS		19.4	345
BPO VSS		170	3021
TKN	Nti	48.2	857
Org N	Noi	13.8	245
FSA	Nai	34.4	612
BSO	Nobsi	2.90	52
USO	Nousi	0.90	16
BPO	Nobpi	8.70	155
UPO	Noupi	1.30	23
Total P	Pti	15.50	276
OP	Pai	12.80	228
Org P	Poi	2.70	48
BSO	Pobsi	0.70	12
USO	Pousi	0.60	11
BPO	Pobpi	0.78	14
UPO	Poupi	0.62	11

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,upo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,upo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,upo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{i20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2141 /d
	μ _{am20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{amT}	0.2829 /d
	b _{a20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0357 /d
Nitrification	K _{i20}	1.0 mgFSA/l
	θ	1.123
Half Saturation Coefficient	K _{NT}	0.6288 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	17911 kgVSS
Endogenous Residue VSS	MX _{EH}	23005 kgVSS
Unbiodegradeable Organic VSS	MX _{Nv}	10342 kgVSS
Total VSS	MX _V	51258 kgVSS
ISS from influent		27418 kgISS
ISS of OHO's		2687 kgISS
ISS	MX _{IOI}	30105 kgISS
TSS	MX _T	81363 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{nh}	16.6 hr

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	17.8 Ml/d
Sludge Age	SRT	30.0 days
Reactor TSS concentration	X _T	6353 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	618.9	11003
BPO COD	Sbpi	479	8514
UPO COD	Supi	29	510
	fs'up		0.04637
VFA COD	Sbsi,a	0	0
FBSO COD	Sbsfi	75	1333
BSO COD	Sbsi	75	1333
USO COD	Susi	36.3	645
	fs'us		0.05865
BO COD	Sbi	554	9847
UO COD	Sui	65	1156
TSS		240.72727	4280
ISS		51.4	914
VSS		189.31818	3366
UPO VSS		19.39	345
BPO VSS		170	3021
TKN	Nti	48.2	857
Org N	Noi	13.8	245
FSA	Nai	34.4	612
BSO	Nobsi	2.90	51.6
USO	Nousi	0.90	16.0
BPO	Nobpi	8.70	155
UPO	Noupi	1.30	23
Total P	Pti	15.5	276
OP	Pai	12.8	228
Org P	Poi	2.7	48.0
BSO	Pobsi	0.7	12.4
USO	Pousi		
BPO	Pobpi	0.78	14
UPO	Poupi	0.62	11.03

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,upo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,upo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,upo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{i20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2691 /d
	μ _{am20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{amT}	0.7157 /d
	b _{a20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0448 /d
Nitrification	K _{i20}	1.0 mgFSA/l
	θ	1.123
Half Saturation Coefficient	K _{NT}	1.5904 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	14653 kgVSS
Endogenous Residue VSS	MX _{EH}	23657 kgVSS
Unbiodegradeable Organic VSS	MX _{Nv}	10342 kgVSS
Total VSS	MX _V	48652 kgVSS
ISS from influent		27418 kgISS
ISS of OHO's		2198 kgISS
ISS	MX _{IOI}	29616 kgISS
TSS	MX _T	78268 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{nh}	16.6 hr

MLE Reactor @ 30 Days SRT

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	1454 mgVSS/l
Endogenous Residue VSS	X_{EH}	1867 mgVSS/l
Unbiodegradable Organic VSS	X_i	839 mgVSS/l
Total VSS	X_V	4161 mgVSS/l
Influent Biodegradable ISS	X_{i0i}	2444 mgISS/l
TSS	X_t	6604 mgTSS/l

Active fraction of VSS	f_{av}	0.349 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.220 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.630 kgVSS/kgTSS

Waste Flow Rate	Q_w	411 m ³ /d
TSS wasted per day		2712 kgTSS/d
VSS wasted per day		1709 kgVSS/d

Flux of N in waste VSS	FN_b	171 kgN/d
Equiv conc in influent	N_i	9.61 mgN/l influent
Effluent Sol Unbiol Org N	N_{ouse}	0.90 mgN/l

Factor of safety reducing μ_{aerT}	Sf	1.25
total unaerated mass fraction	fxt	0.148
Minimum sludge age for nitrification	SRT _m	4.87 days
SRT _m with Safety factor	SRT _{m (SF)}	6.09 Nitrifies!

<u>If no nitrification</u>		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{ie}	38.6 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	37.7 mgFSA-N/l

<u>If complete nitrification</u>		
Effluent NO ₃	N_{ne}	37.7 mgNO ₃ -N/l
Effluent TKN-N	N_{ie}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ae}	0.0 mgFSA-N/l

<u>Nitrification Results</u>		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	37.44 mgNO ₃ -N/l
Effluent TKN-N	N_{ie}	1.15 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.252 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.252 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	964.4 kgVSS

Denitrification	$K_{1(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	Θ	1.2
Denitrification	$K_{2(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	Θ	1.08
Denitrification	K_{1T}	0.3472 mgFSA/l
Half Saturation Coefficient	K_{2T}	0.0742 mgFSA/l

s-recycle ratio	s	1.00 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{um}	0.695
Anoxic sludge mass fraction	f_{x1}	0.149 set = f_{xm} for balanced MLE
Min anoxic sludge mass fraction	f_{x1min}	0.025

Influent RBCOD fraction (Sbsi/Sbi)	$f_{sb/s}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	11.10 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	19.84 mgNO ₃ -N/l influent

A	0.6993	
B	19.3403	
C	1.553	
Optimal a-recycle ratio	a_{opt}	0.08
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00 set = a_{opt} for balanced MLE
recycle limited		

Effluent Nitrate if recycle limited		18.72 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		17.94 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	18.72 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{ie}$	19.87 mgN/l
N removal		58.8%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Carbonaceous Oxygen flux	FO_c	7827 kgO/d
Nitrogenous Oxygen flux	FO_n	3042 kgO/d
Oxygen dmnd recover by denitrification	FO_D	952 kgO/d
Total Oxygen Demand ($FO_c + FO_n - FO_D$)	FO_T	9917 kgO/d
Oxygen utilisation rate	O_T	39.4 mgO/l.h

Alkalinity consumed by nitrification		267 mg CaCO ₃
Alkalinity recovered by denitrification		67 mg CaCO ₃
Total Alkalinity consumption		200 mg CaCO ₃

COD mass balance		
COD in (influent)		11002.7 kgCOD/d
COD out		11003.0 kgCOD/d

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	1189 mgVSS/l
Endogenous Residue VSS	X_{EH}	1920 mgVSS/l
Unbiodegradable Organic VSS	X_i	839 mgVSS/l
Total VSS	X_V	3949 mgVSS/l
Influent Biodegradable ISS	X_{i0i}	2404 mgISS/l
TSS	X_t	6353 mgTSS/l

Active fraction of VSS	f_{av}	0.301 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.187 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.622 kgVSS/kgTSS

Waste Flow Rate	Q_w	411 m ³ /d
TSS wasted per day		2609 kgTSS/d
VSS wasted per day		1622 kgVSS/d

Flux of N in waste VSS	FN_b	162 kgN/d
Equiv conc in influent	N_i	9.12 mgN/l influent
Effluent Sol Unbiol Org N	N_{ouse}	0.90 mgN/l

Factor of safety reducing μ_{aerT}	Sf	1.25
total unaerated mass fraction	fxt	0.148
Minimum sludge age for nitrification	SRT _m	1.77 days
SRT _m with Safety factor	SRT _{m (SF)}	2.21 Nitrifies!

<u>If no nitrification</u>		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{ie}	39.1 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	38.2 mgFSA-N/l

<u>If complete nitrification</u>		
Effluent NO ₃	N_{ne}	38.2 mgNO ₃ -N/l
Effluent TKN-N	N_{ie}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ae}	0.0 mgFSA-N/l

<u>Nitrification Results</u>		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	37.94 mgNO ₃ -N/l
Effluent TKN-N	N_{ie}	1.13 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.234 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.234 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	862.8 kgVSS

Denitrification	$K_{1(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	Θ	1.2
Denitrification	$K_{2(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	Θ	1.08
Denitrification	K_{1T}	1.4930 mgFSA/l
Half Saturation Coefficient	K_{2T}	0.1374 mgFSA/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{um}	0.863
Anoxic sludge mass fraction	f_{x1}	0.148
Min anoxic sludge mass fraction	f_{x1min}	0.007

Influent RBCOD fraction (Sbsi/Sbi)	$f_{sb/s}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	16.80 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	25.55 mgNO ₃ -N/l influent

A	0.6993	
B	14.1403	
C	12.460	
Optimal a-recycle ratio	a_{opt}	0.85
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00
recycle limited		

Effluent Nitrate if recycle limited		18.97 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		12.74 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	18.97 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{ie}$	20.11 mgN/l
N removal		58.3%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Carbonaceous Oxygen flux	FO_c	7956 kgO/d
Nitrogenous Oxygen flux	FO_n	3083 kgO/d
Oxygen dmnd recover by denitrification	FO_D	965 kgO/d
Total Oxygen Demand ($FO_c + FO_n - FO_D$)	FO_T	10074 kgO/d
Oxygen utilisation rate	O_T	40.0 mgO/l.h

Alkalinity consumed by nitrification		271 mg CaCO ₃
Alkalinity recovered by denitrification		68 mg CaCO ₃
Total Alkalinity consumption		203 mg CaCO ₃

COD mass balance		
COD in (influent)		11002.7 kgCOD/d
COD out		11003.0 kgCOD/d

MLE Reactor @ 30 Days SRT

$Q_a S_{1e} + Q_w S_{1e}$	645.3 kgCOD/d
$Q_w X_v f_{cv}$	2530.5 kgCOD/d
$V_P O_c$	7827.2 kgO/d

$Q_a S_{1e} + Q_w S_{1e}$	645.3 kgCOD/d
$Q_w X_v f_{cv}$	2401.8 kgCOD/d
$V_P O_c$	7955.9 kgO/d

MLE Reactor @ 30 Days SRT

N mass balance	
N in (influent)	856.9 kgTKN-N/d
N out	856.9 kgTKN-N/d
$Q_e N_{te} + Q_w N_{te}$	20.5 kgTKN-N/d
$Q_e N_s$	170.9 kgTKN-N/d
$Q_e N_{ne}$	665.5 kgNO3-N/d

TOD balance	
TOD in (influent)	14918.65 kgTOD/d
TOD out	14918.99 kgTOD/d
$TOD_{effluent}$	721.89 kgTOD/d
TOD_{waste}	3328.36 kgTOD/d
TOD_{N2-gas}	951.72 kgTOD/d
FO_i	9917.02 kgTOD/d

Flux of P in waste VSS	FP_s	43 kgP/d
Equiv conc in influent	P_s	2.40 mgP/l
Effluent Sol Unbiod Org P	P_{ouse}	0.60 mgP/l
Effluent TP	P_{te}	13.10 mgP/l
Effluent Ortho-P as P	P_{oe}	12.50 mgOP-P/l

N mass balance	
N in (influent)	856.9 kgTKN-N/d
N out	856.9 kgTKN-N/d
$Q_e N_{te} + Q_w N_{te}$	20.2 kgTKN-N/d
$Q_e N_s$	162.2 kgTKN-N/d
$Q_e N_{ne}$	674.6 kgNO3-N/d

TOD balance	
TOD in (influent)	14918.65 kgTOD/d
TOD out	14918.99 kgTOD/d
$TOD_{effluent}$	720.43 kgTOD/d
TOD_{waste}	3159.95 kgTOD/d
TOD_{N2-gas}	964.61 kgTOD/d
FO_i	10074.00 kgTOD/d

Flux of P in waste VSS	FP_s	41 kgP/d
Equiv conc in influent	P_s	2.28 mgP/l
Effluent Sol Unbiod Org P	P_{ouse}	0.00 mgP/l
Effluent TP	P_{te}	13.22 mgP/l
Effluent Ortho-P as P	P_{oe}	13.22 mgOP-P/l

Effluent Concentrations			General	Special	Unit	Effluent Concentrations			General	Special	Unit
Unbiod Sol COD	S_{use}	36.30	<75	<30	mgCOD/l	Unbiod Sol COD	S_{use}	36.30	<75	<30	mgCOD/l
Undiod Sol Org N	N_{ouse}	0.90	-	-	mgN/l	Undiod Sol Org N	N_{ouse}	0.90	-	-	mgN/l
FSA-N	N_{ne}	0.25	<6	<2	mgFSA-N/l	FSA-N	N_{ne}	0.23	<6	<2	mgFSA-N/l
TKN-N	N_{te}	1.15	-	-	mgTKN-N/l	TKN-N	N_{te}	1.13	-	-	mgTKN-N/l
Nitrate	N_{ne}	18.72	<15	<1.5	mgNO ₃ -N/l	Nitrate	N_{ne}	18.97	<15	<1.5	mgNO ₃ -N/l
Undiod Sol Org P	P_{ouse}	0.60	-	-	mgP/l	Undiod Sol Org P	P_{ouse}	0.00	-	-	mgP/l
Ortho P as P	P_{oe}	12.50	<10	<2.5	mgOP-P/l	Ortho P as P	P_{oe}	13.22	<10	<2.5	mgOP-P/l
TP	P_{te}	13.10	-	-	mgP/l	TP	P_{te}	13.22	-	-	mgP/l

UCT Reactor @ 10 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	22.22 Ml/d
Sludge Age	SRT	10.0 days
Reactor TSS concentration	X _T	4185.54 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti	619
BPO COD	Sbpi	479
UPO COD	Supi	29
	fS'up	0.046
VFA COD	Sbsi,a	0.0
FBSD COD	Sbsfi	75
BSO COD	Sbsi	75
USO COD	Susi	36.3
	fS'us	0.059
BO COD	Sbi	554
UO COD	Sui	65
TSS		241
ISS		51.4
VSS		189
UPO VSS		19.4
BPO VSS		170
TKN	Nti	48.2
Org N	Noi	13.8
FSA	Nai	34.4
BSO	Nobsi	2.90
USO	Nousi	0.90
BPO	Nobpi	8.70
UPO	Noupi	1.30
Total P	Pti	15.50
OP	Pai	12.80
Org P	Poi	2.70
BSO	Pobsi	0.70
USO	Pousi	0.60
BPO	Pobpi	0.78
UPO	Poupi	0.62

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _{oh}	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{ohv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{coHO}	0.15
Yield coefficient of ANO's	Y _a	0.10 mgVSS/mgFSA
COD per mass fraction of FBSD	f _{cm,bsd}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,uipo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,uipo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,uipo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{hT}	0.2141 /d
	μ _{h,20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{ant}	0.2829 /d
	b _{h20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{at}	0.0357 /d
	K _{s,20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{sT}	0.6288 mgFSA/l
	K _{s(20)}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{sT}	0.3472
	K _{s(20)}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{sT}	0.0742
	K ⁺ _{s(20)}	0.255
Denitrification	θ	1.08
primary anoxic of NDBPER system	K ⁺ _{sT}	0.1874

Factor of safety reducing μ _{ant}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _m	6.76 days
SRT _m (with safety factor)	SRT _m	8.45 Nitrifies!

Max unaerated sludge mass fraction	f _{un}	0.40
Total unaerated sludge mass fraction	f _{de}	0.35
Anoxic mass fraction primary anox 2	f _{z,prim anox 2}	0.27
Anaerobic mass fraction	f _{anaer}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments 2

r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N _{nr}	3.9 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{o2,s}	0.0 mgO/l

influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	1.000 :1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)	f _{SD,s}	0.135

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	22.22 Ml/d
Sludge Age	SRT	10.0 days
Reactor TSS concentration	X _T	3959 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti	619
BPO COD	Sbpi	479
UPO COD	Supi	29
	fS'up	0.046
VFA COD	Sbsi,a	0
FBSD COD	Sbsfi	75
BSO COD	Sbsi	75
USO COD	Susi	36
	fS'us	0.059
BO COD	Sbi	554
UO COD	Sui	65
TSS		241
ISS		51
VSS		189
UPO VSS		19
BPO VSS		170
TKN	Nti	48
Org N	Noi	14
FSA	Nai	34
BSO	Nobsi	2.90
USO	Nousi	0.90
BPO	Nobpi	8.70
UPO	Noupi	1.30
Total P	Pti	15.50
OP	Pai	12.80
Org P	Poi	2.70
BSO	Pobsi	0.70
USO	Pousi	0.60
BPO	Pobpi	0.78
UPO	Poupi	0.62

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _{oh}	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{ohv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{coHO}	0.15
Yield coefficient of ANO's	Y _a	0.1 mgVSS/mgFSA
COD per mass fraction of FBSD	f _{cm,bsd}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,uipo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,uipo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,uipo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate OHO	b _{hT}	0.2691 /d
	μ _{h,20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{ant}	0.7157 /d
	b _{h20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{at}	0.0448 /d
	K _{s,20}	1.0
Nitrification	θ	1.123
Half Saturation Coefficient	K _{sT}	1.5904
	K _{s(20)}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{sT}	1.4930
	K _{s(20)}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{sT}	0.1374
	K ⁺ _{s(20)}	0.255
Denitrification	θ	1.08
primary anoxic of NDBPER system	K ⁺ _{sT}	0.3469

Factor of safety reducing μ _{ant}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _m	2.38 days
SRT _m (with safety factor)	SRT _m	2.98 Nitrifies!

Max unaerated sludge mass fraction	f _{un}	0.75
Total unaerated sludge mass fraction	f _{de}	0.35
Anoxic mass fraction primary anox 2	f _{z,prim anox 2}	0.27
Anaerobic mass fraction	f _{anaer}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments 2

r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N _{nr}	3.9 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{o2,s}	0.0 mgO/l

influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)	f _{SD,s}	0.135

UCT Reactor @ 10 Days SRT

Influent TKN	N_0	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_L	305 kgN/d
Equiv conc in influent	N_i	13.72 mgN/l
Effluent Sol Unbiode Org N	N_{unb}	0.90 mgN/l
Effluent ammonia	N_{NH}	1.78 mgFSA-N/l
TKN in effluent	N_{eff}	2.68 mgTKN-N/l
Nitrification capacity	N_c	31.79 mgN/l influent

Denitrification potential BSO (K1)	D_{BBSO}	1.5 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BBSO}	38.11 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{d1}	39.57 mgNO ₂ -N/l influent

	A	0.6993
	B	-6.0320
	C	46.654
Optimal a-recycle ratio	a_{opt}	13.55
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00
	set = a_{opt} for balanced UCT	
	recycle limited	

Effluent Nitrate if recycle limited		3.97 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-3.23 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{NH}	3.97 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₂)	$N_{NH} + N_{NH}$	6.66 mgN/l
N removal		86.2%

Alkalinity consumed by nitrification		227 mg CaCO ₃
Alkalinity recovered by denitrification		99 mg CaCO ₃
Total Alkalinity consumption		128 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{BVL,A}$	0 mgCOD/l
FBSO COD	S_{BVL}	75 mgCOD/l
BSO COD	S_{BVL}	75 mgCOD/l
BO COD	S_{BVL}	554 mgCOD/l

S_{F1} reduction due to O ₂ & NO ₃		33.54 mgCOD/l
Reduced FBSO concentration	$S_{F1,COMP}$	41.46 mgCOD/l

	k_{F120}	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	k_{F1T}	0.0535 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

Trial 1	S_{BVLN}	0.00	MX_{BVL}/Q_L	734	S_{BVLN}	6.42
Trial 2		6.42		753		6.28
Trial 3		6.28		752		6.29
Trial 4		6.29		752		6.29

Flux BO COD obtained by OHO's	95%	11667 kgCOD/d
Flux BO COD obtained by PAO's	5%	642 kgCOD/d
Check total BO COD		12309 kgCOD/d

correct
12309

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{d20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{dT}	0.0357 /d

Activated Sludge Masses

<u>OHO VSS</u>		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	16717 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	7157 kgVSS
<u>PAO VSS</u>		
Polyphosphate Acc Organisms VSS	MX_{PAO}	2129 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	190 kgVSS
Unbiodegradable Organic VSS	MX_{UO}	4306 kgVSS
Total VSS	MX_V	30499 kgVSS
ISS from influent		11424 kgISS
ISS of OHO's		2507 kgISS
ISS of PAO's		2803 kgISS
ISS	MX_{DO}	16735 kgISS
TSS	MX_T	47234 kgTSS
VSS/TSS ratio		0.646 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.380 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	3.40 mgP/l
biomass P-content	ΔP_{OHO}	3.43 mgP/l
Potential P-removal		6.83 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	3.40 mgP/l
biomass P-content	ΔP_{OHO}	3.43 mgP/l
Total Actual P-removal		6.83 mgP/l

TP effluent

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	8131 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	299 kgO/d
Carbonaceous Oxygen flux	FO_L	8430 kgO/d
Nitrogenous Oxygen flux	FO_N	3229 kgO/d
Oxygen dmdnd recover by denitrification	FO_D	1768 kgO/d
Total Oxygen Demand (FO _C + FO _N - FO _D)	FO_T	9890 kgO/d
Oxygen utilisation rate	O_T	56.3 mgO/L/h

Influent TKN	N_0	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_L	284 kgN/d
Equiv conc in influent	N_i	12.79 mgN/l
Effluent Sol Unbiode Org N	N_{unb}	0.90 mgN/l
Effluent ammonia	N_{NH}	0.72 mgFSA-N/l
TKN in effluent	N_{eff}	1.62 mgTKN-N/l
Nitrification capacity	N_c	33.78 mgN/l influent

Denitrification potential BSO (K1)	D_{BBSO}	1.4 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BBSO}	59.94 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{d1}	61.32 mgNO ₂ -N/l influent

	A	0.6993
	B	-25.7836
	C	88.149
Optimal a-recycle ratio	a_{opt}	40.02
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00
	recycle limited	

Effluent Nitrate if recycle limited		4.22 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-22.99 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{NH}	4.22 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₂)	$N_{NH} + N_{NH}$	5.84 mgN/l
N removal		87.9%

Alkalinity consumed by nitrification		241 mg CaCO ₃
Alkalinity recovered by denitrification		106 mg CaCO ₃
Total Alkalinity consumption		136 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{BVL,A}$	0 mgCOD/l
FBSO COD	S_{BVL}	75 mgCOD/l
BSO COD	S_{BVL}	75 mgCOD/l
BO COD	S_{BVL}	554 mgCOD/l

S_{F1} reduction due to O ₂ & NO ₃		33.54 mgCOD/l
Reduced FBSO concentration	$S_{F1,COMP}$	41.46 mgCOD/l

	k_{F120}	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	k_{F1T}	0.0673 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

Trial 1	S_{BVLN}	0.00	MX_{BVL}/Q_L	625	S_{BVLN}	6.04
Trial 2		6.04		640		5.92
Trial 3		5.92		639		5.92
Trial 4		5.92		639		5.92

Flux BO COD obtained by OHO's	95%	11651 kgCOD/d
Flux BO COD obtained by PAO's	5%	658 kgCOD/d
Check total BO COD		12309 kgCOD/d

correct

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{d20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{dT}	0.0448 /d

Activated Sludge Masses

<u>OHO VSS</u>		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	14205 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	7644 kgVSS
<u>PAO VSS</u>		
Polyphosphate Acc Organisms VSS	MX_{PAO}	2045 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	229 kgVSS
Unbiodegradable Organic VSS	MX_{UO}	4306 kgVSS
Total VSS	MX_V	28431 kgVSS
ISS from influent		11424 kgISS
ISS of OHO's		2131 kgISS
ISS of PAO's		2693 kgISS
ISS	MX_{DO}	16248 kgISS
TSS	MX_T	44678 kgTSS
VSS/TSS ratio		0.636 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.38 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	3.27 mgP/l
biomass P-content	ΔP_{OHO}	3.20 mgP/l
Potential P-removal		6.47 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	3.27 mgP/l
biomass P-content	ΔP_{OHO}	3.20 mgP/l
Total Actual P-removal		6.47 mgP/l

TP effluent

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	8415 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	321 kgO/d
Carbonaceous Oxygen flux	FO_L	8736 kgO/d
Nitrogenous Oxygen flux	FO_N	3431 kgO/d
Oxygen dmdnd recover by denitrification	FO_D	1879 kgO/d
Total Oxygen Demand (FO _C + FO _N - FO _D)	FO_T	10288 kgO/d
Oxygen utilisation rate	O_T	58.6 mgO/L/h

UCT Reactor @ 10 Days SRT

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Check	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	3830	12766	30638	47234
Concentration TSS (kgTSS/m ³)	2.09	4.19	4.19	3.872
Volume (m ³)	1830	3050	7320	12200
Volume fraction	15%	25%	60%	100%
Concentration VSS (kgVSS/m ³)	1.35	2.70	2.70	2.50
UPO VSS Concentration (kgUPOVSS/m ³)	0.191	0.382	0.382	0.353

Mass TSS wasted per day 4723.4 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 1128.5 m³/d

COD mass balance	
COD in (influent)	13753 kgCOD/d
COD out	13753 kgCOD/d
$Q_s S_{10} + Q_w S_{10}$	807 kgCOD/d
$Q_w X_{f_{10}}$ or $f_{10} MX_w/Rs$	4517 kgCOD/d
FO_L	8430 kgO/d

N Mass balance	
TKN in (influent)	1071 kgN/d
TKN out	1071 kgN/d
N_{10}	140 kgN/d
N_{waste}	313 kgN/d
$N_{denitrified}$	618 kgN/d

TOD balance	
TOD in (influent)	18648 kgTOD/d
TOD out	18648 kgTOD/d
$TOD_{effluent}$	1024 kgTOD/d
TOD_{waste}	5966 kgTOD/d
TOD_{N_2-gas}	1768 kgTOD/d
FO_L	9890 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S_{10e}	36.30	75	30 mgCOD/l
Unbiol Sol Org N	N_{10e}	0.90	-	- mgN/l
FSA-N	N_{se}	1.78	6	2 mgFSA-N/l
TKN-N	N_{10}	2.68	-	- mgTKN-N/l
Nitrate	N_{10}	3.97	15	1.5 mgNO ₃ -N/l
Unbiol Sol Org P	P_{10e}	0.60	-	- mgP/l
Ortho P as P	P_{10e}	8.67	10	2.5 mgP/l
TP	P_{10}	9.27	-	- mgP/l

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	3623	12075	28980	44678
Concentration TSS (kgTSS/m ³)	1.98	3.96	3.96	3.662
Volume (m ³)	1830	3050	7320	12200
	3623			
Concentration VSS (kgVSS/m ³)	1.26	2.52	2.52	2.33
UPO VSS Concentration (kgUPOVSS/m ³)	0.191	0.382	0.382	0.353

Mass TSS wasted per day 4467.8 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 1128.5 m³/d

COD mass balance	
COD in (influent)	13753.3 kgCOD/d
COD out	13753.3 kgCOD/d
$Q_s S_{10} + Q_w S_{10}$	806.7 kgCOD/d
$Q_w X_{f_{10}}$ or $f_{10} MX_w/Rs$	4210.6 kgCOD/d
FO_L	8736.1 kgO/d

N Mass balance	
TKN in (influent)	1071.11 kgN/d
TKN out	1071.11 kgN/d
N_{10}	123.28 kgN/d
N_{waste}	290.9 kgN/d
$N_{denitrified}$	656.9 kgN/d

TOD balance	
TOD in (influent)	18648.31 kgTOD/d
TOD out	18648.31 kgTOD/d
$TOD_{effluent}$	921.99 kgTOD/d
TOD_{waste}	5559.17 kgTOD/d
TOD_{N_2-gas}	1878.82 kgTOD/d
FO_L	10288.33 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S_{10e}	36.30	75	30 mgCOD/l
Unbiol Sol Org N	N_{10e}	0.90	-	- mgN/l
FSA-N	N_{se}	1.72	6	2 mgFSA-N/l
TKN-N	N_{10}	1.62	-	- mgTKN-N/l
Nitrate	N_{10}	4.22	15	1.5 mgNO ₃ -N/l
Unbiol Sol Org P	P_{10e}	0.60	-	- mgP/l
Ortho P as P	P_{10e}	9.03	10	2.5 mgP/l
TP	P_{10}	9.63	-	- mgP/l

UCT Reactor @ 15 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	22.22 Ml/d
Sludge Age	SRT	15.0 days
Reactor TSS concentration	X _T	5659.38 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti	619 13753
BPO COD	Sbpi	479 10642
UPO COD	Supi	29 638
	fS'up	0.046
VFA COD	Sbsi,a	0.0 0
FBSD COD	Sbsfi	75 1667
BSO COD	Sbsi	75 1667
USO COD	Susi	36.3 807
	fS'us	0.059
BO COD	Sbi	554 12309
UO COD	Sui	65 1444
TSS		241 5349
ISS		51.4 1142
VSS		189 4207
UPO VSS		19.4 431
BPO VSS		170 3776
TKN	Nti	48.2 1071
Org N	Noi	13.8 307
FSA	Nai	34.4 764
BSO	Nobsi	2.90 64
USO	Nousi	0.90 20
BPO	Nobpi	8.70 193
UPO	Noupi	1.30 29
Total P	Pti	15.50 344
OP	Pai	12.80 284
Org P	Poi	2.70 60
BSO	Pobsi	0.70 16
USO	Pousi	0.60 13
BPO	Pobpi	0.78 17
UPO	Poupi	0.62 14

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _{oh}	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{ohv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{coHO}	0.15
Yield coefficient of ANO's	Y _a	0.10 mgVSS/mgFSA
COD per mass fraction of FBSD	f _{cm,bsd}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,uipo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,uipo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,uipo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{hT}	0.2141 /d
	μ _{h,20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{ant}	0.2829 /d
	b _{n20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{aT}	0.0357 /d
	K _{s,20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{sT}	0.6288 mgFSA/l
	K _{s(20)}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{sT}	0.3472
	K _{s(20)}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{sT}	0.0742
	K [*] _{s(20)}	0.255
Denitrification	θ	1.08
primary anoxic of NDBPER system	K [*] _{sT}	0.1874

Factor of safety reducing μ _{ant}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _m	6.76 days
SRT _m (with safety factor)	SRT _m	8.45 Nitrifies!

Max unaerated sludge mass fraction	f _{un}	0.55
Total unaerated sludge mass fraction	f _{de}	0.35
Anoxic mass fraction primary anox 2	f _{z,prim anox 2}	0.27
Anaerobic mass fraction	f _{anaer}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments 2

r-recycle ratio	r	1.0 :1
r-recycle NO ₂ concentration	N _{nr}	4.3 mgNO ₂ -N/l
r-recycle O ₂ concentration	S _{o2,s}	0.0 mgO/l

influent NO ₂ concentration	S _{NO2,i}	0.0 mgNO ₂ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	1.000 :1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)	f _{SD,s}	0.135

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	22.22 Ml/d
Sludge Age	SRT	15.0 days
Reactor TSS concentration	X _T	5367 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti	619 13753
BPO COD	Sbpi	479 10642
UPO COD	Supi	29 638
	fS'up	0.046
VFA COD	Sbsi,a	0 0
FBSD COD	Sbsfi	75 1667
BSO COD	Sbsi	75 1667
USO COD	Susi	36 807
	fS'us	0.059
BO COD	Sbi	554 12309
UO COD	Sui	65 1444
TSS		241 5349
ISS		51 1142
VSS		189 4207
UPO VSS		19 431
BPO VSS		170 3776
TKN	Nti	48 1071
Org N	Noi	14 307
FSA	Nai	34 764
BSO	Nobsi	2.90 64
USO	Nousi	0.90 20
BPO	Nobpi	8.70 193
UPO	Noupi	1.30 29
Total P	Pti	15.50 344
OP	Pai	12.80 284
Org P	Poi	2.70 60
BSO	Pobsi	0.70 16
USO	Pousi	0.60 13
BPO	Pobpi	0.78 17
UPO	Poupi	0.62 14

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _{oh}	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{ohv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{coHO}	0.15
Yield coefficient of ANO's	Y _a	0.1 mgVSS/mgFSA
COD per mass fraction of FBSD	f _{cm,bsd}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,uipo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,uipo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,uipo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate OHO	b _{hT}	0.2691 /d
	μ _{h,20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{ant}	0.7157 /d
	b _{n20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{aT}	0.0448 /d
	K _{s,20}	1.0
Nitrification	θ	1.123
Half Saturation Coefficient	K _{sT}	1.5904
	K _{s(20)}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{sT}	1.4930
	K _{s(20)}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{sT}	0.1374
	K [*] _{s(20)}	0.255
Denitrification	θ	1.08
primary anoxic of NDBPER system	K [*] _{sT}	0.3469

Factor of safety reducing μ _{ant}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _m	2.38 days
SRT _m (with safety factor)	SRT _m	2.98 Nitrifies!

Max unaerated sludge mass fraction	f _{un}	0.81
Total unaerated sludge mass fraction	f _{de}	0.35
Anoxic mass fraction primary anox 2	f _{z,prim anox 2}	0.27
Anaerobic mass fraction	f _{anaer}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments 2

r-recycle ratio	r	1.0 :1
r-recycle NO ₂ concentration	N _{nr}	4.3 mgNO ₂ -N/l
r-recycle O ₂ concentration	S _{o2,s}	0.0 mgO/l

influent NO ₂ concentration	S _{NO2,i}	0.0 mgNO ₂ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)	f _{SD,s}	0.135

UCT Reactor @ 15 Days SRT

Influent TKN	N_0	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_L	269 kgN/d
Equiv conc in influent	N_i	12.10 mgN/l
Effluent Sol Unbiode Org N	N_{unb}	0.90 mgN/l
Effluent ammonia	N_{NH}	0.79 mgFSA-N/l
TKN in effluent	N_{eff}	1.69 mgTKN-N/l
Nitrification capacity	N_c	34.41 mgN/l influent

Denitrification potential BSO (K1)	D_{BBSO}	1.2 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{BPO}	42.71 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{d1}	43.93 mgNO ₃ -N/l influent

	A	0.6993
	B	-7.7715
	C	52.751
Optimal a-recycle ratio	a_{opt}	15.87
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00 set = a_{opt} for balanced UCT
		recycle limited

Effluent Nitrate if recycle limited		4.30 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		-4.97 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{NH}	4.30 mgNO ₃ -N/l influent

Effluent total N (TKN + NO ₃)	$N_{NH} + N_{NH}$	5.99 mgN/l
N removal		87.6%

Alkalinity consumed by nitrification		246 mg CaCO ₃
Alkalinity recovered by denitrification		107 mg CaCO ₃
Total Alkalinity consumption		138 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{BVL,A}$	0 mgCOD/l
FBSO COD	S_{BVL}	75 mgCOD/l
BSO COD	S_{BVL}	75 mgCOD/l
BO COD	S_{BVL}	554 mgCOD/l

S_{F1} reduction due to O ₂ & NO ₃		36.55 mgCOD/l
Reduced FBSO concentration	$S_{F1,COMP}$	38.45 mgCOD/l

	k_{F120}	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	k_{F1T}	0.0535 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

Trial 1	S_{BVLN}	MX _{BVL} /Q _L	S_{BVLN}	5.35
Trial 2	5.35	826	843	5.24
Trial 3	5.24	843	843	5.24
Trial 4	5.24	843	843	5.24

Flux BO COD obtained by OHO's	95%	11688 kgCOD/d
Flux BO COD obtained by PAO's	5%	621 kgCOD/d
Check total BO COD		12309 kgCOD/d

correct
12309

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{d20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{dT}	0.0357 /d

Activated Sludge Masses

<u>OHO VSS</u>		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	18734 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	12031 kgVSS
<u>PAO VSS</u>		
Polyphosphate Acc Organisms VSS	MX_{PAO}	2732 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	366 kgVSS
Unbiodegradable Organic VSS	MX_{UO}	6460 kgVSS
Total VSS	MX_V	40323 kgVSS
ISS from influent		17136 kgISS
ISS of OHO's		2810 kgISS
ISS of PAO's		3597 kgISS
ISS	MX_{DO}	23543 kgISS
TSS	MX_T	63866 kgTSS
VSS/TSS ratio		0.631 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.380 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.91 mgP/l
biomass P-content	ΔP_{OHO}	3.02 mgP/l
Potential P-removal		5.93 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.91 mgP/l
biomass P-content	ΔP_{OHO}	3.02 mgP/l
Total Actual P-removal		5.93 mgP/l

TP effluent P_{le} 9.57 mgP/l

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	8650 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	316 kgO/d
Carbonaceous Oxygen flux	FO_L	8965 kgO/d
Nitrogenous Oxygen flux	FO_N	3495 kgO/d
Oxygen dmdnd recover by denitrification	FO_D	1914 kgO/d
Total Oxygen Demand (FO _C + FO _N - FO _D)	FO_T	10546 kgO/d
Oxygen utilisation rate	O_T	60.0 mgO/L/h

Influent TKN	N_0	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_L	251 kgN/d
Equiv conc in influent	N_i	11.32 mgN/l
Effluent Sol Unbiode Org N	N_{unb}	0.90 mgN/l
Effluent ammonia	N_{NH}	0.50 mgFSA-N/l
TKN in effluent	N_{eff}	1.40 mgTKN-N/l
Nitrification capacity	N_c	35.48 mgN/l influent

Denitrification potential BSO (K1)	D_{BBSO}	1.2 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{BPO}	66.04 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{d1}	67.20 mgNO ₃ -N/l influent

	A	0.6993
	B	-29.9740
	C	98.225
Optimal a-recycle ratio	a_{opt}	45.92
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00
		recycle limited

Effluent Nitrate if recycle limited		4.44 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		-27.18 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{NH}	4.44 mgNO ₃ -N/l influent

Effluent total N (TKN + NO ₃)	$N_{NH} + N_{NH}$	5.84 mgN/l
N removal		87.9%

Alkalinity consumed by nitrification		253 mg CaCO ₃
Alkalinity recovered by denitrification		111 mg CaCO ₃
Total Alkalinity consumption		142 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{BVL,A}$	0 mgCOD/l
FBSO COD	S_{BVL}	75 mgCOD/l
BSO COD	S_{BVL}	75 mgCOD/l
BO COD	S_{BVL}	554 mgCOD/l

S_{F1} reduction due to O ₂ & NO ₃		36.55 mgCOD/l
Reduced FBSO concentration	$S_{F1,COMP}$	38.45 mgCOD/l

	k_{F120}	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	k_{F1T}	0.0673 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

Trial 1	S_{BVLN}	MX _{BVL} /Q _L	S_{BVLN}	5.10
Trial 2	5.10	691	705	5.00
Trial 3	5.00	704	704	5.00
Trial 4	5.00	704	704	5.00

Flux BO COD obtained by OHO's	95%	11677 kgCOD/d
Flux BO COD obtained by PAO's	5%	632 kgCOD/d
Check total BO COD		12309 kgCOD/d

correct

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{d20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{dT}	0.0448 /d

Activated Sludge Masses

<u>OHO VSS</u>		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	15651 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	12634 kgVSS
<u>PAO VSS</u>		
Polyphosphate Acc Organisms VSS	MX_{PAO}	2551 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	429 kgVSS
Unbiodegradable Organic VSS	MX_{UO}	6460 kgVSS
Total VSS	MX_V	37724 kgVSS
ISS from influent		17136 kgISS
ISS of OHO's		2349 kgISS
ISS of PAO's		3358 kgISS
ISS	MX_{DO}	22842 kgISS
TSS	MX_T	60566 kgTSS
VSS/TSS ratio		0.623 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.38 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.72 mgP/l
biomass P-content	ΔP_{OHO}	2.83 mgP/l
Potential P-removal		5.55 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.72 mgP/l
biomass P-content	ΔP_{OHO}	2.83 mgP/l
Total Actual P-removal		5.55 mgP/l

TP effluent P_{le} 9.95 mgP/l

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	8884 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	338 kgO/d
Carbonaceous Oxygen flux	FO_L	9222 kgO/d
Nitrogenous Oxygen flux	FO_N	3603 kgO/d
Oxygen dmdnd recover by denitrification	FO_D	1973 kgO/d
Total Oxygen Demand (FO _C + FO _N - FO _D)	FO_T	10852 kgO/d
Oxygen utilisation rate	O_T	61.8 mgO/L/h

UCT Reactor @ 15 Days SRT

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Check	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	5178	17261	41427	63866
Concentration TSS (kgTSS/m ³)	2.83	5.66	5.66	5.235
Volume (m ³)	1830	3050	7320	12200
Volume fraction	15%	25%	60%	100%
Concentration VSS (kgVSS/m ³)	1.79	3.57	3.57	3.31
UPO VSS Concentration (kgUPOVSS/m ³)	0.286	0.572	0.572	0.529

Mass TSS wasted per day 4257.7 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 752.3 m³/d

COD mass balance	
COD in (influent)	13753.3 kgCOD/d
COD out	13753.3 kgCOD/d
$Q_s S_{10} + Q_w S_{10}$	806.7 kgCOD/d
$Q_w X_{f_{10}}$ or $f_{10} MX_{10}/Rs$	3981.2 kgCOD/d
FO_L	8965.5 kgO/d

N Mass balance	
TKN in (influent)	1071.11 kgN/d
TKN out	1071.11 kgN/d
N_{10}	128.69 kgN/d
N_{waste}	273.3 kgN/d
$N_{denitrified}$	669.1 kgN/d

TOD balance	
TOD in (influent)	18648.31 kgTOD/d
TOD out	18648.31 kgTOD/d
$TOD_{effluent}$	945.43 kgTOD/d
TOD_{waste}	5242.84 kgTOD/d
TOD_{N_2-gas}	1913.61 kgTOD/d
FO_L	10546.43 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S_{10e}	36.30	75	30 mgCOD/l
Unbiol Sol Org N	N_{10e}	0.90	-	- mgN/l
FSA-N	N_{10}	0.79	6	2 mgFSA-N/l
TKN-N	N_{10}	1.69	-	- mgTKN-N/l
Nitrate	N_{10}	4.30	15	1.5 mgNO ₃ -N/l
Unbiol Sol Org P	P_{10e}	0.60	-	- mgP/l
Ortho P as P	P_{10}	9.57	10	2.5 mgP/l
TP	P_{10}	10.17	-	- mgP/l

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	4911	16369	39286	60566
Concentration TSS (kgTSS/m ³)	2.68	5.37	5.37	4.964
Volume (m ³)	1830	3050	7320	12200
Concentration VSS (kgVSS/m ³)	1.67	3.34	3.34	3.09
UPO VSS Concentration (kgUPOVSS/m ³)	0.286	0.572	0.572	0.529

Mass TSS wasted per day 4037.7 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 752.3 m³/d

COD mass balance	
COD in (influent)	13753.3 kgCOD/d
COD out	13753.3 kgCOD/d
$Q_s S_{10} + Q_w S_{10}$	806.7 kgCOD/d
$Q_w X_{f_{10}}$ or $f_{10} MX_{10}/Rs$	3724.6 kgCOD/d
FO_L	9222.1 kgO/d

N Mass balance	
TKN in (influent)	1071.11 kgN/d
TKN out	1071.11 kgN/d
N_{10}	125.34 kgN/d
N_{waste}	255.9 kgN/d
$N_{denitrified}$	689.9 kgN/d

TOD balance	
TOD in (influent)	18648.31 kgTOD/d
TOD out	18648.31 kgTOD/d
$TOD_{effluent}$	917.00 kgTOD/d
TOD_{waste}	4906.01 kgTOD/d
TOD_{N_2-gas}	1973.09 kgTOD/d
FO_L	10852.21 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S_{10e}	36.30	75	30 mgCOD/l
Unbiol Sol Org N	N_{10e}	0.90	-	- mgN/l
FSA-N	N_{10}	0.50	6	2 mgFSA-N/l
TKN-N	N_{10}	1.40	-	- mgTKN-N/l
Nitrate	N_{10}	4.44	15	1.5 mgNO ₃ -N/l
Unbiol Sol Org P	P_{10e}	0.60	-	- mgP/l
Ortho P as P	P_{10}	9.95	10	2.5 mgP/l
TP	P_{10}	10.55	-	- mgP/l

UCT Reactor @ 20 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	22.22 Ml/d
Sludge Age	SRT	20.0 days
Reactor TSS concentration	X _T	7043.61 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti	619
BPO COD	Sbpi	479
UPO COD	Supi	29
	fS'up	0.046
VFA COD	Sbsi,a	0.0
FBSD COD	Sbsfi	75
BSO COD	Sbsi	75
USO COD	Susi	36.3
	fS'us	0.059
BO COD	Sbi	554
UO COD	Sui	65
TSS		241
ISS		51.4
VSS		189
UPO VSS		19.4
BPO VSS		170
TKN	Nti	48.2
Org N	Noi	13.8
FSA	Nai	34.4
BSO	Nobsi	2.90
USO	Nousi	0.90
BPO	Nobpi	8.70
UPO	Noupi	1.30
Total P	Pti	15.50
OP	Pai	12.80
Org P	Poi	2.70
BSO	Pobsi	0.70
USO	Pousi	0.60
BPO	Pobpi	0.78
UPO	Poupi	0.62

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _{oh}	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{ohv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{coHO}	0.15
Yield coefficient of ANO's	Y _a	0.10 mgVSS/mgFSA
COD per mass fraction of FBSD	f _{cm,bsd}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,uipo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,uipo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,uipo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{hT}	0.2141 /d
	μ _{h,m20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{amT}	0.2829 /d
	b _{h20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{aT}	0.0357 /d
	K _{s20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{sT}	0.6288 mgFSA/l
	K _{s(pH)}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{sT}	0.3472
Denitrification	K _{s(pH)}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{sT}	0.0742
Denitrification	K ⁺ _{s(pH)}	0.255
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K ⁺ _{sT}	0.1874

Factor of safety reducing μ _{amT}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _m	6.76 days
SRT _m (with safety factor)	SRT _m	8.45 Nitrifies!

Max unaerated sludge mass fraction	f _{sm}	0.62
Total unaerated sludge mass fraction	f _{st}	0.35
Anoxic mass fraction primary anox 2	f _{z,prim anox 2}	0.27
Anaerobic mass fraction	f _{anaer}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments 2

r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N _{nr}	4.4 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{o2,s}	0.0 mgO ₂ /l

influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
influent DO concentration	O _i	0.0 mgO ₂ /l

s-recycle ratio	s	1.5 :1
s-recycle DO concentration	O _s	1.0 mgO ₂ /l

a-recycle DO concentration	O _a	2.0 mgO ₂ /l

Influent RBCOD fraction (Sbsi/Sbi)	f _{bsi}	0.135

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	22.22 Ml/d
Sludge Age	SRT	20.0 days
Reactor TSS concentration	X _T	6704 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti	619
BPO COD	Sbpi	479
UPO COD	Supi	29
	fS'up	0.046
VFA COD	Sbsi,a	0
FBSD COD	Sbsfi	75
BSO COD	Sbsi	75
USO COD	Susi	36
	fS'us	0.059
BO COD	Sbi	554
UO COD	Sui	65
TSS		241
ISS		51
VSS		189
UPO VSS		19
BPO VSS		170
TKN	Nti	48
Org N	Noi	14
FSA	Nai	34
BSO	Nobsi	2.90
USO	Nousi	0.90
BPO	Nobpi	8.70
UPO	Noupi	1.30
Total P	Pti	15.50
OP	Pai	12.80
Org P	Poi	2.70
BSO	Pobsi	0.70
USO	Pousi	0.60
BPO	Pobpi	0.78
UPO	Poupi	0.62

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _{oh}	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{ohv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{coHO}	0.15
Yield coefficient of ANO's	Y _a	0.1 mgVSS/mgFSA
COD per mass fraction of FBSD	f _{cm,bsd}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,uipo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,uipo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,uipo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate OHO	b _{hT}	0.2691 /d
	μ _{h,m20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{amT}	0.7157 /d
	b _{h20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{aT}	0.0448 /d
	K _{s20}	1.0
Nitrification	θ	1.123
Half Saturation Coefficient	K _{sT}	1.5904
	K _{s(pH)}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{sT}	1.4930
Denitrification	K _{s(pH)}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{sT}	0.1374
Denitrification	K ⁺ _{s(pH)}	0.255
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K ⁺ _{sT}	0.3469

Factor of safety reducing μ _{amT}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _m	2.38 days
SRT _m (with safety factor)	SRT _m	2.98 Nitrifies!

Max unaerated sludge mass fraction	f _{sm}	0.83
Total unaerated sludge mass fraction	f _{st}	0.35
Anoxic mass fraction primary anox 2	f _{z,prim anox 2}	0.27
Anaerobic mass fraction	f _{anaer}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments 2

r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N _{nr}	4.4 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{o2,s}	0.0 mgO ₂ /l

influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
influent DO concentration	O _i	0.0 mgO ₂ /l

s-recycle ratio	s	1.5 :1
s-recycle DO concentration	O _s	1.0 mgO ₂ /l

a-recycle DO concentration	O _a	2.0 mgO ₂ /l

Influent RBCOD fraction (Sbsi/Sbi)	f _{bsi}	0.135

UCT Reactor @ 20 Days SRT

Influent TKN	N_0	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_L	247 kgN/d
Equiv conc in influent	N_i	11.12 mgN/l
Effluent Sol Unbiod Org N	N_{unb}	0.90 mgN/l
Effluent ammonia	N_{NH}	0.55 mgFSA-N/l
TKN in effluent	N_{eff}	1.45 mgTKN-N/l
Nitrification capacity	N_c	35.63 mgN/l influent

Denitrification potential BSO (K1)	D_{BBSO}	1.1 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BBSO}	45.43 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{d1}	46.55 mgNO ₂ -N/l influent

	A	0.6993
	B	-8.6130
	C	61.847
Optimal a-recycle ratio	a_{opt}	17.40
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00 set = a_{opt} for balanced UCT
		recycle limited

Effluent Nitrate if recycle limited		4.18 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-6.18 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{NH}	4.18 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₂)	$N_{NH} + N_{NH}$	5.63 mgN/l
N removal		88.3%

Alkalinity consumed by nitrification		254 mg CaCO ₃
Alkalinity recovered by denitrification		112 mg CaCO ₃
Total Alkalinity consumption		142 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{BVL,A}$	0 mgCOD/l
FBSO COD	S_{BVL}	75 mgCOD/l
BSO COD	S_{BVL}	75 mgCOD/l
BO COD	S_{BVL}	554 mgCOD/l

S_{F1} reduction due to O ₂ & NO ₃		37.84 mgCOD/l
Reduced FBSO concentration	$S_{F1,COMP}$	37.16 mgCOD/l

	$k_{f,120}$	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	$k_{f,T}$	0.0535 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

Trial 1	S_{BVLN}	0.00	MX_{BVL}/Q_L	881	S_{BVLN}	4.86
Trial 2		4.86		897		4.77
Trial 3		4.77		897		4.77
Trial 4		4.77		897		4.77

Flux BO COD obtained by OHO's	95%	11695 kgCOD/d
Flux BO COD obtained by PAO's	5%	614 kgCOD/d
Check total BO COD		12309 kgCOD/d

correct
12309

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{d20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{dT}	0.0357 /d

Activated Sludge Masses

<u>OHO VSS</u>		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	19930 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	17065 kgVSS
<u>PAO VSS</u>		
Polyphosphate Acc Organisms VSS	MX_{PAO}	3223 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	575 kgVSS
Unbiodegradable Organic VSS	MX_{UO}	8613 kgVSS
Total VSS	MX_V	49406 kgVSS
ISS from influent		22848 kgISS
ISS of OHO's		2990 kgISS
ISS of PAO's		4243 kgISS
ISS	MX_{DO}	30081 kgISS
TSS	MX_T	79487 kgTSS
VSS/TSS ratio		0.622 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.380 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.57 mgP/l
biomass P-content	ΔP_{OHO}	2.78 mgP/l
Potential P-removal		5.35 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.57 mgP/l
biomass P-content	ΔP_{OHO}	2.78 mgP/l
Total Actual P-removal		5.35 mgP/l

TP effluent

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	8956 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	332 kgO/d
Carbonaceous Oxygen flux	FO_L	9288 kgO/d
Nitrogenous Oxygen flux	FO_N	3619 kgO/d
Oxygen dmdnd recover by denitrification	FO_D	1999 kgO/d
Total Oxygen Demand (FO _C + FO _N - FO _D)	FO_T	10908 kgO/d
Oxygen utilisation rate	O_T	62.1 mgO/L/h

Influent TKN	N_0	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_L	232 kgN/d
Equiv conc in influent	N_i	10.45 mgN/l
Effluent Sol Unbiod Org N	N_{unb}	0.90 mgN/l
Effluent ammonia	N_{NH}	0.41 mgFSA-N/l
TKN in effluent	N_{eff}	1.31 mgTKN-N/l
Nitrification capacity	N_c	36.44 mgN/l influent

Denitrification potential BSO (K1)	D_{BBSO}	1.1 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BBSO}	69.55 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{d1}	70.62 mgNO ₂ -N/l influent

	A	0.6993
	B	-31.8774
	C	121.413
Optimal a-recycle ratio	a_{opt}	49.12
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00
		recycle limited

Effluent Nitrate if recycle limited		4.27 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-29.45 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{NH}	4.27 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₂)	$N_{NH} + N_{NH}$	5.58 mgN/l
N removal		88.4%

Alkalinity consumed by nitrification		260 mg CaCO ₃
Alkalinity recovered by denitrification		115 mg CaCO ₃
Total Alkalinity consumption		145 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{BVL,A}$	0 mgCOD/l
FBSO COD	S_{BVL}	75 mgCOD/l
BSO COD	S_{BVL}	75 mgCOD/l
BO COD	S_{BVL}	554 mgCOD/l

S_{F1} reduction due to O ₂ & NO ₃		37.84 mgCOD/l
Reduced FBSO concentration	$S_{F1,COMP}$	37.16 mgCOD/l

	$k_{f,120}$	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	$k_{f,T}$	0.0673 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

Trial 1	S_{BVLN}	0.00	MX_{BVL}/Q_L	729	S_{BVLN}	4.67
Trial 2		4.67		742		4.59
Trial 3		4.59		742		4.59
Trial 4		4.59		742		4.59

Flux BO COD obtained by OHO's	95%	11687 kgCOD/d
Flux BO COD obtained by PAO's	5%	622 kgCOD/d
Check total BO COD		12309 kgCOD/d

correct

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{d20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{dT}	0.0448 /d

Activated Sludge Masses

<u>OHO VSS</u>		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	16483 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	17740 kgVSS
<u>PAO VSS</u>		
Polyphosphate Acc Organisms VSS	MX_{PAO}	2950 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	661 kgVSS
Unbiodegradable Organic VSS	MX_{UO}	8613 kgVSS
Total VSS	MX_V	46447 kgVSS
ISS from influent		22848 kgISS
ISS of OHO's		2472 kgISS
ISS of PAO's		3883 kgISS
ISS	MX_{DO}	29204 kgISS
TSS	MX_T	75651 kgTSS
VSS/TSS ratio		0.614 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.38 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.36 mgP/l
biomass P-content	ΔP_{OHO}	2.61 mgP/l
Potential P-removal		4.97 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.36 mgP/l
biomass P-content	ΔP_{OHO}	2.61 mgP/l
Total Actual P-removal		4.97 mgP/l

TP effluent

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	9153 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	354 kgO/d
Carbonaceous Oxygen flux	FO_L	9507 kgO/d
Nitrogenous Oxygen flux	FO_N	3701 kgO/d
Oxygen dmdnd recover by denitrification	FO_D	2044 kgO/d
Total Oxygen Demand (FO _C + FO _N - FO _D)	FO_T	11164 kgO/d
Oxygen utilisation rate	O_T	63.5 mgO/L/h

UCT Reactor @ 20 Days SRT

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Check	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	6445	21483	51559	79487
Concentration TSS (kgTSS/m ³)	3.52	7.04	7.04	6.515
Volume (m ³)	1830	3050	7320	12200
Volume fraction	15%	25%	60%	100%
Concentration VSS (kgVSS/m ³)	2.19	4.38	4.38	4.05
UPO VSS Concentration (kgUPOVSS/m ³)	0.382	0.763	0.763	0.706

Mass TSS wasted per day 3974.4 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 564.3 m³/d 610

COD mass balance	
COD in (influent)	13753.3 kgCOD/d
COD out	13753.3 kgCOD/d
$Q_s S_{10} + Q_w S_{10}$	806.7 kgCOD/d
$Q_w X_{10} f_{10}$ or $f_{10} MX_{10}/Rs$	3658.5 kgCOD/d
FO_L	9288.1 kgO/d

N Mass balance	
TKN in (influent)	1071.11 kgN/d
TKN out	1071.11 kgN/d
N_{10}	121.94 kgN/d
N_{waste}	250.2 kgN/d
$N_{denitrified}$	699.0 kgN/d

TOD balance	
TOD in (influent)	18648.31 kgTOD/d
TOD out	18648.31 kgTOD/d
$TOD_{effluent}$	929.75 kgTOD/d
TOD_{waste}	4811.68 kgTOD/d
TOD_{N2-gas}	1999.05 kgTOD/d
FO_L	10907.83 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S_{10e}	36.30	75	30 mgCOD/l
Unbiol Sol Org N	N_{10e}	0.90	-	- mgN/l
FSA-N	N_{10}	0.55	6	2 mgFSA-N/l
TKN-N	N_{10}	1.45	-	- mgTKN-N/l
Nitrate	N_{10}	4.18	15	1.5 mgNO ₃ -N/l
Unbiol Sol Org P	P_{10e}	0.60	-	- mgP/l
Ortho P as P	P_{10}	10.15	10	2.5 mgP/l
TP	P_{10}	10.75	-	- mgP/l

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	6134	20446	49071	75651
Concentration TSS (kgTSS/m ³)	3.35	6.70	6.70	6.201
Volume (m ³)	1830	3050	7320	12200
Concentration VSS (kgVSS/m ³)	2.06	4.12	4.12	3.81
UPO VSS Concentration (kgUPOVSS/m ³)	0.382	0.763	0.763	0.706

Mass TSS wasted per day 3782.5 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 564.3 m³/d

COD mass balance	
COD in (influent)	13753.3 kgCOD/d
COD out	13753.3 kgCOD/d
$Q_s S_{10} + Q_w S_{10}$	806.7 kgCOD/d
$Q_w X_{10} f_{10}$ or $f_{10} MX_{10}/Rs$	3439.4 kgCOD/d
FO_L	9507.3 kgO/d

N Mass balance	
TKN in (influent)	1071.11 kgN/d
TKN out	1071.11 kgN/d
N_{10}	120.91 kgN/d
N_{waste}	235.4 kgN/d
$N_{denitrified}$	714.8 kgN/d

TOD balance	
TOD in (influent)	18648.31 kgTOD/d
TOD out	18648.31 kgTOD/d
$TOD_{effluent}$	915.68 kgTOD/d
TOD_{waste}	4524.56 kgTOD/d
TOD_{N2-gas}	2044.38 kgTOD/d
FO_L	11163.69 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S_{10e}	36.30	75	30 mgCOD/l
Unbiol Sol Org N	N_{10e}	0.90	-	- mgN/l
FSA-N	N_{10}	0.41	6	2 mgFSA-N/l
TKN-N	N_{10}	1.31	-	- mgTKN-N/l
Nitrate	N_{10}	4.27	15	1.5 mgNO ₃ -N/l
Unbiol Sol Org P	P_{10e}	0.60	-	- mgP/l
Ortho P as P	P_{10}	10.53	10	2.5 mgP/l
TP	P_{10}	11.13	-	- mgP/l

UCT Reactor @ 25 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	22.22 Ml/d
Sludge Age	SRT	25.0 days
Reactor TSS concentration	X _T	8375.34 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti	619
BPO COD	Sbpi	479
UPO COD	Supi	29
	fS'up	0.046
VFA COD	Sbsi,a	0.0
FBSD COD	Sbsfi	75
BSO COD	Sbsi	75
USO COD	Susi	36.3
	fS'us	0.059
BO COD	Sbi	554
UO COD	Sui	65
TSS		241
ISS		51.4
VSS		189
UPO VSS		19.4
BPO VSS		170
TKN	Nti	48.2
Org N	Noi	13.8
FSA	Nai	34.4
BSO	Nobsi	2.90
USO	Nousi	0.90
BPO	Nobpi	8.70
UPO	Noupi	1.30
Total P	Pti	15.50
OP	Pai	12.80
Org P	Poi	2.70
BSO	Pobsi	0.70
USO	Pousi	0.60
BPO	Pobpi	0.78
UPO	Poupi	0.62

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _{oh}	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{ohv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{coHO}	0.15
Yield coefficient of ANO's	Y _a	0.10 mgVSS/mgFSA
COD per mass fraction of FBSD	f _{cm,bsd}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,uipo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,uipo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,uipo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{hT}	0.2141 /d
	μ _{h,20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{ant}	0.2829 /d
	b _{h20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{at}	0.0357 /d
	K _{s,20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{s,T}	0.6288 mgFSA/l
	K _{s,20}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{s,T}	0.3472
	K _{s,20}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{s,T}	0.0742
	K ⁺ _{s,20}	0.255
Denitrification	θ	1.08
primary anoxic of NDBPER system	K ⁺ _{s,T}	0.1874

Factor of safety reducing μ _{ant}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _m	6.76 days
SRT _m (with safety factor)	SRT _m	8.45 Nitrifies!

Max unaerated sludge mass fraction	f _{un}	0.67
Total unaerated sludge mass fraction	f _{de}	0.35
Anoxic mass fraction primary anox 2	f _{z,prim anox 2}	0.27
Anaerobic mass fraction	f _{anaer}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments

r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N _{re}	4.5 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{o2,s}	0.0 mgO/l

influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	1.9 :1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)

f_{SD,s}

0.135

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	22.22 Ml/d
Sludge Age	SRT	25.0 days
Reactor TSS concentration	X _T	7999 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti	619
BPO COD	Sbpi	479
UPO COD	Supi	29
	fS'up	0.046
VFA COD	Sbsi,a	0
FBSD COD	Sbsfi	75
BSO COD	Sbsi	75
USO COD	Susi	36
	fS'us	0.059
BO COD	Sbi	554
UO COD	Sui	65
TSS		241
ISS		51
VSS		189
UPO VSS		19
BPO VSS		170
TKN	Nti	48
Org N	Noi	14
FSA	Nai	34
BSO	Nobsi	2.90
USO	Nousi	0.90
BPO	Nobpi	8.70
UPO	Noupi	1.30
Total P	Pti	15.50
OP	Pai	12.80
Org P	Poi	2.70
BSO	Pobsi	0.70
USO	Pousi	0.60
BPO	Pobpi	0.78
UPO	Poupi	0.62

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _{oh}	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{ohv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{coHO}	0.15
Yield coefficient of ANO's	Y _a	0.1 mgVSS/mgFSA
COD per mass fraction of FBSD	f _{cm,bsd}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,uipo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,uipo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,uipo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate OHO	b _{hT}	0.2691 /d
	μ _{h,20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{ant}	0.7157 /d
	b _{h20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{at}	0.0448 /d
	K _{s,20}	1.0
Nitrification	θ	1.123
Half Saturation Coefficient	K _{s,T}	1.5904
	K _{s,20}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{s,T}	1.4930
	K _{s,20}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{s,T}	0.1374
	K ⁺ _{s,20}	0.255
Denitrification	θ	1.08
primary anoxic of NDBPER system	K ⁺ _{s,T}	0.3469

Factor of safety reducing μ _{ant}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _m	2.38 days
SRT _m (with safety factor)	SRT _m	2.98 Nitrifies!

Max unaerated sludge mass fraction	f _{un}	0.85
Total unaerated sludge mass fraction	f _{de}	0.35
Anoxic mass fraction primary anox 2	f _{z,prim anox 2}	0.27
Anaerobic mass fraction	f _{anaer}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments

r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N _{re}	4.5 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{o2,s}	0.0 mgO/l

influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	1.9 :1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)

f_{SD,s}

0.135

UCT Reactor @ 25 Days SRT

Influent TKN	N_0	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_L	232 kgN/d
Equiv conc in influent	N_i	10.46 mgN/l
Effluent Sol Unbiode Org N	N_{unb}	0.90 mgN/l
Effluent ammonia	N_{NH}	0.44 mgFSA-N/l
TKN in effluent	N_{eff}	1.34 mgTKN-N/l
Nitrification capacity	N_c	36.40 mgN/l influent

Denitrification potential BSO (K1)	D_{BBSO}	1.0 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BBSO}	47.25 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{d1}	48.29 mgNO ₂ -N/l influent

	A	0.6993
	B	-9.1715
	C	69.206
Optimal a-recycle ratio	a_{opt}	18.47
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00 set = a_{opt} for balanced UCT
		recycle limited

Effluent Nitrate if recycle limited		4.08 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-7.02 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{NH}	4.08 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₂)	$N_{NH} + N_{NH}$	5.42 mgN/l
N removal		88.8%

Alkalinity consumed by nitrification		260 mg CaCO ₃
Alkalinity recovered by denitrification		115 mg CaCO ₃
Total Alkalinity consumption		145 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{BVL,A}$	0 mgCOD/l
FBSO COD	S_{BVL}	75 mgCOD/l
BSO COD	S_{BVL}	75 mgCOD/l
BO COD	S_{BVL}	554 mgCOD/l

S_{F1} reduction due to O ₂ & NO ₃		38.7 mgCOD/l
Reduced FBSO concentration	$S_{F1,COMP}$	36.3 mgCOD/l

	k_{F120}	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	k_{F1T}	0.0535 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	S_{BVLN}	MX_{BVL}/Q_L	S_{BVLN}	
Trial 1	0.00	917	754	4.56
Trial 2	4.56	933	766	4.48
Trial 3	4.48	933	766	4.48
Trial 4	4.48	933	766	4.48

Flux BO COD obtained by OHO's	95%	11702 kgCOD/d
Flux BO COD obtained by PAO's	5%	607 kgCOD/d
Check total BO COD		12309 kgCOD/d

correct
12309

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{G20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{GT}	0.0357 /d

Activated Sludge Masses

<u>OHO VSS</u>		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	20726 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	22183 kgVSS
<u>PAO VSS</u>		
Polyphosphate Acc Organisms VSS	MX_{PAO}	3611 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	805 kgVSS
Unbiodegradable Organic VSS	MX_{UO}	10766 kgVSS
Total VSS	MX_V	58092 kgVSS
ISS from influent		28561 kgISS
ISS of OHO's		3109 kgISS
ISS of PAO's		4755 kgISS
ISS	MX_{DO}	36424 kgISS
TSS	MX_T	94516 kgTSS
VSS/TSS ratio		0.615 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.380 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.31 mgP/l
biomass P-content	ΔP_{OHO}	2.61 mgP/l
Potential P-removal		4.92 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.31 mgP/l
biomass P-content	ΔP_{OHO}	2.61 mgP/l
Total Actual P-removal		4.92 mgP/l

TP effluent

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	9160 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	346 kgO/d
Carbonaceous Oxygen flux	FO_L	9505 kgO/d
Nitrogenous Oxygen flux	FO_N	3697 kgO/d
Oxygen dnmnd recover by denitrification	FO_D	2054 kgO/d
Total Oxygen Demand (FO _C + FO _N - FO _D)	FO_T	11148 kgO/d
Oxygen utilisation rate	O_T	63.5 mgO/L/h

Influent TKN	N_0	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_L	219 kgN/d
Equiv conc in influent	N_i	9.88 mgN/l
Effluent Sol Unbiode Org N	N_{unb}	0.90 mgN/l
Effluent ammonia	N_{NH}	0.36 mgFSA-N/l
TKN in effluent	N_{eff}	1.26 mgTKN-N/l
Nitrification capacity	N_c	37.07 mgN/l influent

Denitrification potential BSO (K1)	D_{BBSO}	1.0 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BBSO}	71.85 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{d1}	72.86 mgNO ₂ -N/l influent

	A	0.6993
	B	-33.0724
	C	139.771
Optimal a-recycle ratio	a_{opt}	51.20
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00
		recycle limited

Effluent Nitrate if recycle limited		4.15 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-30.92 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{NH}	4.15 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₂)	$N_{NH} + N_{NH}$	5.41 mgN/l
N removal		88.8%

Alkalinity consumed by nitrification		265 mg CaCO ₃
Alkalinity recovered by denitrification		118 mg CaCO ₃
Total Alkalinity consumption		147 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{BVL,A}$	0 mgCOD/l
FBSO COD	S_{BVL}	75 mgCOD/l
BSO COD	S_{BVL}	75 mgCOD/l
BO COD	S_{BVL}	554 mgCOD/l

S_{F1} reduction due to O ₂ & NO ₃		38.7 mgCOD/l
Reduced FBSO concentration	$S_{F1,COMP}$	36.3 mgCOD/l

	k_{F120}	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	k_{F1T}	0.0673 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	S_{BVLN}	MX_{BVL}/Q_L	S_{BVLN}	
Trial 1	0.00	754	754	4.41
Trial 2	4.41	766	766	4.34
Trial 3	4.34	766	766	4.34
Trial 4	4.34	766	766	4.34

Flux BO COD obtained by OHO's	95%	11695 kgCOD/d
Flux BO COD obtained by PAO's	5%	614 kgCOD/d
Check total BO COD		12309 kgCOD/d

correct

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{G20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{GT}	0.0448 /d

Activated Sludge Masses

<u>OHO VSS</u>		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	17028 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	22909 kgVSS
<u>PAO VSS</u>		
Polyphosphate Acc Organisms VSS	MX_{PAO}	3255 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	912 kgVSS
Unbiodegradable Organic VSS	MX_{UO}	10766 kgVSS
Total VSS	MX_V	54870 kgVSS
ISS from influent		28561 kgISS
ISS of OHO's		2554 kgISS
ISS of PAO's		4285 kgISS
ISS	MX_{DO}	35400 kgISS
TSS	MX_T	90270 kgTSS
VSS/TSS ratio		0.608 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.38 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.08 mgP/l
biomass P-content	ΔP_{OHO}	2.47 mgP/l
Potential P-removal		4.55 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.08 mgP/l
biomass P-content	ΔP_{OHO}	2.47 mgP/l
Total Actual P-removal		4.55 mgP/l

TP effluent

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	9329 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	367 kgO/d
Carbonaceous Oxygen flux	FO_L	9696 kgO/d
Nitrogenous Oxygen flux	FO_N	3764 kgO/d
Oxygen dnmnd recover by denitrification	FO_D	2092 kgO/d
Total Oxygen Demand (FO _C + FO _N - FO _D)	FO_T	11369 kgO/d
Oxygen utilisation rate	O_T	64.7 mgO/L/h

UCT Reactor @ 25 Days SRT

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Check	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	7663	25545	61307	94516
Concentration TSS (kgTSS/m ³)	4.19	8.38	8.38	7.747
Volume (m ³)	1830	3050	7320	12200
Volume fraction	15%	25%	60%	100%
Concentration VSS (kgVSS/m ³)	2.57	5.15	5.15	4.76
UPO VSS Concentration (kgUPOVSS/m ³)	0.477	0.954	0.954	0.882

Mass TSS wasted per day 3780.6 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 451.4 m³/d

COD mass balance	
COD in (influent)	13753.3 kgCOD/d
COD out	13753.3 kgCOD/d
$Q_s S_{10} + Q_w S_{10}$	806.7 kgCOD/d
$Q_w X_{f_{10}}$ or $f_{10} MX_w/Rs$	3441.4 kgCOD/d
FO_L	9505.3 kgO/d

N Mass balance	
TKN in (influent)	1071.11 kgN/d
TKN out	1071.11 kgN/d
N_{10}	118.00 kgN/d
N_{waste}	234.8 kgN/d
$N_{denitrified}$	718.3 kgN/d

TOD balance	
TOD in (influent)	18648.31 kgTOD/d
TOD out	18648.31 kgTOD/d
$TOD_{effluent}$	923.72 kgTOD/d
TOD_{waste}	4522.42 kgTOD/d
TOD_{N_2-gas}	2054.33 kgTOD/d
FO_L	11147.84 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S_{100}	36.30	75	30 mgCOD/l
Unbiol Sol Org N	N_{100}	0.90	-	- mgN/l
FSA-N	N_{90}	0.44	6	2 mgFSA-N/l
TKN-N	N_{10}	1.34	-	- mgTKN-N/l
Nitrate	N_{10}	4.08	15	1.5 mgNO ₃ -N/l
Unbiol Sol Org P	P_{100}	0.60	-	- mgP/l
Ortho P as P	P_{90}	10.58	10	2.5 mgP/l
TP	P_{10}	11.18	-	- mgP/l

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	7319	24397	58553	90270
Concentration TSS (kgTSS/m ³)	4.00	8.00	8.00	7.399
Volume (m ³)	1830	3050	7320	12200
Concentration VSS (kgVSS/m ³)	2.43	4.86	4.86	4.50
UPO VSS Concentration (kgUPOVSS/m ³)	0.477	0.954	0.954	0.882

Mass TSS wasted per day 3610.8 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 451.4 m³/d

COD mass balance	
COD in (influent)	13753.3 kgCOD/d
COD out	13753.3 kgCOD/d
$Q_s S_{10} + Q_w S_{10}$	806.7 kgCOD/d
$Q_w X_{f_{10}}$ or $f_{10} MX_w/Rs$	3250.5 kgCOD/d
FO_L	9696.2 kgO/d

N Mass balance	
TKN in (influent)	1071.11 kgN/d
TKN out	1071.11 kgN/d
N_{10}	117.76 kgN/d
N_{waste}	221.9 kgN/d
$N_{denitrified}$	731.4 kgN/d

TOD balance	
TOD in (influent)	18648.31 kgTOD/d
TOD out	18648.31 kgTOD/d
$TOD_{effluent}$	915.21 kgTOD/d
TOD_{waste}	4272.48 kgTOD/d
TOD_{N_2-gas}	2091.89 kgTOD/d
FO_L	11368.74 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S_{100}	36.30	75	30 mgCOD/l
Unbiol Sol Org N	N_{100}	0.90	-	- mgN/l
FSA-N	N_{90}	0.36	6	2 mgFSA-N/l
TKN-N	N_{10}	1.26	-	- mgTKN-N/l
Nitrate	N_{10}	4.15	15	1.5 mgNO ₃ -N/l
Unbiol Sol Org P	P_{100}	0.60	-	- mgP/l
Ortho P as P	P_{90}	10.95	10	2.5 mgP/l
TP	P_{10}	11.55	-	- mgP/l

UCT Reactor @ 30 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	22.22 Ml/d
Sludge Age	SRT	30.0 days
Reactor TSS concentration	X _T	9667.28 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	619	13753
BPO COD	Sbpi	479	10642
UPO COD	Supi	29	638
	fs'up		0.046
VFA COD	Sbsi,a	0.0	0
FBSO COD	Sbsfi	75	1667
BSO COD	Sbsi	75	1667
USO COD	Susi	36.3	807
	fs'us		0.059
BO COD	Sbi	554	12309
UO COD	Sui	65	1444
TSS		241	5349
ISS		51.4	1142
VSS		189	4207
UPO VSS		19.4	431
BPO VSS		170	3776
TKN	Nti	48.2	1071
Org N	Noi	13.8	307
FSA	Nai	34.4	764
BSO	Nobsi	2.90	64
USO	Nousi	0.90	20
BPO	Nobpi	8.70	193
UPO	Noupi	1.30	29
Total P	Pti	15.50	344
OP	Pai	12.80	284
Org P	Poi	2.70	60
BSO	Pobsi	0.70	16
USO	Pousi	0.60	13
BPO	Pobpi	0.78	17
UPO	Poupi	0.62	14

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _o	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{ov}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _e	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,fbs}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,u}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,u}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,u}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2141 /d
	μ _{hmax20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{amT}	0.2829 /d
	b _{h20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0357 /d
	K _{s20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{sT}	0.6288 mgFSA/l
	K _{s20}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{sT}	0.3472
	K _{s20}	0.101
Denitrification	θ	1.08
for ND system	K _{sT}	0.0742
Half Saturation Coefficient	K _{sT}	0.255
Denitrification	K _{s20}	0.108
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K _{s20}	0.1874

Factor of safety reducing μ _{amT}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _m	6.76 days
SRT _m (with safety factor)	SRT _m	8.45 Nitrifies!

Max unaerated sludge mass fraction	f _{xm}	0.70
Total unaerated sludge mass fraction	f _{xt}	0.35
Anoxic mass fraction primary anox 2	f _{x prim anox 2}	0.27
Anaerobic mass fraction	f _{anox}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments 2

r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N _{tr}	4.6 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{O2,L}	0.0 mgO/l

influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	1.92% :1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)	f _{Sb/s}	0.135

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	22.22 Ml/d
Sludge Age	SRT	30.0 days
Reactor TSS concentration	X _T	9263 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	619	13753
BPO COD	Sbpi	479	10642
UPO COD	Supi	29	638
	fs'up		0.046
VFA COD	Sbsi,a	0	0
FBSO COD	Sbsfi	75	1667
BSO COD	Sbsi	75	1667
USO COD	Susi	36	807
	fs'us		0.059
BO COD	Sbi	554	12309
UO COD	Sui	65	1444
TSS		241	5349
ISS		51	1142
VSS		189	4207
UPO VSS		19	431
BPO VSS		170	3776
TKN	Nti	48	1071
Org N	Noi	14	307
FSA	Nai	34	764
BSO	Nobsi	2.90	64
USO	Nousi	0.90	20
BPO	Nobpi	8.70	193
UPO	Noupi	1.30	29
Total P	Pti	15.50	344
OP	Pai	12.80	284
Org P	Poi	2.70	60
BSO	Pobsi	0.70	16
USO	Pousi	0.60	13
BPO	Pobpi	0.78	17
UPO	Poupi	0.62	14

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _o	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{ov}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _e	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,fbs}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,u}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,u}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,u}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate OHO	b _{HT}	0.2691 /d
	μ _{hmax20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{amT}	0.7157 /d
	b _{h20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0448 /d
	K _{s20}	1.0
Nitrification	θ	1.123
Half Saturation Coefficient	K _{sT}	1.5904
	K _{s20}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{sT}	1.4930
	K _{s20}	0.101
Denitrification	θ	1.08
for ND system	K _{sT}	0.1374
Half Saturation Coefficient	K _{sT}	0.255
Denitrification	K _{s20}	0.108
primary anoxic of NDBPER system	θ	1.08
Half Saturation Coefficient	K _{s20}	0.3469

Factor of safety reducing μ _{amT}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _m	2.38 days
SRT _m (with safety factor)	SRT _m	2.98 Nitrifies!

Max unaerated sludge mass fraction	f _{xm}	0.86
Total unaerated sludge mass fraction	f _{xt}	0.35
Anoxic mass fraction primary anox 2	f _{x prim anox 2}	0.27
Anaerobic mass fraction	f _{anox}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments 2

r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N _{tr}	4.6 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{O2,L}	0.0 mgO/l

influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	1.9 :1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)	f _{Sb/s}	0.135

UCT Reactor @ 30 Days SRT

Influent TKN	N_0	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_L	222 kgN/d
Equiv conc in influent	N_i	9.98 mgN/l
Effluent Sol Unbiode Org N	N_{unb}	0.90 mgN/l
Effluent ammonia	N_{NH}	0.38 mgFSA-N/l
TKN in effluent	N_{de}	1.28 mgTKN-N/l
Nitrification capacity	N_L	36.94 mgN/l influent

Denitrification potential BSO (K1)	D_{BBSO}	1.0 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BPO}	48.57 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{d1}	49.56 mgNO ₂ -N/l influent

	A	0.6993
	B	-9.8938
	C	71.860
Optimal a-recycle ratio	a_{opt}	19.44
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00
	set = a_{opt} for balanced UCT	
	recycle limited	

Effluent Nitrate if recycle limited		4.14 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		-7.74 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{NH}	4.14 mgNO ₃ -N/l influent

Effluent total N (TKN + NO ₃)	$N_{NH} + N_{de}$	5.42 mgN/l
N removal		88.8%

Alkalinity consumed by nitrification		264 mg CaCO ₃
Alkalinity recovered by denitrification		117 mg CaCO ₃
Total Alkalinity consumption		147 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	S_{HSLA}	0 mgCOD/l
FBSO COD	S_{HSL}	75 mgCOD/l
BSO COD	S_{HSL}	75 mgCOD/l
BO COD	S_{HSL}	554 mgCOD/l

S_{FJ} reduction due to O ₂ & NO ₃		39.71498628 mgCOD/l
Reduced FBSO concentration	$S_{FJ,COHV}$	35.28501372 mgCOD/l

	$k_{F,120}$	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	$k_{F,T}$	0.0535 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	S_{DHN}	MX_{BSO}/Q_L	S_{DHN}	
Trial 1	0.00	943		4.31
Trial 2	4.31	959		4.24
Trial 3	4.24	959		4.24
Trial 4	4.24	959		4.24

Flux BO COD obtained by OHO's	95%	11713 kgCOD/d
Flux BO COD obtained by PAO's	5%	596 kgCOD/d
Check total BO COD		12309 kgCOD/d

correct
12309

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{G20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{GT}	0.0357 /d

Activated Sludge Masses

<u>OHO VSS</u>		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	21305 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	27365 kgVSS

<u>PAO VSS</u>		
Polyphosphate Acc Organisms VSS	MX_{PAO}	3884 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	1039 kgVSS

Unbiodegradable Organic VSS	MX_{UO}	12919 kgVSS
Total VSS	MX_V	66513 kgVSS

ISS from influent		34273 kgTSS
ISS of OHO's		3196 kgTSS
ISS of PAO's		5114 kgTSS
ISS	MX_{DO}	42582 kgTSS
TSS	MX_T	109095 kgTSS
VSS/TSS ratio		0.610 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.380 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.07 mgP/l
biomass P-content	ΔP_{OHO}	2.49 mgP/l
Potential P-removal		4.56 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.07 mgP/l
biomass P-content	ΔP_{OHO}	2.49 mgP/l
Total Actual P-removal		4.56 mgP/l

TP effluent P_{de} 10.94 mgP/l

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	9311 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	353 kgO/d
Carbonaceous Oxygen flux	FO_C	9663 kgO/d
Nitrogenous Oxygen flux	FO_N	3752 kgO/d
Oxygen dmdnd recover by denitrification	FO_D	2085 kgO/d
Total Oxygen Demand ($FO_C + FO_N + FO_D$)	FO_T	11330 kgO/d
Oxygen utilisation rate	O_r	64.5 mgO/l.h

Influent TKN	N_0	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_L	210 kgN/d
Equiv conc in influent	N_i	9.46 mgN/l
Effluent Sol Unbiode Org N	N_{unb}	0.90 mgN/l
Effluent ammonia	N_{NH}	0.32 mgFSA-N/l
TKN in effluent	N_{de}	1.22 mgTKN-N/l
Nitrification capacity	N_L	37.51 mgN/l influent

Denitrification potential BSO (K1)	D_{BBSO}	1.0 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BPO}	73.51 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{d1}	74.47 mgNO ₂ -N/l influent

	A	0.6993
	B	-34.2388
	C	143.629
Optimal a-recycle ratio	a_{opt}	52.85
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00
	recycle limited	

Effluent Nitrate if recycle limited		4.20 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		-32.09 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{NH}	4.20 mgNO ₃ -N/l influent

Effluent total N (TKN + NO ₃)	$N_{NH} + N_{de}$	5.43 mgN/l
N removal		88.7%

Alkalinity consumed by nitrification		268 mg CaCO ₃
Alkalinity recovered by denitrification		119 mg CaCO ₃
Total Alkalinity consumption		149 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	S_{HSLA}	0 mgCOD/l
FBSO COD	S_{HSL}	75 mgCOD/l
BSO COD	S_{HSL}	75 mgCOD/l
BO COD	S_{HSL}	554 mgCOD/l

S_{FJ} reduction due to O ₂ & NO ₃		39.71498628 mgCOD/l
Reduced FBSO concentration	$S_{FJ,COHV}$	35.28501372 mgCOD/l

	$k_{F,120}$	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	$k_{F,T}$	0.0673 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	S_{DHN}	MX_{BSO}/Q_L	S_{DHN}	
Trial 1	0.00	772		4.19
Trial 2	4.19	784		4.12
Trial 3	4.12	784		4.12
Trial 4	4.12	784		4.12

Flux BO COD obtained by OHO's	95%	11708 kgCOD/d
Flux BO COD obtained by PAO's	5%	601 kgCOD/d
Check total BO COD		12309 kgCOD/d

correct

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{G20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{GT}	0.0448 /d

Activated Sludge Masses

<u>OHO VSS</u>		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	17422 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	28127 kgVSS

<u>PAO VSS</u>		
Polyphosphate Acc Organisms VSS	MX_{PAO}	3459 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	1163 kgVSS

Unbiodegradable Organic VSS	MX_{UO}	12919 kgVSS
Total VSS	MX_V	63091 kgVSS

ISS from influent		34273 kgTSS
ISS of OHO's		2613 kgTSS
ISS of PAO's		4554 kgTSS
ISS	MX_{DO}	41440 kgTSS
TSS	MX_T	104531 kgTSS
VSS/TSS ratio		0.604 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.38 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	1.84 mgP/l
biomass P-content	ΔP_{OHO}	2.37 mgP/l
Potential P-removal		4.21 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	1.84 mgP/l
biomass P-content	ΔP_{OHO}	2.37 mgP/l
Total Actual P-removal		4.21 mgP/l

TP effluent P_{de} 11.29 mgP/l

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	9459 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	373 kgO/d
Carbonaceous Oxygen flux	FO_C	9832 kgO/d
Nitrogenous Oxygen flux	FO_N	3810 kgO/d
Oxygen dmdnd recover by denitrification	FO_D	2117 kgO/d
Total Oxygen Demand ($FO_C + FO_N + FO_D$)	FO_T	11525 kgO/d
Oxygen utilisation rate	O_r	65.6 mgO/l.h

UCT Reactor @ 30 Days SRT

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Check	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	8846	29485	70764	109095
Concentration TSS (kgTSS/m ³)	4.83	9.67	9.67	8.942
Volume (m ³)	1830	3050	7320	12200
Volume fraction	15%	25%	60%	100%
Concentration VSS (kgVSS/m ³)	2.95	5.89	5.89	5.45
UPO VSS Concentration (kgUPOVSS/m ³)	0.572	1.145	1.145	1.059

Mass TSS wasted per day 3636.5 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 376.2 m³/d

COD mass balance	
COD in (influent)	13753.3 kgCOD/d
COD out	13753.3 kgCOD/d
$Q_u S_{10} + Q_w S_{10}$	806.7 kgCOD/d
$Q_u X_u f_{cv} \text{ or } f_{cv} MX_u/Rs$	3283.5 kgCOD/d
FO_L	9663.2 kgO/d

N Mass balance	
TKN in (influent)	1071.11 kgN/d
TKN out	1071.11 kgN/d
N_{10}	118.37 kgN/d
N_{waste}	223.7 kgN/d
$N_{denitrified}$	729.0 kgN/d

TOD balance	
TOD in (influent)	18648.31 kgTOD/d
TOD out	18648.31 kgTOD/d
$TOD_{effluent}$	920.69 kgTOD/d
TOD_{waste}	4312.58 kgTOD/d
$TOD_{N_2 \text{ gas}}$	2084.91 kgTOD/d
FO_L	11330.12 kgTOD/d

Effluent Concentrations		General	Special	Unit	
Unbiol Sol COD	S_{100}	36.30	75	30	mgCOD/l
Unbiol Sol Org N	N_{1000}	0.90	-	-	mgN/l
FSA-N	N_{10}	0.38	6	2	mgFSA-N/l
TKN-N	N_{10}	1.28	-	-	mgTKN-N/l
Nitrate	N_{10}	4.14	15	1.5	mgNO ₃ -N/l
Unbiol Sol Org P	P_{1000}	0.60	-	-	mgP/l
Ortho P as P	P_{10}	10.94	10	2.5	mgP/l
TP	P_{10}	11.54	-	-	mgP/l

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	8475	28252	67804	104531
Concentration TSS (kgTSS/m ³)	4.63	9.26	9.26	8.568
Volume (m ³)	1830	3050	7320	12200
Concentration VSS (kgVSS/m ³)	2.80	5.59	5.59	5.17
UPO VSS Concentration (kgUPOVSS/m ³)	0.572	1.145	1.145	1.059

Mass TSS wasted per day 3484.4 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 376.2 m³/d

COD mass balance	
COD in (influent)	13753.3 kgCOD/d
COD out	13753.3 kgCOD/d
$Q_u S_{10} + Q_w S_{10}$	806.7 kgCOD/d
$Q_u X_u f_{cv} \text{ or } f_{cv} MX_u/Rs$	3114.6 kgCOD/d
FO_L	9832.1 kgO/d

N Mass balance	
TKN in (influent)	1071.11 kgN/d
TKN out	1071.11 kgN/d
N_{10}	118.53 kgN/d
N_{waste}	212.3 kgN/d
$N_{denitrified}$	740.2 kgN/d

TOD balance	
TOD in (influent)	18648.31 kgTOD/d
TOD out	18648.31 kgTOD/d
$TOD_{effluent}$	915.02 kgTOD/d
TOD_{waste}	4091.42 kgTOD/d
$TOD_{N_2 \text{ gas}}$	2117.09 kgTOD/d
FO_L	11524.78 kgTOD/d

Effluent Concentrations		General	Special	Unit	
Unbiol Sol COD	S_{100}	36.30	75	30	mgCOD/l
Unbiol Sol Org N	N_{1000}	0.90	-	-	mgN/l
FSA-N	N_{10}	0.32	6	2	mgFSA-N/l
TKN-N	N_{10}	1.22	-	-	mgTKN-N/l
Nitrate	N_{10}	4.20	15	1.5	mgNO ₃ -N/l
Unbiol Sol Org P	P_{1000}	0.60	-	-	mgP/l
Ortho P as P	P_{10}	11.29	10	2.5	mgP/l
TP	P_{10}	11.89	-	-	mgP/l

**Annexure A6 – Detailed Reactor Model for Influent
Flow of 45 ML/d**

MLE Reactor @ 10 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	20.0 MI/d
Sludge Age	SRT	10.0 days
Reactor TSS concentration	X _r	3183 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti 619	12378
BPO COD	Sbpi 479	9578
UPO COD	Supi 29	574
	fs'up 0.0464	
VFA COD	Sbsi,a 0.0	0
FBSO COD	Sbsfi 75	1500
BSO COD	Sbsi 75	1500
USO COD	Susi 36.3	726
	fs'us 0.0587	
BO COD	Sbi 554	11078
UO COD	Sui 65	1300
TSS	241	4815
ISS	51.4	1028
VSS	189	3786
UPO VSS	19.4	388
BPO VSS	170	3399
TKN	Nti 48.2	964
Org N	Noi 13.8	276
FSA	Nai 34.4	688
BSO	Nobsi 2.90	58
USO	Nousi 0.90	18
BPO	Nobpi 8.70	174
UPO	Noupi 1.30	26
Total P	Pti 15.50	310
OP	Pai 12.80	256
Org P	Poi 2.70	54
BSO	Pobsi 0.70	14
USO	Pousi 0.60	12
BPO	Pobpi 0.78	16
UPO	Poupi 0.62	12

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,upo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,upo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,upo}	0.518 mgC/mgVSS

Temperature dependant coefficients

	T	16 °C
	b _{H20}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2141 /d
	μ _{Am20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.2829 /d
	b _{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0357 /d
	K _{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K _{HT}	0.6288 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	15873 kgVSS
Endogenous Residue VSS	MX _{EH}	6796 kgVSS
Unbiodegradeable Organic VSS	MX _{lv}	3878 kgVSS
Total VSS	MX _v	26547 kgVSS
ISS from influent		10282 kgISS
ISS of OHO's		2381 kgISS
ISS	MX _{IOI}	12663 kgISS
TSS	MX _t	39209 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{hn}	14.8 hr

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	20.0 MI/d
Sludge Age	SRT	10.0 days
Reactor TSS concentration	X _T	3000 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti 618.9	12378
BPO COD	Sbpi 479	9578
UPO COD	Supi 29	574
	fs'up 0.04637	
VFA COD	Sbsi,a 0	0
FBSO COD	Sbsfi 75	1500
BSO COD	Sbsi 75	1500
USO COD	Susi 36.3	726
	fs'us 0.05865	
BO COD	Sbi 554	11078
UO COD	Sui 65	1300
TSS	240.72727	4815
ISS	51.4	1028
VSS	189.31818	3786
UPO VSS	19.39	388
BPO VSS	170	3399
TKN	Nti 48.2	964
Org N	Noi 13.8	276
FSA	Nai 34.4	688
BSO	Nobsi 2.90	58.0
USO	Nousi 0.90	18.0
BPO	Nobpi 8.70	174
UPO	Noupi 1.30	26
Total P	Pti 15.5	310
OP	Pai 12.8	256
Org P	Poi 2.7	54.0
BSO	Pobsi 0.7	14.0
USO	Pousi 0.6	12
BPO	Pobpi 0.78	16
UPO	Poupi 0.62	12.41

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,upo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,upo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,upo}	0.518 mgC/mgVSS

Temperature dependant coefficients

	T	24 °C
	b _{H20}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2691 /d
	μ _{Am20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.7157 /d
	b _{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0448 /d
	K _{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K _{HT}	1.5904 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	13507 kgVSS
Endogenous Residue VSS	MX _{EH}	7269 kgVSS
Unbiodegradeable Organic VSS	MX _{lv}	3878 kgVSS
Total VSS	MX _v	24654 kgVSS
ISS from influent		10282 kgISS
ISS of OHO's		2026 kgISS
ISS	MX _{IOI}	12308 kgISS
TSS	MX _t	36962 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{hn}	14.8 hr

MLE Reactor @ 10 Days SRT

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X _{BH}	1288 mgVSS/l
Endogenous Residue VSS	X _{EH}	552 mgVSS/l
Unbiodegradable Organic VSS	X _I	315 mgVSS/l
Total VSS	X _V	2155 mgVSS/l
Influent Biodegradable ISS	X _{IOI}	1028 mgISS/l
TSS	X _t	3183 mgTSS/l

Active fraction of VSS	f _{av}	0.598 kgVSS/kgVSS
Active fraction of TSS	f _{at}	0.405 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.677 kgVSS/kgTSS

Waste Flow Rate	Q _w	1232 m ³ /d
TSS wasted per day		3921 kgTSS/d
VSS wasted per day		2655 kgVSS/d

Flux of N in waste VSS	FN _s	265 kgN/d
Equiv conc in influent	N _s	13.27 mgN/l influent
Effluent Sol Unbiodeg Org N	N _{ouse}	0.90 mgN/l

Factor of safety reducing μ _{AMT}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.148
Minimum sludge age for nitrification	SRT _m	4.87 days
SRT _m with Safety factor	SRT _{m (Sf)}	6.09 Nitrifies!

If no nitrification		
Effluent NO ₃	N _{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	34.9 mgTKN-N/l
Effluent FSA-N	N _{ae} = N _{an}	34.0 mgFSA-N/l

If complete nitrification		
Effluent NO ₃	N _{ne}	34.0 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	0.9 mgTKN-N/l
Effluent FSA-N	N _{ae}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	N _{ne} = N _c	33.22 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	1.71 mgTKN-N/l
(calculated N _{ae})	(N _{ae})	0.810 mgFSA-N/l
Effluent FSA-N	N _{ae}	0.810 mgFSA-N/l
Nitrifier sludge mass	MX _{BA}	489.6 kgVSS

Denitrification	K ₁₍₂₀₎	0.72 mgFSA/l
Half Saturation Coefficient	Θ	1.2
	K _{1T}	0.3472 mgFSA/l
Denitrification	K ₂₍₂₀₎	0.101 mgFSA/l
Half Saturation Coefficient	Θ	1.08
	K _{2T}	0.0742 mgFSA/l

s-recycle ratio	s	1.00 :1
s-recycle DO concentration	O _s	1.0 mgO/l
a-recycle DO concentration	O _a	2.0 mgO/l

Max unaerated sludge mass fraction	f _{xm}	0.401
Anoxic sludge mass fraction	f _{x1}	0.148 set = f_{xm} for balanced MLE
Min anoxic sludge mass fraction	f _{x1min}	0.032

Influent RBCOD fraction (Sbsi/Sbi)	f _{sb's}	0.135

Denitrification potential BSO (K1)	D _{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D _{pBPO}	8.74 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D _{p1}	17.49 mgNO ₃ -N/l influent

	A	0.6993
	B	17.4756
	C	1.062
Optimal a-recycle ratio	a _{opt}	0.06
Maximum practical a-recycle ratio	a _{max}	6
chosen a-recycle ratio	a	0.00 set = a_{opt} for balanced MLE
recycle limited		

Effluent Nitrate if recycle limited		16.61 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		16.08 mgNO ₃ -N/l
Actual Effluent Nitrate	N _{ne}	16.61 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	N _{ne} + N _{te}	18.32 mgN/l
N removal		62.0%

Volume of Primary Anoxic Tank	V _{anox}	1828 m ³
Volume of Aerobic Tank	V _{aer}	10492 m ³

Carbonaceous Oxygen flux	FO _c	7721 kgO/d
Nitrogenous Oxygen flux	FO _N	3036 kgO/d
Oxygen dmnd recover by denitrification	FO _D	950 kgO/d
Total Oxygen Demand (FO _c + FO _N - FO _D)	FO _T	9807 kgO/d
Oxygen utilisation rate	O _T	38.9 mgO/l.h

Alkalinity consumed by nitrification		237 mg CaCO ₃
Alkalinity recovered by denitrification		59 mg CaCO ₃
Total Alkalinity consumption		178 mg CaCO ₃

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X _{BH}	1096 mgVSS/l
Endogenous Residue VSS	X _{EH}	590 mgVSS/l
Unbiodegradable Organic VSS	X _I	315 mgVSS/l
Total VSS	X _V	2001 mgVSS/l
Influent Biodegradable ISS	X _{IOI}	999 mgISS/l
TSS	X _t	3000 mgTSS/l

Active fraction of VSS	f _{av}	0.548 kgVSS/kgVSS
Active fraction of TSS	f _{at}	0.365 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.667 kgVSS/kgTSS

Waste Flow Rate	Q _w	1232 m ³ /d
TSS wasted per day		3696 kgTSS/d
VSS wasted per day		2465 kgVSS/d

Flux of N in waste VSS	FN _s	247 kgN/d
Equiv conc in influent	N _s	12.33 mgN/l influent
Effluent Sol Unbiodeg Org N	N _{ouse}	0.90 mgN/l

Factor of safety reducing μ _{AMT}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.148
Minimum sludge age for nitrification	SRT _m	1.77 days
SRT _m with Safety factor	SRT _{m (Sf)}	2.21 Nitrifies!

If no nitrification		
Effluent NO ₃	N _{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	35.9 mgTKN-N/l
Effluent FSA-N	N _{ae} = N _{an}	35.0 mgFSA-N/l

If complete nitrification		
Effluent NO ₃	N _{ne}	35.0 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	0.9 mgTKN-N/l
Effluent FSA-N	N _{ae}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	N _{ne} = N _c	34.48 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	1.40 mgTKN-N/l
(calculated N _{ae})	(N _{ae})	0.496 mgFSA-N/l
Effluent FSA-N	N _{ae}	0.496 mgFSA-N/l
Nitrifier sludge mass	MX _{BA}	476.1 kgVSS

Denitrification	K ₁₍₂₀₎	0.72 mgFSA/l
Half Saturation Coefficient	Θ	1.2
	K _{1T}	1.4930 mgFSA/l
Denitrification	K ₂₍₂₀₎	0.101 mgFSA/l
Half Saturation Coefficient	Θ	1.08
	K _{2T}	0.1374 mgFSA/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O _s	1.0 mgO/l
a-recycle DO concentration	O _a	2.0 mgO/l

Max unaerated sludge mass fraction	f _{xm}	0.747
Anoxic sludge mass fraction	f _{x1}	0.148
Min anoxic sludge mass fraction	f _{x1min}	0.009

Influent RBCOD fraction (Sbsi/Sbi)	f _{sb's}	0.135

Denitrification potential BSO (K1)	D _{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D _{pBPO}	13.77 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D _{p1}	22.52 mgNO ₃ -N/l influent

	A	0.6993
	B	13.7091
	C	9.856
Optimal a-recycle ratio	a _{opt}	0.69
Maximum practical a-recycle ratio	a _{max}	6
chosen a-recycle ratio	a	0.00
recycle limited		

Effluent Nitrate if recycle limited		17.24 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		12.31 mgNO ₃ -N/l
Actual Effluent Nitrate	N _{ne}	17.24 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	N _{ne} + N _{te}	18.63 mgN/l
N removal		61.3%

Volume of Primary Anoxic Tank	V _{anox}	1828 m ³
Volume of Aerobic Tank	V _{aer}	10492 m ³

Carbonaceous Oxygen flux	FO _c	8001 kgO/d
Nitrogenous Oxygen flux	FO _N	3151 kgO/d
Oxygen dmnd recover by denitrification	FO _D	986 kgO/d
Total Oxygen Demand (FO _c + FO _N - FO _D)	FO _T	10166 kgO/d
Oxygen utilisation rate	O _T	40.4 mgO/l.h

Alkalinity consumed by nitrification		246 mg CaCO ₃
Alkalinity recovered by denitrification		62 mg CaCO ₃
Total Alkalinity consumption		185 mg CaCO ₃

MLE Reactor @ 10 Days SRT

COD mass balance	
COD in (influent)	12378.0 kgCOD/d
COD out	12378.4 kgCOD/d
$Q_e S_{Te} + Q_w S_{Te}$	726.0 kgCOD/d
$Q_w X_v f_{cv}$	3931.6 kgCOD/d
$V_p O_c$	7720.8 kgO/d

COD mass balance	
COD in (influent)	12378.0 kgCOD/d
COD out	12378.4 kgCOD/d
$Q_e S_{Te} + Q_w S_{Te}$	726.0 kgCOD/d
$Q_w X_v f_{cv}$	3651.3 kgCOD/d
$V_p O_c$	8001.1 kgO/d

MLE Reactor @ 10 Days SRT

N mass balance		
N in (influent)		964.0 kgTKN-N/d
N out		964.0 kgTKN-N/d
$Q_e N_{te} + Q_w N_{te}$		34.2 kgTKN-N/d
$Q N_s$		265.5 kgTKN-N/d
$Q N_{ne}$		664.3 kgNO3-N/d

TOD balance		
TOD in (influent)		16783.48 kgTOD/d
TOD out		16783.87 kgTOD/d
$TOD_{effluent}$		827.97 kgTOD/d
TOD_{waste}		5199.11 kgTOD/d
TOD_{N_2-gas}		949.99 kgTOD/d
FO_t		9806.80 kgTOD/d

Flux of P in waste VSS	FP_s	66 kgP/d
Equiv conc in influent	P_s	3.32 mgP/l
Effluent Sol Unbiod Org P	P_{ouse}	0.60 mgP/l
Effluent TP	P_{te}	12.18 mgP/l
Effluent Ortho-P as P	P_{oe}	11.58 mgOP-P/l

N mass balance		
N in (influent)		964.0 kgTKN-N/d
N out		964.0 kgTKN-N/d
$Q_e N_{te} + Q_w N_{te}$		27.9 kgTKN-N/d
$Q N_s$		246.5 kgTKN-N/d
$Q N_{ne}$		689.5 kgNO3-N/d

TOD balance		
TOD in (influent)		16783.48 kgTOD/d
TOD out		16783.87 kgTOD/d
$TOD_{effluent}$		800.99 kgTOD/d
TOD_{waste}		4830.56 kgTOD/d
TOD_{N_2-gas}		986.05 kgTOD/d
FO_t		10166.26 kgTOD/d

Flux of P in waste VSS	FP_s	62 kgP/d
Equiv conc in influent	P_s	3.08 mgP/l
Effluent Sol Unbiod Org P	P_{ouse}	0.00 mgP/l
Effluent TP	P_{te}	12.42 mgP/l
Effluent Ortho-P as P	P_{oe}	12.42 mgOP-P/l

Effluent Concentrations			General	Special	Unit	Effluent Concentrations			General	Special	Unit
Unbiod Sol COD	S_{use}	36.30	<75	<30	mgCOD	Unbiod Sol COD	S_{use}	36.30	<75	<30	mgCOD/l
Undiod Sol Org N	N_{ouse}	0.90	-	-	mgN/l	Undiod Sol Org N	N_{ouse}	0.90	-	-	mgN/l
FSA-N	N_{ae}	0.81	<6	<2	mgFSA	FSA-N	N_{ae}	0.50	<6	<2	mgFSA-N/l
TKN-N	N_{te}	1.71	-	-	mgTKN	TKN-N	N_{te}	1.40	-	-	mgTKN-N/l
Nitrate	N_{ne}	16.61	<15	<1.5	mgNO ₃	Nitrate	N_{ne}	17.24	<15	<1.5	mgNO ₃ -N/l
Undiod Sol Org P	P_{ouse}	0.60	-	-	mgP/l	Undiod Sol Org P	P_{ouse}	0.00	-	-	mgP/l
Ortho P as P	P_{oe}	11.58	<10	<2.5	mgOP-P	Ortho P as P	P_{oe}	12.42	<10	<2.5	mgOP-P/l
TP	P_{te}	12.18	-	-	mgP/l	TP	P_{te}	12.42	-	-	mgP/l

MLE Reactor @ 15 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	20.0 MI/d
Sludge Age	SRT	15.0 days
Reactor TSS concentration	X _r	4307 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti 619	12378
BPO COD	Sbpi 479	9578
UPO COD	Supi 29	574
	fs'up	0.0464
VFA COD	Sbsi,a 0.0	0
FBSO COD	Sbsfi 75	1500
BSO COD	Sbsi 75	1500
USO COD	Susi 36.3	726
	fs'us	0.0587
BO COD	Sbi 554	11078
UO COD	Sui 65	1300
TSS	241	4815
ISS	51.4	1028
VSS	189	3786
UPO VSS	19.4	388
BPO VSS	170	3399
TKN	Nti 48.2	964
Org N	Noi 13.8	276
FSA	Nai 34.4	688
BSO	Nobsi 2.90	58
USO	Nousi 0.90	18
BPO	Nobpi 8.70	174
UPO	Noupi 1.30	26
Total P	Pti 15.50	310
OP	Pai 12.80	256
Org P	Poi 2.70	54
BSO	Pobsi 0.70	14
USO	Pousi 0.60	12
BPO	Pobpi 0.78	16
UPO	Poupi 0.62	12

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,upo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,upo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,upo}	0.518 mgC/mgVSS

Temperature dependant coefficients

	T	16 °C
	b _{H20}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2141 /d
	μ _{Am20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.2829 /d
	b _{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0357 /d
	K _{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K _{HT}	0.6288 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	17757 kgVSS
Endogenous Residue VSS	MX _{EH}	11404 kgVSS
Unbiodegradeable Organic VSS	MX _{lv}	5818 kgVSS
Total VSS	MX _v	34979 kgVSS
ISS from influent		15423 kgISS
ISS of OHO's		2664 kgISS
ISS	MX _{IOI}	18086 kgISS
TSS	MX _t	53065 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{hn}	14.8 hr

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	20.0 MI/d
Sludge Age	SRT	15.0 days
Reactor TSS concentration	X _T	4083 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti 618.9	12378
BPO COD	Sbpi 479	9578
UPO COD	Supi 29	574
	fs'up	0.04637
VFA COD	Sbsi,a 0	0
FBSO COD	Sbsfi 75	1500
BSO COD	Sbsi 75	1500
USO COD	Susi 36.3	726
	fs'us	0.05865
BO COD	Sbi 554	11078
UO COD	Sui 65	1300
TSS	240.72727	4815
ISS	51.4	1028
VSS	189.31818	3786
UPO VSS	19.39	388
BPO VSS	170	3399
TKN	Nti 48.2	964
Org N	Noi 13.8	276
FSA	Nai 34.4	688
BSO	Nobsi 2.90	58.0
USO	Nousi 0.90	18.0
BPO	Nobpi 8.70	174
UPO	Noupi 1.30	26
Total P	Pti 15.5	310
OP	Pai 12.8	256
Org P	Poi 2.7	54.0
BSO	Pobsi 0.7	14.0
USO	Pousi	12
BPO	Pobpi 0.78	16
UPO	Poupi 0.62	12.41

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,upo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,upo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,upo}	0.518 mgC/mgVSS

Temperature dependant coefficients

	T	24 °C
	b _{H20}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2691 /d
	μ _{Am20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.7157 /d
	b _{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0448 /d
	K _{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K _{HT}	1.5904 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	14848 kgVSS
Endogenous Residue VSS	MX _{EH}	11986 kgVSS
Unbiodegradeable Organic VSS	MX _{lv}	5818 kgVSS
Total VSS	MX _v	32651 kgVSS
ISS from influent		15423 kgISS
ISS of OHO's		2227 kgISS
ISS	MX _{IOI}	17650 kgISS
TSS	MX _t	50301 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{hn}	14.8 hr

MLE Reactor @ 15 Days SRT

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	1441 mgVSS/l
Endogenous Residue VSS	X_{EH}	926 mgVSS/l
Unbiodegradable Organic VSS	X_I	472 mgVSS/l
Total VSS	X_V	2839 mgVSS/l
Influent Biodegradable ISS	X_{IOI}	1468 mgISS/l
TSS	X_t	4307 mgTSS/l

Active fraction of VSS	f_{av}	0.508 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.335 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.659 kgVSS/kgTSS

Waste Flow Rate	Q_w	821 m ³ /d
TSS wasted per day		3538 kgTSS/d
VSS wasted per day		2332 kgVSS/d

Flux of N in waste VSS	FN_s	233 kgN/d
Equiv conc in influent	N_s	11.66 mgN/l influent
Effluent Sol Unbiodeg Org N	N_{ouse}	0.90 mgN/l

Factor of safety reducing $\mu_{A_{MT}}$	Sf	1.25
total unaerated mass fraction	fxt	0.148
Minimum sludge age for nitrification	SRT_m	4.87 days
SRT_m with Safety factor	$SRT_{m(SF)}$	6.09 Nitrifies!

If no nitrification		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	36.5 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	35.6 mgFSA-N/l

If complete nitrification		
Effluent NO ₃	N_{ne}	35.6 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ae}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	35.18 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	1.36 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.464 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.464 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	687.4 kgVSS

Denitrification	$K_{1(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	Θ	1.2
	K_{1T}	0.3472 mgFSA/l
Denitrification	$K_{2(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	Θ	1.08
	K_{2T}	0.0742 mgFSA/l

s-recycle ratio	s	1.00 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.548
Anoxic sludge mass fraction	f_{x1}	0.148 set = f_{xm} for balanced MLE
Min anoxic sludge mass fraction	f_{x1min}	0.028

Influent RBCOD fraction (Sbsi/Sbi)	$f_{sb's}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	9.78 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	18.53 mgNO ₃ -N/l influent

	A	0.6993
	B	18.3974
	C	1.179
Optimal a-recycle ratio	a_{opt}	0.06
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00 set = a_{opt} for balanced MLE
recycle limited		

Effluent Nitrate if recycle limited		17.59 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		17.00 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	17.59 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{te}$	18.95 mgN/l
N removal		60.7%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Carbonaceous Oxygen flux	FO_c	8199 kgO/d
Nitrogenous Oxygen flux	FO_N	3215 kgO/d
Oxygen dmnd recover by denitrification	FO_D	1006 kgO/d
Total Oxygen Demand ($FO_c + FO_N - FO_D$)	FO_T	10408 kgO/d
Oxygen utilisation rate	O_T	41.3 mgO/l.h

Alkalinity consumed by nitrification		251 mg CaCO ₃
Alkalinity recovered by denitrification		63 mg CaCO ₃
Total Alkalinity consumption		188 mg CaCO ₃

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	1205 mgVSS/l
Endogenous Residue VSS	X_{EH}	973 mgVSS/l
Unbiodegradable Organic VSS	X_I	472 mgVSS/l
Total VSS	X_V	2650 mgVSS/l
Influent Biodegradable ISS	X_{IOI}	1433 mgISS/l
TSS	X_t	4083 mgTSS/l

Active fraction of VSS	f_{av}	0.455 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.295 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.649 kgVSS/kgTSS

Waste Flow Rate	Q_w	821 m ³ /d
TSS wasted per day		3353 kgTSS/d
VSS wasted per day		2177 kgVSS/d

Flux of N in waste VSS	FN_s	218 kgN/d
Equiv conc in influent	N_s	10.88 mgN/l influent
Effluent Sol Unbiodeg Org N	N_{ouse}	0.90 mgN/l

Factor of safety reducing $\mu_{A_{MT}}$	Sf	1.25
total unaerated mass fraction	fxt	0.148
Minimum sludge age for nitrification	SRT_m	1.77 days
SRT_m with Safety factor	$SRT_{m(SF)}$	2.21 Nitrifies!

If no nitrification		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	37.3 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	36.4 mgFSA-N/l

If complete nitrification		
Effluent NO ₃	N_{ne}	36.4 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ae}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	36.06 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	1.26 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.356 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.356 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	646.7 kgVSS

Denitrification	$K_{1(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	Θ	1.2
	K_{1T}	1.4930 mgFSA/l
Denitrification	$K_{2(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	Θ	1.08
	K_{2T}	0.1374 mgFSA/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.805
Anoxic sludge mass fraction	f_{x1}	0.148
Min anoxic sludge mass fraction	f_{x1min}	0.008

Influent RBCOD fraction (Sbsi/Sbi)	$f_{sb's}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	15.14 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	23.88 mgNO ₃ -N/l influent

	A	0.6993
	B	13.9251
	C	11.007
Optimal a-recycle ratio	a_{opt}	0.76
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00
recycle limited		

Effluent Nitrate if recycle limited		18.03 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		12.53 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	18.03 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{te}$	19.29 mgN/l
N removal		60.0%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Carbonaceous Oxygen flux	FO_c	8429 kgO/d
Nitrogenous Oxygen flux	FO_N	3296 kgO/d
Oxygen dmnd recover by denitrification	FO_D	1031 kgO/d
Total Oxygen Demand ($FO_c + FO_N - FO_D$)	FO_T	10693 kgO/d
Oxygen utilisation rate	O_T	42.5 mgO/l.h

Alkalinity consumed by nitrification		257 mg CaCO ₃
Alkalinity recovered by denitrification		64 mg CaCO ₃
Total Alkalinity consumption		193 mg CaCO ₃

MLE Reactor @ 15 Days SRT

COD mass balance	
COD in (influent)	12378.0 kgCOD/d
COD out	12378.4 kgCOD/d
$Q_e S_{Te} + Q_w S_{Te}$	726.0 kgCOD/d
$Q_w X_v f_{cv}$	3453.6 kgCOD/d
$V_p O_c$	8198.8 kgO/d

COD mass balance	
COD in (influent)	12378.0 kgCOD/d
COD out	12378.4 kgCOD/d
$Q_e S_{Te} + Q_w S_{Te}$	726.0 kgCOD/d
$Q_w X_v f_{cv}$	3223.8 kgCOD/d
$V_p O_c$	8428.6 kgO/d

MLE Reactor @ 15 Days SRT

N mass balance		
N in (influent)		964.0 kgTKN-N/d
N out		964.0 kgTKN-N/d
$Q_u N_{ie} + Q_w N_{te}$		27.3 kgTKN-N/d
$Q N_s$		233.2 kgTKN-N/d
$Q N_{ne}$		703.5 kgNO3-N/d

TOD balance		
TOD in (influent)		16783.48 kgTOD/d
TOD out		16783.87 kgTOD/d
$TOD_{effluent}$		815.76 kgTOD/d
TOD_{waste}		4554.19 kgTOD/d
TOD_{N_2-gas}		1006.04 kgTOD/d
FO_t		10407.88 kgTOD/d

Flux of P in waste VSS	FP_s	58 kgP/d
Equiv conc in influent	P_s	2.91 mgP/l
Effluent Sol Unbiod Org P	P_{ouse}	0.60 mgP/l
Effluent TP	P_{te}	12.59 mgP/l
Effluent Ortho-P as P	P_{oe}	11.99 mgOP-P/l

N mass balance		
N in (influent)		964.0 kgTKN-N/d
N out		964.0 kgTKN-N/d
$Q_u N_{ie} + Q_w N_{te}$		25.1 kgTKN-N/d
$Q N_s$		217.7 kgTKN-N/d
$Q N_{ne}$		721.2 kgNO3-N/d

TOD balance		
TOD in (influent)		16783.48 kgTOD/d
TOD out		16783.87 kgTOD/d
$TOD_{effluent}$		806.28 kgTOD/d
TOD_{waste}		4253.08 kgTOD/d
TOD_{N_2-gas}		1031.32 kgTOD/d
FO_t		10693.19 kgTOD/d

Flux of P in waste VSS	FP_s	54 kgP/d
Equiv conc in influent	P_s	2.72 mgP/l
Effluent Sol Unbiod Org P	P_{ouse}	0.00 mgP/l
Effluent TP	P_{te}	12.78 mgP/l
Effluent Ortho-P as P	P_{oe}	12.78 mgOP-P/l

Effluent Concentrations			General	Special	Unit	Effluent Concentrations			General	Special	Unit
Unbiod Sol COD	S_{use}	36.30	<75	<30	mgCOD	Unbiod Sol COD	S_{use}	36.30	<75	<30	mgCOD/l
Undiod Sol Org N	N_{ouse}	0.90	-	-	mgN/l	Undiod Sol Org N	N_{ouse}	0.90	-	-	mgN/l
FSA-N	N_{ae}	0.46	<6	<2	mgFSA-N	FSA-N	N_{ae}	0.36	<6	<2	mgFSA-N/l
TKN-N	N_{te}	1.36	-	-	mgTKN	TKN-N	N_{te}	1.26	-	-	mgTKN-N/l
Nitrate	N_{ne}	17.59	<15	<1.5	mgNO ₃	Nitrate	N_{ne}	18.03	<15	<1.5	mgNO ₃ -N/l
Undiod Sol Org P	P_{ouse}	0.60	-	-	mgP/l	Undiod Sol Org P	P_{ouse}	0.00	-	-	mgP/l
Ortho P as P	P_{oe}	11.99	<10	<2.5	mgOP-P	Ortho P as P	P_{oe}	12.78	<10	<2.5	mgOP-P/l
TP	P_{te}	12.59	-	-	mgP/l	TP	P_{te}	12.78	-	-	mgP/l

MLE Reactor @ 20 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	20.0 MI/d
Sludge Age	SRT	20.0 days
Reactor TSS concentration	X _r	5373 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti 619	12378
BPO COD	Sbpi 479	9578
UPO COD	Supi 29	574
	fs'up	0.0464
VFA COD	Sbsi,a 0.0	0
FBSO COD	Sbsfi 75	1500
BSO COD	Sbsi 75	1500
USO COD	Susi 36.3	726
	fs'us	0.0587
BO COD	Sbi 554	11078
UO COD	Sui 65	1300
TSS	241	4815
ISS	51.4	1028
VSS	189	3786
UPO VSS	19.4	388
BPO VSS	170	3399
TKN	Nti 48.2	964
Org N	Noi 13.8	276
FSA	Nai 34.4	688
BSO	Nobsi 2.90	58
USO	Nousi 0.90	18
BPO	Nobpi 8.70	174
UPO	Noupi 1.30	26
Total P	Pti 15.50	310
OP	Pai 12.80	256
Org P	Poi 2.70	54
BSO	Pobsi 0.70	14
USO	Pousi 0.60	12
BPO	Pobpi 0.78	16
UPO	Poupi 0.62	12

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,upo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,upo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,upo}	0.518 mgC/mgVSS

Temperature dependant coefficients

	T	16 °C
	b _{H20}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2141 /d
	μ _{Am20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.2829 /d
	b _{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0357 /d
	K _{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K _{HT}	0.6288 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	18878 kgVSS
Endogenous Residue VSS	MX _{EH}	16165 kgVSS
Unbiodegradable Organic VSS	MX _{iv}	7757 kgVSS
Total VSS	MX _v	42800 kgVSS
ISS from influent		20564 kgISS
ISS of OHO's		2832 kgISS
ISS	MX _{IOI}	23395 kgISS
TSS	MX _t	66195 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{hn}	14.8 hr

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	20.0 MI/d
Sludge Age	SRT	20.0 days
Reactor TSS concentration	X _T	5122 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti 618.9	12378
BPO COD	Sbpi 479	9578
UPO COD	Supi 29	574
	fs'up	0.04637
VFA COD	Sbsi,a 0	0
FBSO COD	Sbsfi 75	1500
BSO COD	Sbsi 75	1500
USO COD	Susi 36.3	726
	fs'us	0.05865
BO COD	Sbi 554	11078
UO COD	Sui 65	1300
TSS	240.72727	4815
ISS	51.4	1028
VSS	189.31818	3786
UPO VSS	19.39	388
BPO VSS	170	3399
TKN	Nti 48.2	964
Org N	Noi 13.8	276
FSA	Nai 34.4	688
BSO	Nobsi 2.90	58.0
USO	Nousi 0.90	18.0
BPO	Nobpi 8.70	174
UPO	Noupi 1.30	26
Total P	Pti 15.5	310
OP	Pai 12.8	256
Org P	Poi 2.7	54.0
BSO	Pobsi 0.7	14.0
USO	Pousi 0.6	12
BPO	Pobpi 0.78	16
UPO	Poupi 0.62	12.41

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,upo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,upo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,upo}	0.518 mgC/mgVSS

Temperature dependant coefficients

	T	24 °C
	b _{H20}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2691 /d
	μ _{Am20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.7157 /d
	b _{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0448 /d
	K _{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K _{HT}	1.5904 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	15624 kgVSS
Endogenous Residue VSS	MX _{EH}	16816 kgVSS
Unbiodegradable Organic VSS	MX _{iv}	7757 kgVSS
Total VSS	MX _v	40196 kgVSS
ISS from influent		20564 kgISS
ISS of OHO's		2344 kgISS
ISS	MX _{IOI}	22907 kgISS
TSS	MX _t	63103 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{hn}	14.8 hr

MLE Reactor @ 20 Days SRT

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	1532 mgVSS/l
Endogenous Residue VSS	X_{EH}	1312 mgVSS/l
Unbiodegradable Organic VSS	X_I	630 mgVSS/l
Total VSS	X_V	3474 mgVSS/l
Influent Biodegradable ISS	X_{IOI}	1899 mgISS/l
TSS	X_t	5373 mgTSS/l

Active fraction of VSS	f_{av}	0.441 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.285 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.647 kgVSS/kgTSS

Waste Flow Rate	Q_w	616 m ³ /d
TSS wasted per day		3310 kgTSS/d
VSS wasted per day		2140 kgVSS/d

Flux of N in waste VSS	FN_s	214 kgN/d
Equiv conc in influent	N_s	10.70 mgN/l influent
Effluent Sol Unbiodeg Org N	N_{ouse}	0.90 mgN/l

Factor of safety reducing $\mu_{A_{MT}}$	Sf	1.25
total unaerated mass fraction	fxt	0.148
Minimum sludge age for nitrification	SRT_m	4.87 days
SRT_m with Safety factor	$SRT_{m(SF)}$	6.09 Nitrifies!

If no nitrification		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	37.5 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	36.6 mgFSA-N/l

If complete nitrification		
Effluent NO ₃	N_{ne}	36.6 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ae}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	36.25 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	1.25 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.347 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.347 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	846.3 kgVSS

Denitrification	$K_{1(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	Θ	1.2
	K_{1T}	0.3472 mgFSA/l
Denitrification	$K_{2(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	Θ	1.08
	K_{2T}	0.0742 mgFSA/l

s-recycle ratio	s	1.00 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.621
Anoxic sludge mass fraction	f_{x1}	0.148 set = f_{xm} for balanced MLE
Min anoxic sludge mass fraction	f_{x1min}	0.027

Influent RBCOD fraction (Sbsi/Sbi)	$f_{sb's}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	10.40 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	19.14 mgNO ₃ -N/l influent

	A	0.6993
	B	18.8571
	C	1.336
Optimal a-recycle ratio	a_{opt}	0.07
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00 set = a_{opt} for balanced MLE
recycle limited		

Effluent Nitrate if recycle limited		18.13 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		17.46 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	18.13 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{te}$	19.37 mgN/l
N removal		59.8%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Carbonaceous Oxygen flux	FO_c	8483 kgO/d
Nitrogenous Oxygen flux	FO_N	3314 kgO/d
Oxygen dmnd recover by denitrification	FO_D	1037 kgO/d
Total Oxygen Demand ($FO_c + FO_N - FO_D$)	FO_T	10760 kgO/d
Oxygen utilisation rate	O_T	42.7 mgO/l.h

Alkalinity consumed by nitrification		259 mg CaCO ₃
Alkalinity recovered by denitrification		65 mg CaCO ₃
Total Alkalinity consumption		194 mg CaCO ₃

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	1268 mgVSS/l
Endogenous Residue VSS	X_{EH}	1365 mgVSS/l
Unbiodegradable Organic VSS	X_I	630 mgVSS/l
Total VSS	X_V	3263 mgVSS/l
Influent Biodegradable ISS	X_{IOI}	1859 mgISS/l
TSS	X_t	5122 mgTSS/l

Active fraction of VSS	f_{av}	0.389 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.248 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.637 kgVSS/kgTSS

Waste Flow Rate	Q_w	616 m ³ /d
TSS wasted per day		3155 kgTSS/d
VSS wasted per day		2010 kgVSS/d

Flux of N in waste VSS	FN_s	201 kgN/d
Equiv conc in influent	N_s	10.05 mgN/l influent
Effluent Sol Unbiodeg Org N	N_{ouse}	0.90 mgN/l

Factor of safety reducing $\mu_{A_{MT}}$	Sf	1.25
total unaerated mass fraction	fxt	0.148
Minimum sludge age for nitrification	SRT_m	1.77 days
SRT_m with Safety factor	$SRT_{m(SF)}$	2.21 Nitrifies!

If no nitrification		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	38.2 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	37.3 mgFSA-N/l

If complete nitrification		
Effluent NO ₃	N_{ne}	37.3 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ae}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	36.96 mgNO ₃ -N/l
Effluent TKN-N	N_{te}	1.19 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.293 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.293 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	779.3 kgVSS

Denitrification	$K_{1(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	Θ	1.2
	K_{1T}	1.4930 mgFSA/l
Denitrification	$K_{2(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	Θ	1.08
	K_{2T}	0.1374 mgFSA/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.834
Anoxic sludge mass fraction	f_{x1}	0.148
Min anoxic sludge mass fraction	f_{x1min}	0.007

Influent RBCOD fraction (Sbsi/Sbi)	$f_{sb's}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	15.93 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	24.67 mgNO ₃ -N/l influent

	A	0.6993
	B	14.0322
	C	11.691
Optimal a-recycle ratio	a_{opt}	0.80
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00
recycle limited		

Effluent Nitrate if recycle limited		18.48 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		12.63 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	18.48 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{te}$	19.67 mgN/l
N removal		59.2%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Carbonaceous Oxygen flux	FO_c	8676 kgO/d
Nitrogenous Oxygen flux	FO_N	3378 kgO/d
Oxygen dmnd recover by denitrification	FO_D	1057 kgO/d
Total Oxygen Demand ($FO_c + FO_N - FO_D$)	FO_T	10997 kgO/d
Oxygen utilisation rate	O_T	43.7 mgO/l.h

Alkalinity consumed by nitrification		264 mg CaCO ₃
Alkalinity recovered by denitrification		66 mg CaCO ₃
Total Alkalinity consumption		198 mg CaCO ₃

MLE Reactor @ 20 Days SRT

COD mass balance	
COD in (influent)	12378 kgCOD/d
COD out	12378 kgCOD/d
$Q_e S_{Te} + Q_w S_{Te}$	726 kgCOD/d
$Q_w X_v f_{cv}$	3169 kgCOD/d
$V_p O_c$	8483 kgO/d

COD mass balance	
COD in (influent)	12378 kgCOD/d
COD out	12378 kgCOD/d
$Q_e S_{Te} + Q_w S_{Te}$	726.0 kgCOD/d
$Q_w X_v f_{cv}$	2976.5 kgCOD/d
$V_p O_c$	8675.9 kgO/d

MLE Reactor @ 20 Days SRT

N mass balance		
N in (influent)		964.0 kgTKN-N/d
N out		964.0 kgTKN-N/d
$Q_u N_{1e} + Q_w N_{1e}$		24.9 kgTKN-N/d
$Q N_s$		214.0 kgTKN-N/d
$Q N_{ne}$		725.1 kgNO3-N/d

TOD balance		
TOD in (influent)		16784 kgTOD/d
TOD out		16784 kgTOD/d
$TOD_{effluent}$		814 kgTOD/d
TOD_{waste}		4173 kgTOD/d
TOD_{N_2-gas}		1037 kgTOD/d
FO_t		10760 kgTOD/d

Flux of P in waste VSS	FP_s	53 kgP/d
Equiv conc in influent	P_s	2.67 mgP/l
Effluent Sol Unbiod Org P	P_{ouse}	0.60 mgP/l
Effluent TP	P_{te}	12.83 mgP/l
Effluent Ortho-P as P	P_{oe}	12.23 mgOP-P/l

N mass balance		
N in (influent)		964.0 kgTKN-N/d
N out		964.0 kgTKN-N/d
$Q_u N_{1e} + Q_w N_{1e}$		23.9 kgTKN-N/d
$Q N_s$		201.0 kgTKN-N/d
$Q N_{ne}$		739.2 kgNO3-N/d

TOD balance		
TOD in (influent)		16784 kgTOD/d
TOD out		16784 kgTOD/d
$TOD_{effluent}$		809 kgTOD/d
TOD_{waste}		3921 kgTOD/d
TOD_{N_2-gas}		1057 kgTOD/d
FO_t		10997 kgTOD/d

Flux of P in waste VSS	FP_s	50 kgP/d
Equiv conc in influent	P_s	2.51 mgP/l
Effluent Sol Unbiod Org P	P_{ouse}	0.00 mgP/l
Effluent TP	P_{te}	12.99 mgP/l
Effluent Ortho-P as P	P_{oe}	12.99 mgOP-P/l

Effluent Concentrations			General	Special	Unit	Effluent Concentrations			General	Special	Unit
Unbiod Sol COD	S_{use}	36.30	<75	<30	mgCOD	Unbiod Sol COD	S_{use}	36.30	<75	<30	mgCOD/l
Undiod Sol Org N	N_{ouse}	0.90	-	-	mgN/l	Undiod Sol Org N	N_{ouse}	0.90	-	-	mgN/l
FSA-N	N_{ae}	0.35	<6	<2	mgFSA	FSA-N	N_{ae}	0.29	<6	<2	mgFSA-N/l
TKN-N	N_{te}	1.25	-	-	mgTKN	TKN-N	N_{te}	1.19	-	-	mgTKN-N/l
Nitrate	N_{ne}	18.13	<15	<1.5	mgNO ₃	Nitrate	N_{ne}	18.48	<15	<1.5	mgNO ₃ -N/l
Undiod Sol Org P	P_{ouse}	0.60	-	-	mgP/l	Undiod Sol Org P	P_{ouse}	0.00	-	-	mgP/l
Ortho P as P	P_{oe}	12.23	<10	<2.5	mgOP-P	Ortho P as P	P_{oe}	12.99	<10	<2.5	mgOP-P/l
TP	P_{te}	12.83	-	-	mgP/l	TP	P_{te}	12.99	-	-	mgP/l

MLE Reactor @ 25 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	20.0 MI/d
Sludge Age	SRT	25.0 days
Reactor TSS concentration	X _r	6410 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti 619	12378
BPO COD	Sbpi 479	9578
UPO COD	Supi 29	574
	fs'up	0.0464
VFA COD	Sbsi,a 0.0	0
FBSO COD	Sbsfi 75	1500
BSO COD	Sbsi 75	1500
USO COD	Susi 36.3	726
	fs'us	0.0587
BO COD	Sbi 554	11078
UO COD	Sui 65	1300
TSS	241	4815
ISS	51.4	1028
VSS	189	3786
UPO VSS	19.4	388
BPO VSS	170	3399
TKN	Nti 48.2	964
Org N	Noi 13.8	276
FSA	Nai 34.4	688
BSO	Nobsi 2.90	58
USO	Nousi 0.90	18
BPO	Nobpi 8.70	174
UPO	Noupi 1.30	26
Total P	Pti 15.50	310
OP	Pai 12.80	256
Org P	Poi 2.70	54
BSO	Pobsi 0.70	14
USO	Pousi 0.60	12
BPO	Pobpi 0.78	16
UPO	Poupi 0.62	12

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,upo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,upo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,upo}	0.518 mgC/mgVSS

Temperature dependant coefficients

	T	16 °C
	b _{H20}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2141 /d
	μ _{Am20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.2829 /d
	b _{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0357 /d
	K _{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K _{HT}	0.6288 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	19621 kgVSS
Endogenous Residue VSS	MX _{EH}	21001 kgVSS
Unbiodegradable Organic VSS	MX _{iv}	9696 kgVSS
Total VSS	MX _v	50318 kgVSS
ISS from influent		25705 kgISS
ISS of OHO's		2943 kgISS
ISS	MX _{IOI}	28648 kgISS
TSS	MX _t	78966 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{hn}	14.8 hr

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	20.0 MI/d
Sludge Age	SRT	25.0 days
Reactor TSS concentration	X _T	6140 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti 618.9	12378
BPO COD	Sbpi 479	9578
UPO COD	Supi 29	574
	fs'up	0.04637
VFA COD	Sbsi,a 0	0
FBSO COD	Sbsfi 75	1500
BSO COD	Sbsi 75	1500
USO COD	Susi 36.3	726
	fs'us	0.05865
BO COD	Sbi 554	11078
UO COD	Sui 65	1300
TSS	240.72727	4815
ISS	51.4	1028
VSS	189.31818	3786
UPO VSS	19.39	388
BPO VSS	170	3399
TKN	Nti 48.2	964
Org N	Noi 13.8	276
FSA	Nai 34.4	688
BSO	Nobsi 2.90	58.0
USO	Nousi 0.90	18.0
BPO	Nobpi 8.70	174
UPO	Noupi 1.30	26
Total P	Pti 15.5	310
OP	Pai 12.8	256
Org P	Poi 2.7	54.0
BSO	Pobsi 0.7	14.0
USO	Pousi 0.6	12
BPO	Pobpi 0.78	16
UPO	Poupi 0.62	12.41

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,upo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,upo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,upo}	0.518 mgC/mgVSS

Temperature dependant coefficients

	T	24 °C
	b _{H20}	0.24 /d
	Θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2691 /d
	μ _{Am20}	0.45 /d
	Θ	1.123
nitrifiers max spec. growth rate	μ _{AmT}	0.7157 /d
	b _{A20}	0.0400 /d
	Θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0448 /d
	K _{n20}	1.0 mgFSA/l
Nitrification	Θ	1.123
Half Saturation Coefficient	K _{HT}	1.5904 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	16129 kgVSS
Endogenous Residue VSS	MX _{EH}	21700 kgVSS
Unbiodegradable Organic VSS	MX _{iv}	9696 kgVSS
Total VSS	MX _v	47525 kgVSS
ISS from influent		25705 kgISS
ISS of OHO's		2419 kgISS
ISS	MX _{IOI}	28124 kgISS
TSS	MX _t	75649 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{hn}	14.8 hr

MLE Reactor @ 25 Days SRT

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X _{BH}	1593 mgVSS/l
Endogenous Residue VSS	X _{EH}	1705 mgVSS/l
Unbiodegradable Organic VSS	X _I	787 mgVSS/l
Total VSS	X _V	4084 mgVSS/l
Influent Biodegradable ISS	X _{IOI}	2325 mgISS/l
TSS	X _t	6410 mgTSS/l

Active fraction of VSS	f _{av}	0.390 kgVSS/kgVSS
Active fraction of TSS	f _{at}	0.248 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.637 kgVSS/kgTSS

Waste Flow Rate	Q _w	493 m ³ /d
TSS wasted per day		3159 kgTSS/d
VSS wasted per day		2013 kgVSS/d

Flux of N in waste VSS	FN _s	201 kgN/d
Equiv conc in influent	N _s	10.06 mgN/l influent
Effluent Sol Unbiodeg Org N	N _{ouse}	0.90 mgN/l

Factor of safety reducing μ _{AMT}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.148
Minimum sludge age for nitrification	SRT _m	4.87 days
SRT _m with Safety factor	SRT _{m (Sf)}	6.09 Nitrifies!

<u>If no nitrification</u>		
Effluent NO ₃	N _{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	38.1 mgTKN-N/l
Effluent FSA-N	N _{ae} = N _{an}	37.2 mgFSA-N/l

<u>If complete nitrification</u>		
Effluent NO ₃	N _{ne}	37.2 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	0.9 mgTKN-N/l
Effluent FSA-N	N _{ae}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	N _{ne} = N _c	36.95 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	1.19 mgTKN-N/l
(calculated N _{ae})	(N _{ae})	0.288 mgFSA-N/l
Effluent FSA-N	N _{ae}	0.288 mgFSA-N/l
Nitrifier sludge mass	MX _{BA}	976.5 kgVSS

Denitrification	K ₁₍₂₀₎	0.72 mgFSA/l
Half Saturation Coefficient	Θ	1.2
	K _{1T}	0.3472 mgFSA/l
	K ₂₍₂₀₎	0.101 mgFSA/l
Denitrification	Θ	1.08
Half Saturation Coefficient	K _{2T}	0.0742 mgFSA/l

s-recycle ratio	s	1.00 :1
s-recycle DO concentration	O _s	1.0 mgO/l
a-recycle DO concentration	O _a	2.0 mgO/l

Max unaerated sludge mass fraction	f _{xm}	0.666
Anoxic sludge mass fraction	f _{x1}	0.148 set = f_{xm} for balanced MLE
Min anoxic sludge mass fraction	f _{x1min}	0.026

Influent RBCOD fraction (Sbsi/Sbi)	f _{sb's}	0.135

Denitrification potential BSO (K1)	D _{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D _{pBPO}	10.81 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D _{p1}	19.55 mgNO ₃ -N/l influent

	A	0.6993
	B	19.1432
	C	1.459
Optimal a-recycle ratio	a _{opt}	0.08
Maximum practical a-recycle ratio	a _{max}	6
chosen a-recycle ratio	a	0.00 set = a_{opt} for balanced MLE
recycle limited		

Effluent Nitrate if recycle limited		18.47 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		17.74 mgNO ₃ -N/l
Actual Effluent Nitrate	N _{ne}	18.47 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	N _{ne} + N _{te}	19.66 mgN/l
N removal		59.2%

Volume of Primary Anoxic Tank	V _{anox}	1828 m ³
Volume of Aerobic Tank	V _{aer}	10492 m ³

Carbonaceous Oxygen flux	FO _c	8672 kgO/d
Nitrogenous Oxygen flux	FO _N	3377 kgO/d
Oxygen dmnd recover by denitrification	FO _D	1057 kgO/d
Total Oxygen Demand (FO _c + FO _N - FO _D)	FO _T	10992 kgO/d
Oxygen utilisation rate	O _T	43.7 mgO/l.h

Alkalinity consumed by nitrification		264 mg CaCO ₃
Alkalinity recovered by denitrification		66 mg CaCO ₃
Total Alkalinity consumption		198 mg CaCO ₃

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X _{BH}	1309 mgVSS/l
Endogenous Residue VSS	X _{EH}	1761 mgVSS/l
Unbiodegradable Organic VSS	X _I	787 mgVSS/l
Total VSS	X _V	3858 mgVSS/l
Influent Biodegradable ISS	X _{IOI}	2283 mgISS/l
TSS	X _t	6140 mgTSS/l

Active fraction of VSS	f _{av}	0.339 kgVSS/kgVSS
Active fraction of TSS	f _{at}	0.213 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.628 kgVSS/kgTSS

Waste Flow Rate	Q _w	493 m ³ /d
TSS wasted per day		3026 kgTSS/d
VSS wasted per day		1901 kgVSS/d

Flux of N in waste VSS	FN _s	190 kgN/d
Equiv conc in influent	N _s	9.50 mgN/l influent
Effluent Sol Unbiodeg Org N	N _{ouse}	0.90 mgN/l

Factor of safety reducing μ _{AMT}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.148
Minimum sludge age for nitrification	SRT _m	1.77 days
SRT _m with Safety factor	SRT _{m (Sf)}	2.21 Nitrifies!

<u>If no nitrification</u>		
Effluent NO ₃	N _{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	38.7 mgTKN-N/l
Effluent FSA-N	N _{ae} = N _{an}	37.8 mgFSA-N/l

<u>If complete nitrification</u>		
Effluent NO ₃	N _{ne}	37.8 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	0.9 mgTKN-N/l
Effluent FSA-N	N _{ae}	0.0 mgFSA-N/l

Nitrification Results		
Effluent NO ₃ if no denitrification	N _{ne} = N _c	37.54 mgNO ₃ -N/l
Effluent TKN-N	N _{te}	1.16 mgTKN-N/l
(calculated N _{ae})	(N _{ae})	0.257 mgFSA-N/l
Effluent FSA-N	N _{ae}	0.257 mgFSA-N/l
Nitrifier sludge mass	MX _{BA}	884.8 kgVSS

Denitrification	K ₁₍₂₀₎	0.72 mgFSA/l
Half Saturation Coefficient	Θ	1.2
	K _{1T}	1.4930 mgFSA/l
	K ₂₍₂₀₎	0.101 mgFSA/l
Denitrification	Θ	1.08
Half Saturation Coefficient	K _{2T}	0.1374 mgFSA/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O _s	1.0 mgO/l
a-recycle DO concentration	O _a	2.0 mgO/l

Max unaerated sludge mass fraction	f _{xm}	0.852
Anoxic sludge mass fraction	f _{x1}	0.148
Min anoxic sludge mass fraction	f _{x1min}	0.007

Influent RBCOD fraction (Sbsi/Sbi)	f _{sb's}	0.135

Denitrification potential BSO (K1)	D _{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D _{pBPO}	16.44 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D _{p1}	25.19 mgNO ₃ -N/l influent

	A	0.6993
	B	14.0969
	C	12.141
Optimal a-recycle ratio	a _{opt}	0.83
Maximum practical a-recycle ratio	a _{max}	6
chosen a-recycle ratio	a	0.00
recycle limited		

Effluent Nitrate if recycle limited		18.77 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		12.70 mgNO ₃ -N/l
Actual Effluent Nitrate	N _{ne}	18.77 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	N _{ne} + N _{te}	19.93 mgN/l
N removal		58.7%

Volume of Primary Anoxic Tank	V _{anox}	1828 m ³
Volume of Aerobic Tank	V _{aer}	10492 m ³

Carbonaceous Oxygen flux	FO _c	8837 kgO/d
Nitrogenous Oxygen flux	FO _N	3431 kgO/d
Oxygen dmnd recover by denitrification	FO _D	1074 kgO/d
Total Oxygen Demand (FO _c + FO _N - FO _D)	FO _T	11194 kgO/d
Oxygen utilisation rate	O _T	44.5 mgO/l.h

Alkalinity consumed by nitrification		268 mg CaCO ₃
Alkalinity recovered by denitrification		67 mg CaCO ₃
Total Alkalinity consumption		201 mg CaCO ₃

MLE Reactor @ 25 Days SRT

COD mass balance	
COD in (influent)	12378.0 kgCOD/d
COD out	12378.4 kgCOD/d
$Q_e S_{Te} + Q_w S_{Te}$	726.0 kgCOD/d
$Q_w X_v f_{cv}$	2980.9 kgCOD/d
$V_p O_c$	8671.5 kgO/d

COD mass balance	
COD in (influent)	12378.0 kgCOD/d
COD out	12378.4 kgCOD/d
$Q_e S_{Te} + Q_w S_{Te}$	726.0 kgCOD/d
$Q_w X_v f_{cv}$	2815.4 kgCOD/d
$V_p O_c$	8837.0 kgO/d

MLE Reactor @ 25 Days SRT

N mass balance		
N in (influent)		964.0 kgTKN-N/d
N out		964.0 kgTKN-N/d
$Q_u N_{ie} + Q_w N_{te}$		23.8 kgTKN-N/d
$Q N_s$		201.3 kgTKN-N/d
$Q N_{ne}$		739.0 kgNO3-N/d

TOD balance		
TOD in (influent)		16783.48 kgTOD/d
TOD out		16783.87 kgTOD/d
$TOD_{effluent}$		814.01 kgTOD/d
TOD_{waste}		3921.25 kgTOD/d
TOD_{N_2-gas}		1056.73 kgTOD/d
FO_t		10991.89 kgTOD/d

Flux of P in waste VSS	FP_s	50 kgP/d
Equiv conc in influent	P_s	2.52 mgP/l
Effluent Sol Unbiod Org P	P_{ouse}	0.60 mgP/l
Effluent TP	P_{te}	12.98 mgP/l
Effluent Ortho-P as P	P_{oe}	12.38 mgOP-P/l

N mass balance		
N in (influent)		964.0 kgTKN-N/d
N out		964.0 kgTKN-N/d
$Q_u N_{ie} + Q_w N_{te}$		23.1 kgTKN-N/d
$Q N_s$		190.1 kgTKN-N/d
$Q N_{ne}$		750.8 kgNO3-N/d

TOD balance		
TOD in (influent)		16783.48 kgTOD/d
TOD out		16783.87 kgTOD/d
$TOD_{effluent}$		811.27 kgTOD/d
TOD_{waste}		3704.61 kgTOD/d
TOD_{N_2-gas}		1073.58 kgTOD/d
FO_t		11194.40 kgTOD/d

Flux of P in waste VSS	FP_s	48 kgP/d
Equiv conc in influent	P_s	2.38 mgP/l
Effluent Sol Unbiod Org P	P_{ouse}	0.00 mgP/l
Effluent TP	P_{te}	13.12 mgP/l
Effluent Ortho-P as P	P_{oe}	13.12 mgOP-P/l

Effluent Concentrations			General	Special	Unit	Effluent Concentrations			General	Special	Unit
Unbiod Sol COD	S_{use}	36.30	<75	<30	mgCOD	Unbiod Sol COD	S_{use}	36.30	<75	<30	mgCOD/l
Undiod Sol Org N	N_{ouse}	0.90	-	-	mgN/l	Undiod Sol Org N	N_{ouse}	0.90	-	-	mgN/l
FSA-N	N_{ae}	0.29	<6	<2	mgFSA	FSA-N	N_{ae}	0.26	<6	<2	mgFSA-N/l
TKN-N	N_{te}	1.19	-	-	mgTKN	TKN-N	N_{te}	1.16	-	-	mgTKN-N/l
Nitrate	N_{ne}	18.47	<15	<1.5	mgNO ₃	Nitrate	N_{ne}	18.77	<15	<1.5	mgNO ₃ -N/l
Undiod Sol Org P	P_{ouse}	0.60	-	-	mgP/l	Undiod Sol Org P	P_{ouse}	0.00	-	-	mgP/l
Ortho P as P	P_{oe}	12.38	<10	<2.5	mgOP-P	Ortho P as P	P_{oe}	13.12	<10	<2.5	mgOP-P/l
TP	P_{te}	12.98	-	-	mgP/l	TP	P_{te}	13.12	-	-	mgP/l

MLE Reactor @ 30 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	20.0 Ml/d
Sludge Age	SRT	30.0 days
Reactor TSS concentration	X _r	7430 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti	619 12378
BPO COD	Sbpi	479 9578
UPO COD	Supi	29 574
	fs'up	0.0464
VFA COD	Sbsi,a	0 0
FBSO COD	Sbsfi	75 1500
BSO COD	Sbsi	75 1500
USO COD	Susi	36.3 726
	fs'us	0.0587
BO COD	Sbi	554 11078
UO COD	Sui	65 1300
TSS		241 4815
ISS		51.4 1028
VSS		189 3786
UPO VSS		19.4 388
BPO VSS		170 3399
TKN	Nti	48.2 964
Org N	Noi	13.8 276
FSA	Nai	34.4 688
BSO	Nobsi	2.90 58
USO	Nousi	0.90 18
BPO	Nobpi	8.70 174
UPO	Noupi	1.30 26
Total P	Pti	15.50 310
OP	Pai	12.80 256
Org P	Poi	2.70 54
BSO	Pobsi	0.70 14
USO	Pousi	0.60 12
BPO	Pobpi	0.78 16
UPO	Poupi	0.62 12

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{IOHO}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,upo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,upo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,upo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{i20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2141 /d
	μ _{am20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{amT}	0.2829 /d
	b _{a20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0357 /d
	K _{i20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{NT}	0.6288 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	20150 kgVSS
Endogenous Residue VSS	MX _{EH}	25881 kgVSS
Unbiodegradeable Organic VSS	MX _{Nv}	11635 kgVSS
Total VSS	MX _V	57666 kgVSS
ISS from influent		30845 kgISS
ISS of OHO's		3022 kgISS
ISS	MX _{IOI}	33868 kgISS
TSS	MX _T	91534 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{nh}	14.8 hr

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	20.0 Ml/d
Sludge Age	SRT	30.0 days
Reactor TSS concentration	X _T	7147 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti	618.9 12378
BPO COD	Sbpi	479 9578
UPO COD	Supi	29 574
	fs'up	0.04637
VFA COD	Sbsi,a	0 0
FBSO COD	Sbsfi	75 1500
BSO COD	Sbsi	75 1500
USO COD	Susi	36.3 726
	fs'us	0.05865
BO COD	Sbi	554 11078
UO COD	Sui	65 1300
TSS		240.72727 4815
ISS		51.4 1028
VSS		189.31818 3786
UPO VSS		19.39 388
BPO VSS		170 3399
TKN	Nti	48.2 964
Org N	Noi	13.8 276
FSA	Nai	34.4 688
BSO	Nobsi	2.90 58.0
USO	Nousi	0.90 18.0
BPO	Nobpi	8.70 174
UPO	Noupi	1.30 26
Total P	Pti	15.5 310
OP	Pai	12.8 256
Org P	Poi	2.7 54.0
BSO	Pobsi	0.7 14.0
USO	Pousi	
BPO	Pobpi	0.78 16
UPO	Poupi	0.62 12.41

Constants

COD/VSS ratio	f _{cv}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _H	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{Hv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _H	0.2
ISS content of OHO's	f _{IOHO}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,bso}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,upo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,upo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,upo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{i20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{HT}	0.2691 /d
	μ _{am20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{amT}	0.7157 /d
	b _{a20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{AT}	0.0448 /d
	K _{i20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{NT}	1.5904 mgFSA/l

Activated Sludge Masses

Ordinary Heterotrophic Organisms VSS	MX _{BH}	16485 kgVSS
Endogenous Residue VSS	MX _{EH}	26614 kgVSS
Unbiodegradeable Organic VSS	MX _{Nv}	11635 kgVSS
Total VSS	MX _V	54733 kgVSS
ISS from influent		30845 kgISS
ISS of OHO's		2473 kgISS
ISS	MX _{IOI}	33318 kgISS
TSS	MX _T	88052 kgTSS

Reactor Volume	V _p	12320 m ³
Nominal hydraulic retention time	R _{nh}	14.8 hr

MLE Reactor @ 30 Days SRT

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	1636 mgVSS/l
Endogenous Residue VSS	X_{EH}	2101 mgVSS/l
Unbiodegradable Organic VSS	X_i	944 mgVSS/l
Total VSS	X_v	4681 mgVSS/l
Influent Biodegradable ISS	X_{i0i}	2749 mgISS/l
TSS	X_t	7430 mgTSS/l

Active fraction of VSS	f_{av}	0.349 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.220 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.630 kgVSS/kgTSS

Waste Flow Rate	Q_w	411 m ³ /d
TSS wasted per day		3051 kgTSS/d
VSS wasted per day		1922 kgVSS/d

Flux of N in waste VSS	FN_b	192 kgN/d
Equiv conc in influent	N_i	9.61 mgN/l influent
Effluent Sol Unbiol Org N	N_{ouse}	0.90 mgN/l

Factor of safety reducing μ_{aerT}	Sf	1.25
total unaerated mass fraction	fxt	0.148
Minimum sludge age for nitrification	SRT _m	4.87 days
SRT _m with Safety factor	SRT _{m (SF)}	6.09 Nitrifies!

<u>If no nitrification</u>		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{ie}	38.6 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	37.7 mgFSA-N/l

<u>If complete nitrification</u>		
Effluent NO ₃	N_{ne}	37.7 mgNO ₃ -N/l
Effluent TKN-N	N_{ie}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ae}	0.0 mgFSA-N/l

<u>Nitrification Results</u>		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	37.44 mgNO ₃ -N/l
Effluent TKN-N	N_{ie}	1.15 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.252 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.252 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	1084.9 kgVSS

Denitrification	$K_{1(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	Θ	1.2
Denitrification	$K_{2(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	Θ	1.08
Denitrification	K_{1T}	0.3472 mgFSA/l
Half Saturation Coefficient	K_{2T}	0.0742 mgFSA/l

s-recycle ratio	s	1.00 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.695
Anoxic sludge mass fraction	f_{x1}	0.149 set = f_{xm} for balanced MLE
Min anoxic sludge mass fraction	f_{x1min}	0.025

Influent RBCOD fraction (Sbsi/Sbi)	$f_{Sb's}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	11.10 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	19.84 mgNO ₃ -N/l influent

A	0.6993	
B	19.3403	
C	1.553	
Optimal a-recycle ratio	a_{opt}	0.08
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00 set = a_{opt} for balanced MLE
recycle limited		

Effluent Nitrate if recycle limited		18.72 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		17.94 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	18.72 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{ie}$	19.87 mgN/l
N removal		58.8%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Carbonaceous Oxygen flux	FO_c	8806 kgO/d
Nitrogenous Oxygen flux	FO_n	3422 kgO/d
Oxygen dmnd recover by denitrification	FO_D	1071 kgO/d
Total Oxygen Demand ($FO_c + FO_n - FO_D$)	FO_T	11157 kgO/d
Oxygen utilisation rate	O_T	44.3 mgO/l.h

Alkalinity consumed by nitrification		267 mg CaCO ₃
Alkalinity recovered by denitrification		67 mg CaCO ₃
Total Alkalinity consumption		200 mg CaCO ₃

COD mass balance		
COD in (influent)		12378.0 kgCOD/d
COD out		12378.4 kgCOD/d

Activated Sludge Concentrations

Ordinary Heterotrophic Organisms VSS	X_{BH}	1338 mgVSS/l
Endogenous Residue VSS	X_{EH}	2160 mgVSS/l
Unbiodegradable Organic VSS	X_i	944 mgVSS/l
Total VSS	X_v	4443 mgVSS/l
Influent Biodegradable ISS	X_{i0i}	2704 mgISS/l
TSS	X_t	7147 mgTSS/l

Active fraction of VSS	f_{av}	0.301 kgVSS/kgVSS
Active fraction of TSS	f_{at}	0.187 kgVSS/kgTSS
VSS/TSS ratio	VSS/TSS	0.622 kgVSS/kgTSS

Waste Flow Rate	Q_w	411 m ³ /d
TSS wasted per day		2935 kgTSS/d
VSS wasted per day		1824 kgVSS/d

Flux of N in waste VSS	FN_b	182 kgN/d
Equiv conc in influent	N_i	9.12 mgN/l influent
Effluent Sol Unbiol Org N	N_{ouse}	0.90 mgN/l

Factor of safety reducing μ_{aerT}	Sf	1.25
total unaerated mass fraction	fxt	0.148
Minimum sludge age for nitrification	SRT _m	1.77 days
SRT _m with Safety factor	SRT _{m (SF)}	2.21 Nitrifies!

<u>If no nitrification</u>		
Effluent NO ₃	N_{ne}	0 mgNO ₃ -N/l
Effluent TKN-N	N_{ie}	39.1 mgTKN-N/l
Effluent FSA-N	$N_{ae} = N_{an}$	38.2 mgFSA-N/l

<u>If complete nitrification</u>		
Effluent NO ₃	N_{ne}	38.2 mgNO ₃ -N/l
Effluent TKN-N	N_{ie}	0.9 mgTKN-N/l
Effluent FSA-N	N_{ae}	0.0 mgFSA-N/l

<u>Nitrification Results</u>		
Effluent NO ₃ if no denitrification	$N_{ne} = N_c$	37.94 mgNO ₃ -N/l
Effluent TKN-N	N_{ie}	1.13 mgTKN-N/l
(calculated N_{ae})	(N_{ae})	0.234 mgFSA-N/l
Effluent FSA-N	N_{ae}	0.234 mgFSA-N/l
Nitrifier sludge mass	MX_{BA}	970.7 kgVSS

Denitrification	$K_{1(20)}$	0.72 mgFSA/l
Half Saturation Coefficient	Θ	1.2
Denitrification	$K_{2(20)}$	0.101 mgFSA/l
Half Saturation Coefficient	Θ	1.08
Denitrification	K_{1T}	1.4930 mgFSA/l
Half Saturation Coefficient	K_{2T}	0.1374 mgFSA/l

s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O_s	1.0 mgO/l
a-recycle DO concentration	O_a	2.0 mgO/l

Max unaerated sludge mass fraction	f_{xm}	0.863
Anoxic sludge mass fraction	f_{x1}	0.148
Min anoxic sludge mass fraction	f_{x1min}	0.007

Influent RBCOD fraction (Sbsi/Sbi)	$f_{Sb's}$	0.135

Denitrification potential BSO (K1)	D_{pBSO}	8.75 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{pBPO}	16.80 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	25.55 mgNO ₃ -N/l influent

A	0.6993	
B	14.1403	
C	12.460	
Optimal a-recycle ratio	a_{opt}	0.85
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	0.00
recycle limited		

Effluent Nitrate if recycle limited		18.97 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		12.74 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{ne}	18.97 mgNO ₃ -N/l

Effluent total N (TKN + NO ₃)	$N_{ne} + N_{ie}$	20.11 mgN/l
N removal		58.3%

Volume of Primary Anoxic Tank	V_{anox}	1828 m ³
Volume of Aerobic Tank	V_{aer}	10492 m ³

Carbonaceous Oxygen flux	FO_c	8950 kgO/d
Nitrogenous Oxygen flux	FO_n	3468 kgO/d
Oxygen dmnd recover by denitrification	FO_D	1085 kgO/d
Total Oxygen Demand ($FO_c + FO_n - FO_D$)	FO_T	11333 kgO/d
Oxygen utilisation rate	O_T	45.0 mgO/l.h

Alkalinity consumed by nitrification		271 mg CaCO ₃
Alkalinity recovered by denitrification		68 mg CaCO ₃
Total Alkalinity consumption		203 mg CaCO ₃

COD mass balance		
COD in (influent)		12378.0 kgCOD/d
COD out		12378.4 kgCOD/d

MLE Reactor @ 30 Days SRT

$Q_e S_{ie} + Q_w S_{ie}$	726.0 kgCOD/d
$Q_w X_v f_{cv}$	2846.8 kgCOD/d
$V_P O_c$	8805.6 kgO/d

$Q_e S_{ie} + Q_w S_{ie}$	726.0 kgCOD/d
$Q_w X_v f_{cv}$	2702.0 kgCOD/d
$V_P O_c$	8950.4 kgO/d

MLE Reactor @ 30 Days SRT

N mass balance	
N in (influent)	964.0 kgTKN-N/d
N out	964.0 kgTKN-N/d
$Q_e N_{te} + Q_w N_{te}$	23.0 kgTKN-N/d
$Q_e N_s$	192.2 kgTKN-N/d
$Q_e N_{ne}$	748.7 kgNO3-N/d

TOD balance	
TOD in (influent)	16783.48 kgTOD/d
TOD out	16783.87 kgTOD/d
$TOD_{effluent}$	814.26 kgTOD/d
TOD_{waste}	3742.27 kgTOD/d
TOD_{N_2-gas}	1070.69 kgTOD/d
FO_i	11156.65 kgTOD/d

Flux of P in waste VSS	FP_s	48 kgP/d
Equiv conc in influent	P_s	2.40 mgP/l
Effluent Sol Unbiod Org P	P_{ouse}	0.60 mgP/l
Effluent TP	P_{te}	13.10 mgP/l
Effluent Ortho-P as P	P_{oe}	12.50 mgOP-P/l

N mass balance	
N in (influent)	964.0 kgTKN-N/d
N out	964.0 kgTKN-N/d
$Q_e N_{te} + Q_w N_{te}$	22.7 kgTKN-N/d
$Q_e N_s$	182.4 kgTKN-N/d
$Q_e N_{ne}$	758.9 kgNO3-N/d

TOD balance	
TOD in (influent)	16783.48 kgTOD/d
TOD out	16783.87 kgTOD/d
$TOD_{effluent}$	812.61 kgTOD/d
TOD_{waste}	3552.82 kgTOD/d
TOD_{N_2-gas}	1085.19 kgTOD/d
FO_i	11333.24 kgTOD/d

Flux of P in waste VSS	FP_s	46 kgP/d
Equiv conc in influent	P_s	2.28 mgP/l
Effluent Sol Unbiod Org P	P_{ouse}	0.00 mgP/l
Effluent TP	P_{te}	13.22 mgP/l
Effluent Ortho-P as P	P_{oe}	13.22 mgOP-P/l

Effluent Concentrations			General	Special	Unit	Effluent Concentrations			General	Special	Unit
Unbiod Sol COD	S_{use}	36.30	<75	<30	mgCOD/l	Unbiod Sol COD	S_{use}	36.30	<75	<30	mgCOD/l
Undiod Sol Org N	N_{ouse}	0.90	-	-	mgN/l	Undiod Sol Org N	N_{ouse}	0.90	-	-	mgN/l
FSA-N	N_{ne}	0.25	<6	<2	mgFSA-N/l	FSA-N	N_{ne}	0.23	<6	<2	mgFSA-N/l
TKN-N	N_{te}	1.15	-	-	mgTKN-N/l	TKN-N	N_{te}	1.13	-	-	mgTKN-N/l
Nitrate	N_{ne}	18.72	<15	<1.5	mgNO ₃ -N/l	Nitrate	N_{ne}	18.97	<15	<1.5	mgNO ₃ -N/l
Undiod Sol Org P	P_{ouse}	0.60	-	-	mgP/l	Undiod Sol Org P	P_{ouse}	0.00	-	-	mgP/l
Ortho P as P	P_{oe}	12.50	<10	<2.5	mgOP-P/l	Ortho P as P	P_{oe}	13.22	<10	<2.5	mgOP-P/l
TP	P_{te}	13.10	-	-	mgP/l	TP	P_{te}	13.22	-	-	mgP/l

UCT Reactor @ 10 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	25.00 Ml/d
Sludge Age	SRT	10.0 days
Reactor TSS concentration	X _r	4708.74 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	619	15473
BPO COD	Sbpi	479	11973
UPO COD	Supi	29	718
	fS'up		0.046
VFA COD	Sbsi,a	0.0	0
FBSO COD	Sbsfi	75	1875
BSO COD	Sbsi	75	1875
USO COD	Susi	36.3	908
	fS'us		0.059
BO COD	Sbi	554	13848
UO COD	Sui	65	1625
TSS		241	6018
ISS		51.4	1285
VSS		189	4733
UPO VSS		19.4	484
BPO VSS		170	4248
TKN	Nti	48.2	1205
Org N	Noi	13.8	345
FSA	Nai	34.4	860
BSO	Nobsi	2.90	73
USO	Nousi	0.90	23
BPO	Nobpi	8.70	218
UPO	Noupi	1.30	33
Total P	Pti	15.50	388
OP	Pai	12.80	320
Org P	Poi	2.70	68
BSO	Pobsi	0.70	18
USO	Pousi	0.60	15
BPO	Pobpi	0.78	19
UPO	Poupi	0.62	16

Constants			
COD/VSS ratio	f _{co}	1.481	mgCOD/mgVSS
Yield coefficient of OHO's	Y _{oh}	0.67	mgCOD/mgCOD
Yield coefficient of OHO's	Y _{oh}	0.45	mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2	
ISS content of OHO's	f _{coHO}	0.15	
Yield coefficient of ANO's	Y _a	0.10	mgVSS/mgFSA
COD per mass fraction of FBSO	f _{co,FBSO}	1.42	mgCOD/mg
COD per mass fraction of USO	f _{co,USO}	1.493	mgCOD/mg
N Content of UPO and biomass VSS	f _{N,UPO}	0.1	mgN/mgVSS
P Content of UPO and biomass VSS	f _{P,UPO}	0.025	mgP/mgVSS
C Content of UPO and biomass VSS	f _{C,UPO}	0.518	mgC/mgVSS

Temperature dependant coefficients		T	16 °C
Endogenous respiration rate heterotrophs	b _{h,20}	0.24	/d
	θ	1.029	
	b _{h,T}	0.2141	/d
nitrifiers max spec. growth rate	μ _{h,n,20}	0.45	/d
	θ	1.123	
	μ _{h,n,T}	0.2829	/d
Endogenous respiration rate autotrophs	b _{a,20}	0.0400	/d
	θ	1.029	
	b _{a,T}	0.0357	/d
Nitrification	K _{s,20}	1.0	mgFSA/l
	θ	1.123	
	K _{s,T}	0.6288	mgFSA/l
Denitrification	K _{d,20}	0.72	
	θ	1.2	
	K _{d,T}	0.3472	
Denitrification for ND system	K _{d,20}	0.101	
	θ	1.08	
	K _{d,T}	0.0742	
Denitrification primary anoxic of NDBPER system	K [*] _{d,20}	0.255	
	θ	1.08	
	K [*] _{d,T}	0.1874	
Factor of safety reducing μ _{h,n,T}	Sf	1.25	
total unaerated mass fraction	f _{xt}	0.351	
Minimum sludge age for nitrification	SRT _{min}	6.76	days
SRT _{min} (with safety factor)	SRT _{min}	8.45	Nitrifies!

Max unaerated sludge mass fraction	f _{un}	0.40	
Total unaerated sludge mass fraction	f _{xt}	0.35	
Anoxic mass fraction primary anox 2	f _{a,prim anox 2}	0.27	
Anaerobic mass fraction	f _{a,anox}	0.08	
Aerobic mass fraction	f _{aer}	0.65	Ok!

Nr of equal size compartments		2
r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N _{nr}	3.9 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{O2,r}	0.0 mgO/l
influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
influent DO concentration	O _i	0.0 mgO/l
s-recycle ratio	s	1.000 :1
s-recycle DO concentration	O _s	1.0 mgO/l
a-recycle DO concentration	O _a	2.0 mgO/l
Influent RBCOD fraction (Sbsi/Sbi)	f _{Sbsi}	0.135

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	25.00 Ml/d
Sludge Age	SRT	10.0 days
Reactor TSS concentration	X _r	4454 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	619	15473
BPO COD	Sbpi	479	11973
UPO COD	Supi	29	718
	fS'up		0.046
VFA COD	Sbsi,a	0	0
FBSO COD	Sbsfi	75	1875
BSO COD	Sbsi	75	1875
USO COD	Susi	36	908
	fS'us		0.059
BO COD	Sbi	554	13848
UO COD	Sui	65	1625
TSS		241	6018
ISS		51	1285
VSS		189	4733
UPO VSS		19	484
BPO VSS		170	4248
TKN	Nti	48	1205
Org N	Noi	14	345
FSA	Nai	34	860
BSO	Nobsi	2.90	73
USO	Nousi	0.90	23
BPO	Nobpi	8.70	218
UPO	Noupi	1.30	33
Total P	Pti	15.50	388
OP	Pai	12.80	320
Org P	Poi	2.70	68
BSO	Pobsi	0.70	18
USO	Pousi	0.60	15
BPO	Pobpi	0.78	19
UPO	Poupi	0.62	16

Constants			
COD/VSS ratio	f _{co}	1.481	mgCOD/mgVSS
Yield coefficient of OHO's	Y _{oh}	0.67	mgCOD/mgCOD
Yield coefficient of OHO's	Y _{oh}	0.45	mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2	
ISS content of OHO's	f _{coHO}	0.15	
Yield coefficient of ANO's	Y _a	0.1	mgVSS/mgFSA
COD per mass fraction of FBSO	f _{co,FBSO}	1.42	mgCOD/mg
COD per mass fraction of USO	f _{co,USO}	1.493	mgCOD/mg
N Content of UPO and biomass VSS	f _{N,UPO}	0.1	mgN/mgVSS
P Content of UPO and biomass VSS	f _{P,UPO}	0.025	mgP/mgVSS
C Content of UPO and biomass VSS	f _{C,UPO}	0.518	mgC/mgVSS

Temperature dependant coefficients		T	24 °C
Endogenous respiration rate OHO	b _{h,20}	0.24	/d
	θ	1.029	
	b _{h,T}	0.2691	/d
nitrifiers max spec. growth rate	μ _{h,n,20}	0.45	/d
	θ	1.123	
	μ _{h,n,T}	0.7157	/d
Endogenous respiration rate autotrophs	b _{a,20}	0.0400	/d
	θ	1.029	
	b _{a,T}	0.0448	/d
Nitrification	K _{s,20}	1.0	
	θ	1.123	
	K _{s,T}	1.5904	
Denitrification	K _{d,20}	0.72	
	θ	1.2	
	K _{d,T}	1.4930	
Denitrification for ND system	K _{d,20}	0.101	
	θ	1.08	
	K _{d,T}	0.1374	
Denitrification primary anoxic of NDBPER system	K [*] _{d,20}	0.255	
	θ	1.08	
	K [*] _{d,T}	0.3469	
Factor of safety reducing μ _{h,n,T}	Sf	1.25	
total unaerated mass fraction	f _{xt}	0.351	
Minimum sludge age for nitrification	SRT _{min}	2.38	days
SRT _{min} (with safety factor)	SRT _{min}	2.98	Nitrifies!

Max unaerated sludge mass fraction	f _{un}	0.75	
Total unaerated sludge mass fraction	f _{xt}	0.35	
Anoxic mass fraction primary anox 2	f _{a,prim anox 2}	0.27	
Anaerobic mass fraction	f _{a,anox}	0.08	
Aerobic mass fraction	f _{aer}	0.65	

Nr of equal size compartments		2
r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N _{nr}	3.9 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{O2,r}	0.0 mgO/l
influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
influent DO concentration	O _i	0.0 mgO/l
s-recycle ratio	s	1.0 :1
s-recycle DO concentration	O _s	1.0 mgO/l
a-recycle DO concentration	O _a	2.0 mgO/l
Influent RBCOD fraction (Sbsi/Sbi)	f _{Sbsi}	0.135

UCT Reactor @ 10 Days SRT

Influent TKN	N_i	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_e	343 kgN/d
Equiv conc in influent	N_i	13.72 mgN/l
Effluent Sol Unbiol Org N	$N_{u,UBO}$	0.90 mgN/l
Effluent ammonia	$N_{u,e}$	1.78 mgFSA-N/l
TKN in effluent	N_e	2.68 mgTKN-N/l
Nitrification capacity	N_i	31.79 mgN/l influent

Denitrification potential BSO (K1)	D_{HBSO}	1.5 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{HBPO}	38.11 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	39.57 mgNO ₃ -N/l influent

	A	0.6993
	B	-6.0320
	C	46.654
Optimal a-recycle ratio	a_{opt}	13.55
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00
recycle limited		

Effluent Nitrate if recycle limited		3.97 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		-3.23 mgNO ₃ -N/l
Actual Effluent Nitrate	$N_{u,e}$	3.97 mgNO ₃ -N/l influent

Effluent total N (TKN + NO ₃)	$N_{u,e} + N_{u,e}$	6.66 mgN/l
N removal		86.2%

Alkalinity consumed by nitrification		227 mg CaCO ₃
Alkalinity recovered by denitrification		99 mg CaCO ₃
Total Alkalinity consumption		128 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{u,i,A}$	0 mgCOD/l
FBSO COD	$S_{u,i,F}$	75 mgCOD/l
BSO COD	$S_{u,i}$	75 mgCOD/l
BO COD	$S_{u,i}$	554 mgCOD/l

$S_{F,i}$ reduction due to O ₂ & NO ₃		33.54 mgCOD/l
Reduced FBSO concentration	$S_{F,i,conv}$	41.46 mgCOD/l

	$k_{f,120}$	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	$k_{f,T}$	0.0535 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	$S_{u,TKN}$	MX_{BPO}/Q_i	$S_{u,TKN}$	
Trial 1	0.00	734		6.42
Trial 2	6.42	753		6.28
Trial 3	6.28	752		6.29
Trial 4	6.29	752		6.29

Flux BO COD obtained by OHO's	95%	13125 kgCOD/d
Flux BO COD obtained by PAO's	5%	722 kgCOD/d
Check total BO COD		13848 kgCOD/d

correct

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{Gv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_e	0.25
ISS content of PAO's	f_{BPAO}	0.15

	$b_{d,20}$	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	$b_{d,T}$	0.0357 /d

Activated Sludge Masses

OHO VSS		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	18806 kgVSS
Endogenous Residue VSS OHO	$MX_{e,OHO}$	8052 kgVSS

PAO VSS		
Polyphosphate Acc Organisms VSS	MX_{PAO}	2395 kgVSS
Endogenous Residue VSS PAO	$MX_{e,PAO}$	214 kgVSS

Unbiodegradable Organic VSS	MX_u	4845 kgVSS
Total VSS	MX_v	34311 kgVSS

ISS from influent		12852 kgISS
ISS of OHO's		2821 kgISS
ISS of PAO's		3154 kgISS
ISS	MX_{O_3}	18827 kgISS
TSS	MX_t	53138 kgTSS
VSS/TSS ratio		0.646 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.380 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	3.40 mgP/l
biomass P-content	ΔP_{OHO}	3.43 mgP/l
Potential P-removal		6.83 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	3.40 mgP/l
biomass P-content	ΔP_{OHO}	3.43 mgP/l
Total Actual P-removal		6.83 mgP/l

TP effluent

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	9148 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	336 kgO/d
Carbonaceous Oxygen flux	FO_c	9483 kgO/d
Nitrogenous Oxygen flux	FO_n	3632 kgO/d
Oxygen dmdm recover by denitrification	FO_{D_2}	1989 kgO/d
Total Oxygen Demand ($FO_c + FO_n - FO_{D_2}$)	FO_T	11127 kgO/d
Oxygen utilisation rate	O_T	63.3 mgO/l.h

Influent TKN	N_i	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_e	320 kgN/d
Equiv conc in influent	N_i	12.79 mgN/l
Effluent Sol Unbiol Org N	$N_{u,UBO}$	0.90 mgN/l
Effluent ammonia	$N_{u,e}$	0.72 mgFSA-N/l
TKN in effluent	N_e	1.62 mgTKN-N/l
Nitrification capacity	N_i	33.78 mgN/l influent

Denitrification potential BSO (K1)	D_{HBSO}	1.4 mgNO ₃ -N/l influent
Denitrification potential BPO (K2)	D_{HBPO}	59.94 mgNO ₃ -N/l influent
Denitr potential primary anoxic tank	D_{p1}	61.32 mgNO ₃ -N/l influent

	A	0.6993
	B	-25.7836
	C	88.149
Optimal a-recycle ratio	a_{opt}	40.02
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00
recycle limited		

Effluent Nitrate if recycle limited		4.22 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		-22.99 mgNO ₃ -N/l
Actual Effluent Nitrate	$N_{u,e}$	4.22 mgNO ₃ -N/l influent

Effluent total N (TKN + NO ₃)	$N_{u,e} + N_{u,e}$	5.84 mgN/l
N removal		87.9%

Alkalinity consumed by nitrification		241 mg CaCO ₃
Alkalinity recovered by denitrification		106 mg CaCO ₃
Total Alkalinity consumption		136 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{u,i,A}$	0 mgCOD/l
FBSO COD	$S_{u,i,F}$	75 mgCOD/l
BSO COD	$S_{u,i}$	75 mgCOD/l
BO COD	$S_{u,i}$	554 mgCOD/l

$S_{F,i}$ reduction due to O ₂ & NO ₃		33.54 mgCOD/l
Reduced FBSO concentration	$S_{F,i,conv}$	41.46 mgCOD/l

	$k_{f,120}$	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	$k_{f,T}$	0.0673 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	$S_{u,TKN}$	MX_{BPO}/Q_i	$S_{u,TKN}$	
Trial 1	0.00	625		6.04
Trial 2	6.04	640		5.92
Trial 3	5.92	639		5.92
Trial 4	5.92	639		5.92

Flux BO COD obtained by OHO's	95%	13107 kgCOD/d
Flux BO COD obtained by PAO's	5%	741 kgCOD/d
Check total BO COD		13848 kgCOD/d

correct

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{Gv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_e	0.25
ISS content of PAO's	f_{BPAO}	0.15

	$b_{d,20}$	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	$b_{d,T}$	0.0448 /d

Activated Sludge Masses

OHO VSS		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	15981 kgVSS
Endogenous Residue VSS OHO	$MX_{e,OHO}$	8600 kgVSS

PAO VSS		
Polyphosphate Acc Organisms VSS	MX_{PAO}	2301 kgVSS
Endogenous Residue VSS PAO	$MX_{e,PAO}$	258 kgVSS

Unbiodegradable Organic VSS	MX_u	4845 kgVSS
Total VSS	MX_v	31984 kgVSS

ISS from influent		12852 kgISS
ISS of OHO's		2397 kgISS
ISS of PAO's		3029 kgISS
ISS	MX_{O_3}	18279 kgISS
TSS	MX_t	50263 kgTSS
VSS/TSS ratio		0.636 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.38 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	3.27 mgP/l
biomass P-content	ΔP_{OHO}	3.20 mgP/l
Potential P-removal		6.47 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	3.27 mgP/l
biomass P-content	ΔP_{OHO}	3.20 mgP/l
Total Actual P-removal		6.47 mgP/l

TP effluent

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	9466 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	362 kgO/d
Carbonaceous Oxygen flux	FO_c	9828 kgO/d
Nitrogenous Oxygen flux	FO_n	3860 kgO/d
Oxygen dmdm recover by denitrification	FO_{D_2}	2114 kgO/d
Total Oxygen Demand ($FO_c + FO_n - FO_{D_2}$)	FO_T	11574 kgO/d
Oxygen utilisation rate	O_T	65.9 mgO/l.h

UCT Reactor @ 10 Days SRT

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Check	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	4308	14362	34468	53138
Concentration TSS (kgTSS/m ³)	2.35	4.71	4.71	4.356
Volume (m ³)	1830	3050	7320	12200
Volume fraction	15%	25%	60%	100%
Concentration VSS (kgVSS/m ³)	1.52	3.04	3.04	2.81
UPO VSS Concentration (kgUPOVSS/m ³)	0.215	0.429	0.429	0.397

Mass TSS wasted per day 5313.8 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 1128.5 m³/d

COD mass balance	
COD in (influent)	15473 kgCOD/d
COD out	15473 kgCOD/d
$Q_a S_{a0} + Q_w S_{w0}$	908 kgCOD/d
$Q_a X_{f_{cv}}$ or $f_{cv} MX_{cv}/Rs$	5082 kgCOD/d
FO_L	9483 kgO/d

N Mass balance	
TKN in (influent)	1205 kgN/d
TKN out	1205 kgN/d
N_{10}	159 kgN/d
N_{waste}	351 kgN/d
$N_{nitrified}$	695 kgN/d

TOD balance	
TOD in (influent)	20979 kgTOD/d
TOD out	20979 kgTOD/d
$TOD_{effluent}$	1159 kgTOD/d
TOD_{waste}	6704 kgTOD/d
$TOD_{N_2\text{ gas}}$	1989 kgTOD/d
FO_L	11127 kgTOD/d

<u>Effluent Concentrations</u>		General	Special	Unit
Unbiol Sol COD	S_{100}	36.30	75	30 mgCOD/l
Unbiol Sol Org N	N_{1000}	0.90	-	- mgN/l
FSA-N	N_{90}	1.78	6	2 mgFSA-N/l
TKN-N	N_{10}	2.68	-	- mgTKN-N/l
Nitrate	N_{10}	3.97	15	1.5 mgNO ₃ -N/l
Unbiol Sol Org P	P_{1000}	0.60	-	- mgP/l
Ortho P as P	P_{100}	8.67	10	2.5 mgP/l
TP	P_{10}	9.27	-	- mgP/l

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	4075	13585	32603	50263
Concentration TSS (kgTSS/m ³)	2.23	4.45	4.45	4.120
Volume (m ³)	1830	3050	7320	12200
	4075			
Concentration VSS (kgVSS/m ³)	1.42	2.83	2.83	2.62
UPO VSS Concentration (kgUPOVSS/m ³)	0.215	0.429	0.429	0.397

Mass TSS wasted per day 5026.3 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 1128.5 m³/d

COD mass balance	
COD in (influent)	15473 kgCOD/d
COD out	15473 kgCOD/d
$Q_a S_{a0} + Q_w S_{w0}$	908 kgCOD/d
$Q_a X_{f_{cv}}$ or $f_{cv} MX_{cv}/Rs$	4737 kgCOD/d
FO_L	9828 kgO/d

N Mass balance	
TKN in (influent)	1205 kgN/d
TKN out	1205 kgN/d
N_{10}	140 kgN/d
N_{waste}	326 kgN/d
$N_{nitrified}$	739 kgN/d

TOD balance	
TOD in (influent)	20979 kgTOD/d
TOD out	20979 kgTOD/d
$TOD_{effluent}$	1043 kgTOD/d
TOD_{waste}	6248 kgTOD/d
$TOD_{N_2\text{ gas}}$	2114 kgTOD/d
FO_L	11574 kgTOD/d

<u>Effluent Concentrations</u>		General	Special	Unit
Unbiol Sol COD	S_{100}	36.30	75	30 mgCOD/l
Unbiol Sol Org N	N_{1000}	0.90	-	- mgN/l
FSA-N	N_{90}	0.72	6	2 mgFSA-N/l
TKN-N	N_{10}	1.62	-	- mgTKN-N/l
Nitrate	N_{10}	4.22	15	1.5 mgNO ₃ -N/l
Unbiol Sol Org P	P_{1000}	0.60	-	- mgP/l
Ortho P as P	P_{100}	9.03	10	2.5 mgP/l
TP	P_{10}	9.63	-	- mgP/l

UCT Reactor @ 15 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	25.00 Ml/d
Sludge Age	SRT	15.0 days
Reactor TSS concentration	X _T	6366.80 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti	619 15473
BPO COD	Sbpi	479 11973
UPO COD	Supi	29 718
	fS'up	0.046
VFA COD	Sbsi,a	0 0
FBSD COD	Sbsfi	75 1875
BSO COD	Sbsi	75 1875
USO COD	Susi	36.3 908
	fS'us	0.059
BO COD	Sbi	554 13848
UO COD	Sui	65 1625
TSS		241 6018
ISS		51.4 1285
VSS		189 4733
UPO VSS		19.4 484
BPO VSS		170 4248
TKN	Nti	48.2 1205
Org N	Noi	13.8 345
FSA	Nai	34.4 860
BSO	Nobsi	2.90 73
USO	Nousi	0.90 23
BPO	Nobpi	8.70 218
UPO	Noupi	1.30 33
Total P	Pti	15.50 388
OP	Pai	12.80 320
Org P	Poi	2.70 68
BSO	Pobsi	0.70 18
USO	Pousi	0.60 15
BPO	Pobpi	0.78 19
UPO	Poupi	0.62 16

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _{oh}	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{ohv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{coHO}	0.15
Yield coefficient of ANO's	Y _a	0.10 mgVSS/mgFSA
COD per mass fraction of FBSD	f _{cm,bsd}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,uipo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,uipo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,uipo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{hT}	0.2141 /d
	μ _{h,20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{h,nit}	0.2829 /d
	b _{h20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{aT}	0.0357 /d
	K _{s,20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{s,T}	0.6288 mgFSA/l
	K _{s,20}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{s,T}	0.3472
	K _{s,20}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{s,T}	0.0742
	K ⁺ _{s,20}	0.255
Denitrification	θ	1.08
primary anoxic of NDBPER system	K ⁺ _{s,T}	0.1874

Factor of safety reducing μ _{h,nit}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _{min}	6.76 days
SRT _{min} (with safety factor)	SRT _{min}	8.45 Nitrifies!

Max unaerated sludge mass fraction	f _{sm}	0.55
Total unaerated sludge mass fraction	f _{de}	0.35
Anoxic mass fraction primary anox 2	f _{s,prim anox 2}	0.27
Anaerobic mass fraction	f _{s,anox}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments 2

r-recycle ratio	r	1.0 :1
r-recycle NO ₂ concentration	N _{nr}	4.3 mgNO ₂ -N/l
r-recycle O ₂ concentration	S _{o2,s}	0.0 mgO/l

influent NO ₂ concentration	S _{NO2,i}	0.0 mgNO ₂ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	1.203 :1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)	f _{Sb/s}	0.135

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	25.00 Ml/d
Sludge Age	SRT	15.0 days
Reactor TSS concentration	X _T	6038 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti	619 15473
BPO COD	Sbpi	479 11973
UPO COD	Supi	29 718
	fS'up	0.046
VFA COD	Sbsi,a	0 0
FBSD COD	Sbsfi	75 1875
BSO COD	Sbsi	75 1875
USO COD	Susi	36 908
	fS'us	0.059
BO COD	Sbi	554 13848
UO COD	Sui	65 1625
TSS		241 6018
ISS		51 1285
VSS		189 4733
UPO VSS		19 484
BPO VSS		170 4248
TKN	Nti	48 1205
Org N	Noi	14 345
FSA	Nai	34 860
BSO	Nobsi	2.90 73
USO	Nousi	0.90 23
BPO	Nobpi	8.70 218
UPO	Noupi	1.30 33
Total P	Pti	15.50 388
OP	Pai	12.80 320
Org P	Poi	2.70 68
BSO	Pobsi	0.70 18
USO	Pousi	0.60 15
BPO	Pobpi	0.78 19
UPO	Poupi	0.62 16

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _{oh}	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{ohv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{coHO}	0.15
Yield coefficient of ANO's	Y _a	0.1 mgVSS/mgFSA
COD per mass fraction of FBSD	f _{cm,bsd}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,uipo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,uipo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,uipo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate OHO	b _{hT}	0.2691 /d
	μ _{h,20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{h,nit}	0.7157 /d
	b _{h20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{aT}	0.0448 /d
	K _{s,20}	1.0
Nitrification	θ	1.123
Half Saturation Coefficient	K _{s,T}	1.5904
	K _{s,20}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{s,T}	1.4930
	K _{s,20}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{s,T}	0.1374
	K ⁺ _{s,20}	0.255
Denitrification	θ	1.08
primary anoxic of NDBPER system	K ⁺ _{s,T}	0.3469

Factor of safety reducing μ _{h,nit}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _{min}	2.38 days
SRT _{min} (with safety factor)	SRT _{min}	2.98 Nitrifies!

Max unaerated sludge mass fraction	f _{sm}	0.81
Total unaerated sludge mass fraction	f _{de}	0.35
Anoxic mass fraction primary anox 2	f _{s,prim anox 2}	0.27
Anaerobic mass fraction	f _{s,anox}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments 2

r-recycle ratio	r	1.0 :1
r-recycle NO ₂ concentration	N _{nr}	4.3 mgNO ₂ -N/l
r-recycle O ₂ concentration	S _{o2,s}	0.0 mgO/l

influent NO ₂ concentration	S _{NO2,i}	0.0 mgNO ₂ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	1.2 :1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)	f _{Sb/s}	0.135

UCT Reactor @ 15 Days SRT

Influent TKN	N_0	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_L	302 kgN/d
Equiv conc in influent	N_i	12.10 mgN/l
Effluent Sol Unbiode Org N	N_{unb}	0.90 mgN/l
Effluent ammonia	N_{NH}	0.79 mgFSA-N/l
TKN in effluent	N_{eff}	1.69 mgTKN-N/l
Nitrification capacity	N_c	34.41 mgN/l influent

Denitrification potential BSO (K1)	D_{BDSO}	1.2 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BPO}	42.71 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{d1}	43.93 mgNO ₂ -N/l influent

	A	0.6993
	B	-7.5588
	C	54.454
Optimal a-recycle ratio	a_{opt}	15.75
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00 set = a_{opt} for balanced UCT
		recycle limited

Effluent Nitrate if recycle limited		4.20 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-4.90 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{NH}	4.20 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₂)	$N_{NH} + N_{NH}$	5.89 mgN/l
N removal		87.8%

Alkalinity consumed by nitrification		246 mg CaCO ₃
Alkalinity recovered by denitrification		108 mg CaCO ₃
Total Alkalinity consumption		138 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{BVL,A}$	0 mgCOD/l
FBSO COD	S_{BVL}	75 mgCOD/l
BSO COD	S_{BVL}	75 mgCOD/l
BO COD	S_{BVL}	554 mgCOD/l

S_{F1} reduction due to O ₂ & NO ₃		36.55 mgCOD/l
Reduced FBSO concentration	$S_{F1,COMP}$	38.45 mgCOD/l

	k_{F120}	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	k_{F1T}	0.0535 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	S_{BVLN}	MX_{BVL}/Q_L	S_{BVLN}	
Trial 1	0.00	826	5.35	
Trial 2	5.35	843	5.24	
Trial 3	5.24	843	5.24	
Trial 4	5.24	843	5.24	

Flux BO COD obtained by OHO's	95%	13148 kgCOD/d
Flux BO COD obtained by PAO's	5%	699 kgCOD/d
Check total BO COD		13848 kgCOD/d

correct
13848

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{d20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{dT}	0.0357 /d

Activated Sludge Masses

<u>OHO VSS</u>			
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	21076 kgVSS	
Endogenous Residue VSS OHO	$MX_{E,OHO}$	13535 kgVSS	
<u>PAO VSS</u>			
Polyphosphate Acc Organisms VSS	MX_{PAO}	3073 kgVSS	
Endogenous Residue VSS PAO	$MX_{E,PAO}$	411 kgVSS	
Unbiodegradable Organic VSS	MX_{UO}	7267 kgVSS	
Total VSS	MX_V	45363 kgVSS	
ISS from influent		19278 kgISS	
ISS of OHO's		3161 kgISS	
ISS of PAO's		4046 kgISS	
ISS	MX_{DO}	26486 kgISS	
TSS	MX_T	71849 kgTSS	
VSS/TSS ratio		0.631 kgVSS/kgTSS	

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.380 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.91 mgP/l
biomass P-content	ΔP_{OHO}	3.02 mgP/l
Potential P-removal		5.93 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.91 mgP/l
biomass P-content	ΔP_{OHO}	3.02 mgP/l
Total Actual P-removal		5.93 mgP/l

TP effluent

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	9731 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	355 kgO/d
Carbonaceous Oxygen flux	FO_L	10086 kgO/d
Nitrogenous Oxygen flux	FO_N	3931 kgO/d
Oxygen dmdnd recover by denitrification	FO_D	2160 kgO/d
Total Oxygen Demand (FO _C + FO _N - FO _D)	FO_T	11857 kgO/d
Oxygen utilisation rate	O_T	67.5 mgO/L/h

Influent TKN	N_0	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_L	283 kgN/d
Equiv conc in influent	N_i	11.32 mgN/l
Effluent Sol Unbiode Org N	N_{unb}	0.90 mgN/l
Effluent ammonia	N_{NH}	0.50 mgFSA-N/l
TKN in effluent	N_{eff}	1.40 mgTKN-N/l
Nitrification capacity	N_c	35.48 mgN/l influent

Denitrification potential BSO (K1)	D_{BDSO}	1.2 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BPO}	66.04 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{d1}	67.20 mgNO ₂ -N/l influent

	A	0.6993
	B	-29.7613
	C	104.430
Optimal a-recycle ratio	a_{opt}	45.82
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00
		recycle limited

Effluent Nitrate if recycle limited		4.33 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-27.11 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{NH}	4.33 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₂)	$N_{NH} + N_{NH}$	5.73 mgN/l
N removal		88.1%

Alkalinity consumed by nitrification		253 mg CaCO ₃
Alkalinity recovered by denitrification		111 mg CaCO ₃
Total Alkalinity consumption		142 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{BVL,A}$	0 mgCOD/l
FBSO COD	S_{BVL}	75 mgCOD/l
BSO COD	S_{BVL}	75 mgCOD/l
BO COD	S_{BVL}	554 mgCOD/l

S_{F1} reduction due to O ₂ & NO ₃		36.55 mgCOD/l
Reduced FBSO concentration	$S_{F1,COMP}$	38.45 mgCOD/l

	k_{F120}	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	k_{F1T}	0.0673 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	S_{BVLN}	MX_{BVL}/Q_L	S_{BVLN}	
Trial 1	0.00	691	5.10	
Trial 2	5.10	705	5.00	
Trial 3	5.00	704	5.00	
Trial 4	5.00	704	5.00	

Flux BO COD obtained by OHO's	95%	13136 kgCOD/d
Flux BO COD obtained by PAO's	5%	711 kgCOD/d
Check total BO COD		13848 kgCOD/d

correct

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{d20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{dT}	0.0448 /d

Activated Sludge Masses

<u>OHO VSS</u>			
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	17607 kgVSS	
Endogenous Residue VSS OHO	$MX_{E,OHO}$	14213 kgVSS	
<u>PAO VSS</u>			
Polyphosphate Acc Organisms VSS	MX_{PAO}	2870 kgVSS	
Endogenous Residue VSS PAO	$MX_{E,PAO}$	483 kgVSS	
Unbiodegradable Organic VSS	MX_{UO}	7267 kgVSS	
Total VSS	MX_V	42439 kgVSS	
ISS from influent		19278 kgISS	
ISS of OHO's		2641 kgISS	
ISS of PAO's		3778 kgISS	
ISS	MX_{DO}	25697 kgISS	
TSS	MX_T	68136 kgTSS	
VSS/TSS ratio		0.623 kgVSS/kgTSS	

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.38 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.72 mgP/l
biomass P-content	ΔP_{OHO}	2.83 mgP/l
Potential P-removal		5.55 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.72 mgP/l
biomass P-content	ΔP_{OHO}	2.83 mgP/l
Total Actual P-removal		5.55 mgP/l

TP effluent

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	9995 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	380 kgO/d
Carbonaceous Oxygen flux	FO_L	10375 kgO/d
Nitrogenous Oxygen flux	FO_N	4054 kgO/d
Oxygen dmdnd recover by denitrification	FO_D	2228 kgO/d
Total Oxygen Demand (FO _C + FO _N - FO _D)	FO_T	12201 kgO/d
Oxygen utilisation rate	O_T	69.4 mgO/L/h

UCT Reactor @ 15 Days SRT

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Check	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	5826	19419	46605	71849
Concentration TSS (kgTSS/m ³)	3.18	6.37	6.37	5.889
Volume (m ³)	1830	3050	7320	12200
Volume fraction	15%	25%	60%	100%
Concentration VSS (kgVSS/m ³)	2.01	4.02	4.02	3.72
UPO VSS Concentration (kgUPOVSS/m ³)	0.322	0.644	0.644	0.596

Mass TSS wasted per day 4790.0 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 752.3 m³/d

COD mass balance	
COD in (influent)	15472.5 kgCOD/d
COD out	15472.5 kgCOD/d
$Q_s S_{10} + Q_w S_{10}$	907.5 kgCOD/d
$Q_w X_{f_{10}}$ or $f_{10} MX_{10}/Rs$	4478.9 kgCOD/d
FO_L	10086.1 kgO/d

N Mass balance	
TKN in (influent)	1205.00 kgN/d
TKN out	1205.00 kgN/d
N_{10}	142.76 kgN/d
N_{waste}	306.9 kgN/d
$N_{denitrified}$	755.4 kgN/d

TOD balance	
TOD in (influent)	20979.35 kgTOD/d
TOD out	20979.35 kgTOD/d
$TOD_{effluent}$	1067.75 kgTOD/d
TOD_{waste}	5894.06 kgTOD/d
TOD_{N_2-gas}	2160.41 kgTOD/d
FO_L	11857.13 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S_{10e}	36.30	75	30 mgCOD/l
Unbiol Sol Org N	N_{10e}	0.90	-	- mgN/l
FSA-N	N_{10}	0.79	6	2 mgFSA-N/l
TKN-N	N_{10}	1.69	-	- mgTKN-N/l
Nitrate	N_{10}	4.20	15	1.5 mgNO ₃ -N/l
Unbiol Sol Org P	P_{10e}	0.60	-	- mgP/l
Ortho P as P	P_{10}	9.57	10	2.5 mgP/l
TP	P_{10}	10.17	-	- mgP/l

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	5525	18415	44197	68136
Concentration TSS (kgTSS/m ³)	3.02	6.04	6.04	5.585
Volume (m ³)	1830	3050	7320	12200
	5525			
Concentration VSS (kgVSS/m ³)	1.88	3.76	3.76	3.48
UPO VSS Concentration (kgUPOVSS/m ³)	0.322	0.644	0.644	0.596

Mass TSS wasted per day 4542.4 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 752.3 m³/d

COD mass balance	
COD in (influent)	15472.5 kgCOD/d
COD out	15472.5 kgCOD/d
$Q_s S_{10} + Q_w S_{10}$	907.5 kgCOD/d
$Q_w X_{f_{10}}$ or $f_{10} MX_{10}/Rs$	4190.1 kgCOD/d
FO_L	10374.9 kgO/d

N Mass balance	
TKN in (influent)	1205.00 kgN/d
TKN out	1205.00 kgN/d
N_{10}	138.90 kgN/d
N_{waste}	287.2 kgN/d
$N_{denitrified}$	778.9 kgN/d

TOD balance	
TOD in (influent)	20979.35 kgTOD/d
TOD out	20979.35 kgTOD/d
$TOD_{effluent}$	1035.64 kgTOD/d
TOD_{waste}	5515.24 kgTOD/d
TOD_{N_2-gas}	2227.56 kgTOD/d
FO_L	12200.90 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S_{10e}	36.30	75	30 mgCOD/l
Unbiol Sol Org N	N_{10e}	0.90	-	- mgN/l
FSA-N	N_{10}	0.50	6	2 mgFSA-N/l
TKN-N	N_{10}	1.40	-	- mgTKN-N/l
Nitrate	N_{10}	4.33	15	1.5 mgNO ₃ -N/l
Unbiol Sol Org P	P_{10e}	0.60	-	- mgP/l
Ortho P as P	P_{10}	9.95	10	2.5 mgP/l
TP	P_{10}	10.55	-	- mgP/l

UCT Reactor @ 20 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	25.00 Ml/d
Sludge Age	SRT	20.0 days
Reactor TSS concentration	X _T	7924.06 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti	619 15473
BPO COD	Sbpi	479 11973
UPO COD	Supi	29 718
	fS'up	0.046
VFA COD	Sbsi,a	0 0
FBSD COD	Sbsfi	75 1875
BSO COD	Sbsi	75 1875
USO COD	Susi	36.3 908
	fS'us	0.059
BO COD	Sbi	554 13848
UO COD	Sui	65 1625
TSS		241 6018
ISS		51.4 1285
VSS		189 4733
UPO VSS		19.4 484
BPO VSS		170 4248
TKN	Nti	48.2 1205
Org N	Noi	13.8 345
FSA	Nai	34.4 860
BSO	Nobsi	2.90 73
USO	Nousi	0.90 23
BPO	Nobpi	8.70 218
UPO	Noupi	1.30 33
Total P	Pti	15.50 388
OP	Pai	12.80 320
Org P	Poi	2.70 68
BSO	Pobsi	0.70 18
USO	Pousi	0.60 15
BPO	Pobpi	0.78 19
UPO	Poupi	0.62 16

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _{oh}	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{ohv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{coHO}	0.15
Yield coefficient of ANO's	Y _a	0.10 mgVSS/mgFSA
COD per mass fraction of FBSD	f _{cm,bsd}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,uipo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,uipo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,uipo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{hT}	0.2141 /d
	μ _{h,m20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{h,nT}	0.2829 /d
	b _{n20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{aT}	0.0357 /d
	K _{s,20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{s,T}	0.6288 mgFSA/l
	K _{s,20}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{s,T}	0.3472
	K _{s,20}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{s,T}	0.0742
	K ⁺ _{s,20}	0.255
Denitrification	θ	1.08
primary anoxic of NDBPER system	K ⁺ _{s,T}	0.1874

Factor of safety reducing μ _{h,nT}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _m	6.76 days
SRT _m (with safety factor)	SRT _m	8.45 Nitrifies!

Max unaerated sludge mass fraction	f _{sm}	0.62
Total unaerated sludge mass fraction	f _{se}	0.35
Anoxic mass fraction primary anox 2	f _{z,prim anox 2}	0.27
Anaerobic mass fraction	f _{z,anox 2}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments 2

r-recycle ratio	r	1.0 :1
r-recycle NO ₂ concentration	N _{nr}	4.4 mgNO ₂ -N/l
r-recycle O ₂ concentration	S _{o2,s}	0.0 mgO/l

influent NO ₂ concentration	S _{NO2,i}	0.0 mgNO ₂ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	2.121 :1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)	f _{Sb/s}	0.135

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	25.00 Ml/d
Sludge Age	SRT	20.0 days
Reactor TSS concentration	X _T	7542 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti	619 15473
BPO COD	Sbpi	479 11973
UPO COD	Supi	29 718
	fS'up	0.046
VFA COD	Sbsi,a	0 0
FBSD COD	Sbsfi	75 1875
BSO COD	Sbsi	75 1875
USO COD	Susi	36 908
	fS'us	0.059
BO COD	Sbi	554 13848
UO COD	Sui	65 1625
TSS		241 6018
ISS		51 1285
VSS		189 4733
UPO VSS		19 484
BPO VSS		170 4248
TKN	Nti	48 1205
Org N	Noi	14 345
FSA	Nai	34 860
BSO	Nobsi	2.90 73
USO	Nousi	0.90 23
BPO	Nobpi	8.70 218
UPO	Noupi	1.30 33
Total P	Pti	15.50 388
OP	Pai	12.80 320
Org P	Poi	2.70 68
BSO	Pobsi	0.70 18
USO	Pousi	0.60 15
BPO	Pobpi	0.78 19
UPO	Poupi	0.62 16

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _{oh}	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{ohv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{coHO}	0.15
Yield coefficient of ANO's	Y _a	0.1 mgVSS/mgFSA
COD per mass fraction of FBSD	f _{cm,bsd}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,uipo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,uipo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,uipo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate OHO	b _{hT}	0.2691 /d
	μ _{h,m20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{h,nT}	0.7157 /d
	b _{n20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{aT}	0.0448 /d
	K _{s,20}	1.0
Nitrification	θ	1.123
Half Saturation Coefficient	K _{s,T}	1.5904
	K _{s,20}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{s,T}	1.4930
	K _{s,20}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{s,T}	0.1374
	K ⁺ _{s,20}	0.255
Denitrification	θ	1.08
primary anoxic of NDBPER system	K ⁺ _{s,T}	0.3469

Factor of safety reducing μ _{h,nT}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _m	2.38 days
SRT _m (with safety factor)	SRT _m	2.98 Nitrifies!

Max unaerated sludge mass fraction	f _{sm}	0.83
Total unaerated sludge mass fraction	f _{se}	0.35
Anoxic mass fraction primary anox 2	f _{z,prim anox 2}	0.27
Anaerobic mass fraction	f _{z,anox 2}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments 2

r-recycle ratio	r	1.0 :1
r-recycle NO ₂ concentration	N _{nr}	4.4 mgNO ₂ -N/l
r-recycle O ₂ concentration	S _{o2,s}	0.0 mgO/l

influent NO ₂ concentration	S _{NO2,i}	0.0 mgNO ₂ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	2.1 :1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)	f _{Sb/s}	0.135

UCT Reactor @ 20 Days SRT

Influent TKN	N_0	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_L	278 kgN/d
Equiv conc in influent	N_i	11.12 mgN/l
Effluent Sol Unbiod Org N	N_{unb}	0.90 mgN/l
Effluent ammonia	N_{NH}	0.55 mgFSA-N/l
TKN in effluent	N_{eff}	1.45 mgTKN-N/l
Nitrification capacity	N_c	35.63 mgN/l influent

Denitrification potential BSO (K1)	D_{BBSO}	1.1 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BBSO}	45.43 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{d1}	46.55 mgNO ₂ -N/l influent

	A	0.6993
	B	-7.9887
	C	67.375
Optimal a-recycle ratio	a_{opt}	17.07
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00 set = a_{opt} for balanced UCT
		recycle limited

Effluent Nitrate if recycle limited		3.91 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-5.98 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{NH}	3.91 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₂)	$N_{NH} + N_{NH}$	5.36 mgN/l
N removal		88.9%

Alkalinity consumed by nitrification		254 mg CaCO ₃
Alkalinity recovered by denitrification		113 mg CaCO ₃
Total Alkalinity consumption		141 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{BVL,A}$	0 mgCOD/l
FBSO COD	S_{BVL}	75 mgCOD/l
BSO COD	S_{BVL}	75 mgCOD/l
BO COD	S_{BVL}	554 mgCOD/l

S_{F1} reduction due to O ₂ & NO ₃		37.84 mgCOD/l
Reduced FBSO concentration	$S_{F1,COMP}$	37.16 mgCOD/l

	k_{F120}	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	k_{F1T}	0.0535 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

Trial 1	S_{BVLN}	0.00	MX_{BVL}/Q_L	881	S_{BVLN}	4.86
Trial 2		4.86		897		4.77
Trial 3		4.77		897		4.77
Trial 4		4.77		897		4.77

Flux BO COD obtained by OHO's	95%	13157 kgCOD/d
Flux BO COD obtained by PAO's	5%	690 kgCOD/d
Check total BO COD		13848 kgCOD/d

correct
13848

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{G20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{GT}	0.0357 /d

Activated Sludge Masses

OHO VSS		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	22421 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	19199 kgVSS

PAO VSS		
Polyphosphate Acc Organisms VSS	MX_{PAO}	3626 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	647 kgVSS

Unbiodegradable Organic VSS	MX_{UO}	9689 kgVSS
Total VSS	MX_V	55582 kgVSS

ISS from influent		25705 kgISS
ISS of OHO's		3363 kgISS
ISS of PAO's		4773 kgISS
ISS	MX_{DO}	33841 kgISS
TSS	MX_T	89423 kgTSS
VSS/TSS ratio		0.622 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.380 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.57 mgP/l
biomass P-content	ΔP_{OHO}	2.78 mgP/l
Potential P-removal		5.35 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.57 mgP/l
biomass P-content	ΔP_{OHO}	2.78 mgP/l
Total Actual P-removal		5.35 mgP/l

TP effluent P_{le} 10.15 mgP/l

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	10075 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	374 kgO/d
Carbonaceous Oxygen flux	FO_L	10449 kgO/d
Nitrogenous Oxygen flux	FO_N	4071 kgO/d
Oxygen dnmnd recover by denitrification	FO_D	2268 kgO/d
Total Oxygen Demand (FO _C + FO _N - FO _D)	FO_T	12252 kgO/d
Oxygen utilisation rate	O_T	69.7 mgO/L/h

Influent TKN	N_0	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_L	261 kgN/d
Equiv conc in influent	N_i	10.45 mgN/l
Effluent Sol Unbiod Org N	N_{unb}	0.90 mgN/l
Effluent ammonia	N_{NH}	0.41 mgFSA-N/l
TKN in effluent	N_{eff}	1.31 mgTKN-N/l
Nitrification capacity	N_c	36.44 mgN/l influent

Denitrification potential BSO (K1)	D_{BBSO}	1.1 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BBSO}	69.55 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{d1}	70.62 mgNO ₂ -N/l influent

	A	0.6993
	B	-31.2531
	C	140.787
Optimal a-recycle ratio	a_{opt}	48.82
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00
		recycle limited

Effluent Nitrate if recycle limited		4.00 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-29.24 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{NH}	4.00 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₂)	$N_{NH} + N_{NH}$	5.30 mgN/l
N removal		89.0%

Alkalinity consumed by nitrification		260 mg CaCO ₃
Alkalinity recovered by denitrification		116 mg CaCO ₃
Total Alkalinity consumption		144 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{BVL,A}$	0 mgCOD/l
FBSO COD	S_{BVL}	75 mgCOD/l
BSO COD	S_{BVL}	75 mgCOD/l
BO COD	S_{BVL}	554 mgCOD/l

S_{F1} reduction due to O ₂ & NO ₃		37.84 mgCOD/l
Reduced FBSO concentration	$S_{F1,COMP}$	37.16 mgCOD/l

	k_{F120}	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	k_{F1T}	0.0673 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

Trial 1	S_{BVLN}	0.00	MX_{BVL}/Q_L	729	S_{BVLN}	4.67
Trial 2		4.67		742		4.59
Trial 3		4.59		742		4.59
Trial 4		4.59		742		4.59

Flux BO COD obtained by OHO's	95%	13148 kgCOD/d
Flux BO COD obtained by PAO's	5%	699 kgCOD/d
Check total BO COD		13848 kgCOD/d

correct

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{G20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{GT}	0.0448 /d

Activated Sludge Masses

OHO VSS		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	18543 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	19958 kgVSS

PAO VSS		
Polyphosphate Acc Organisms VSS	MX_{PAO}	3318 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	744 kgVSS

Unbiodegradable Organic VSS	MX_{UO}	9689 kgVSS
Total VSS	MX_V	52253 kgVSS

ISS from influent		25705 kgISS
ISS of OHO's		2781 kgISS
ISS of PAO's		4369 kgISS
ISS	MX_{DO}	32855 kgISS
TSS	MX_T	85107 kgTSS
VSS/TSS ratio		0.614 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.38 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.36 mgP/l
biomass P-content	ΔP_{OHO}	2.61 mgP/l
Potential P-removal		4.97 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.36 mgP/l
biomass P-content	ΔP_{OHO}	2.61 mgP/l
Total Actual P-removal		4.97 mgP/l

TP effluent P_{le} 10.53 mgP/l

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	10297 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	399 kgO/d
Carbonaceous Oxygen flux	FO_L	10696 kgO/d
Nitrogenous Oxygen flux	FO_N	4163 kgO/d
Oxygen dnmnd recover by denitrification	FO_D	2320 kgO/d
Total Oxygen Demand (FO _C + FO _N - FO _D)	FO_T	12539 kgO/d
Oxygen utilisation rate	O_T	71.4 mgO/L/h

UCT Reactor @ 20 Days SRT

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Check	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	7251	24168	58004	89423
Concentration TSS (kgTSS/m ³)	3.96	7.92	7.92	7.330
Volume (m ³)	1830	3050	7320	12200
Volume fraction	15%	25%	60%	100%
Concentration VSS (kgVSS/m ³)	2.46	4.93	4.93	4.56
UPO VSS Concentration (kgUPOVSS/m ³)	0.429	0.859	0.859	0.794

Mass TSS wasted per day 4471.2 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 564.3 m³/d

COD mass balance	
COD in (influent)	15472.5 kgCOD/d
COD out	15472.5 kgCOD/d
$Q_s S_{in} + Q_w S_{iw}$	907.5 kgCOD/d
$Q_w X_{f_{ox}}$ or $f_{ox} MX_{iw}/Rs$	4115.8 kgCOD/d
FO_L	10449.2 kgO/d

N Mass balance	
TKN in (influent)	1205.00 kgN/d
TKN out	1205.00 kgN/d
N_{D_2}	130.91 kgN/d
N_{waste}	280.9 kgN/d
$N_{denitrified}$	793.2 kgN/d

TOD balance	
TOD in (influent)	20979.35 kgTOD/d
TOD out	20979.35 kgTOD/d
$TOD_{effluent}$	1049.00 kgTOD/d
TOD_{waste}	5410.11 kgTOD/d
TOD_{N_2-gas}	2268.43 kgTOD/d
FO_L	12251.81 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S_{uise}	36.30	75	30 mgCOD/l
Unbiol Sol Org N	N_{uise}	0.90	-	- mgN/l
FSA-N	N_{se}	0.55	6	2 mgFSA-N/l
TKN-N	N_{te}	1.45	-	- mgTKN-N/l
Nitrate	N_{ne}	3.91	15	1.5 mgNO ₃ -N/l
Unbiol Sol Org P	P_{uise}	0.60	-	- mgP/l
Ortho P as P	P_{oe}	10.15	10	2.5 mgP/l
TP	P_{te}	10.75	-	- mgP/l

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	6901	23002	55205	85107
Concentration TSS (kgTSS/m ³)	3.77	7.54	7.54	6.976
Volume (m ³)	1830	3050	7320	12200
	6901			
Concentration VSS (kgVSS/m ³)	2.32	4.63	4.63	4.28
UPO VSS Concentration (kgUPOVSS/m ³)	0.429	0.859	0.859	0.794

Mass TSS wasted per day 4255.4 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 564.3 m³/d

COD mass balance	
COD in (influent)	15472.5 kgCOD/d
COD out	15472.5 kgCOD/d
$Q_s S_{in} + Q_w S_{iw}$	907.5 kgCOD/d
$Q_w X_{f_{ox}}$ or $f_{ox} MX_{iw}/Rs$	3869.3 kgCOD/d
FO_L	10695.7 kgO/d

N Mass balance	
TKN in (influent)	1205.00 kgN/d
TKN out	1205.00 kgN/d
N_{D_2}	129.60 kgN/d
N_{waste}	264.3 kgN/d
$N_{denitrified}$	811.1 kgN/d

TOD balance	
TOD in (influent)	20979.35 kgTOD/d
TOD out	20979.35 kgTOD/d
$TOD_{effluent}$	1033.12 kgTOD/d
TOD_{waste}	5087.15 kgTOD/d
TOD_{N_2-gas}	2319.87 kgTOD/d
FO_L	12539.20 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S_{uise}	36.30	75	30 mgCOD/l
Unbiol Sol Org N	N_{uise}	0.90	-	- mgN/l
FSA-N	N_{se}	0.41	6	2 mgFSA-N/l
TKN-N	N_{te}	1.31	-	- mgTKN-N/l
Nitrate	N_{ne}	4.00	15	1.5 mgNO ₃ -N/l
Unbiol Sol Org P	P_{uise}	0.60	-	- mgP/l
Ortho P as P	P_{oe}	10.53	10	2.5 mgP/l
TP	P_{te}	11.13	-	- mgP/l

UCT Reactor @ 25 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	25.00 Ml/d
Sludge Age	SRT	25.0 days
Reactor TSS concentration	X _T	9422.26 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	619	15473
BPO COD	Sbpi	479	11973
UPO COD	Supi	29	718
	fS'up		0.046
VFA COD	Sbsi,a	0.0	0
FBSD COD	Sbsfi	75	1875
BSO COD	Sbsi	75	1875
USO COD	Susi	36.3	908
	fS'us		0.059
BO COD	Sbi	554	13848
UO COD	Sui	65	1625
TSS		241	6018
ISS		51.4	1285
VSS		189	4733
UPO VSS		19.4	484
BPO VSS		170	4248
TKN	Nti	48.2	1205
Org N	Noi	13.8	345
FSA	Nai	34.4	860
BSO	Nobsi	2.90	73
USO	Nousi	0.90	23
BPO	Nobpi	8.70	218
UPO	Noupi	1.30	33
Total P	Pti	15.50	388
OP	Pai	12.80	320
Org P	Poi	2.70	68
BSO	Pobsi	0.70	18
USO	Pousi	0.60	15
BPO	Pobpi	0.78	19
UPO	Poupi	0.62	16

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _{oh}	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{ohv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{coHO}	0.15
Yield coefficient of ANO's	Y _a	0.10 mgVSS/mgFSA
COD per mass fraction of FBSD	f _{cm,bsd}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,uipo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,uipo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,uipo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{hT}	0.2141 /d
	μ _{h,20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{hnt}	0.2829 /d
	b _{h20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{at}	0.0357 /d
	K _{s,20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{s,T}	0.6288 mgFSA/l
	K _{s,20}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{s,T}	0.3472
	K _{s,20}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{s,T}	0.0742
	K ⁺ _{s,20}	0.255
Denitrification	θ	1.08
primary anoxic of NDBPER system	K ⁺ _{s,T}	0.1874

Factor of safety reducing μ _{hnt}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _m	6.76 days
SRT _m (with safety factor)	SRT _m	8.45 Nitrifies!

Max unaerated sludge mass fraction	f _{sm}	0.67
Total unaerated sludge mass fraction	f _{st}	0.35
Anoxic mass fraction primary anox 2	f _{z,prim anox 2}	0.27
Anaerobic mass fraction	f _{z,anox}	0.08
Aerobic mass fraction	f _{act}	0.65

Nr of equal size compartments

r-recyle ratio	r	1.0 :1
r-recyle NO ₃ concentration	N _{nr}	4.5 mgNO ₃ -N/l
r-recyle O ₂ concentration	S _{o2,s}	0.0 mgO/l

influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recyle ratio	s	1.7 :1
s-recyle DO concentration	O _s	1.0 mgO/l

a-recyle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)

f_{SD,s}

0.135

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	25.00 Ml/d
Sludge Age	SRT	25.0 days
Reactor TSS concentration	X _T	8999 mgTSS/l

Influent Characteristics		Concentration mg/l	Flux kg/d
Total COD	Sti	619	15473
BPO COD	Sbpi	479	11973
UPO COD	Supi	29	718
	fS'up		0.046
VFA COD	Sbsi,a	0	0
FBSD COD	Sbsfi	75	1875
BSO COD	Sbsi	75	1875
USO COD	Susi	36	908
	fS'us		0.059
BO COD	Sbi	554	13848
UO COD	Sui	65	1625
TSS		241	6018
ISS		51	1285
VSS		189	4733
UPO VSS		19	484
BPO VSS		170	4248
TKN	Nti	48	1205
Org N	Noi	14	345
FSA	Nai	34	860
BSO	Nobsi	2.90	73
USO	Nousi	0.90	23
BPO	Nobpi	8.70	218
UPO	Noupi	1.30	33
Total P	Pti	15.50	388
OP	Pai	12.80	320
Org P	Poi	2.70	68
BSO	Pobsi	0.70	18
USO	Pousi	0.60	15
BPO	Pobpi	0.78	19
UPO	Poupi	0.62	16

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _{oh}	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{ohv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{coHO}	0.15
Yield coefficient of ANO's	Y _a	0.1 mgVSS/mgFSA
COD per mass fraction of FBSD	f _{cm,bsd}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,uipo}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,uipo}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,uipo}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate OHO	b _{hT}	0.2691 /d
	μ _{h,20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{hnt}	0.7157 /d
	b _{h20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{at}	0.0448 /d
	K _{s,20}	1.0
Nitrification	θ	1.123
Half Saturation Coefficient	K _{s,T}	1.5904
	K _{s,20}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{s,T}	1.4930
	K _{s,20}	0.101
for ND system	θ	1.08
Half Saturation Coefficient	K _{s,T}	0.1374
	K ⁺ _{s,20}	0.255
Denitrification	θ	1.08
primary anoxic of NDBPER system	K ⁺ _{s,T}	0.3469

Factor of safety reducing μ _{hnt}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _m	2.38 days
SRT _m (with safety factor)	SRT _m	2.98 Nitrifies!

Max unaerated sludge mass fraction	f _{sm}	0.85
Total unaerated sludge mass fraction	f _{st}	0.35
Anoxic mass fraction primary anox 2	f _{z,prim anox 2}	0.27
Anaerobic mass fraction	f _{z,anox}	0.08
Aerobic mass fraction	f _{act}	0.65

Nr of equal size compartments

2

r-recyle ratio	r	1.0 :1
r-recyle NO ₃ concentration	N _{nr}	4.5 mgNO ₃ -N/l
r-recyle O ₂ concentration	S _{o2,s}	0.0 mgO/l

influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recyle ratio	s	1.7 :1
s-recyle DO concentration	O _s	1.0 mgO/l

a-recyle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)

f_{SD,s}

0.135

UCT Reactor @ 25 Days SRT

Influent TKN	N_0	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_L	261 kgN/d
Equiv conc in influent	N_i	10.46 mgN/l
Effluent Sol Unbiode Org N	N_{unb}	0.90 mgN/l
Effluent ammonia	N_{NH}	0.44 mgFSA-N/l
TKN in effluent	N_{eff}	1.34 mgTKN-N/l
Nitrification capacity	N_c	36.40 mgN/l influent

Denitrification potential BSO (K1)	D_{BBSO}	1.0 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BBSO}	47.25 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{d1}	48.29 mgNO ₂ -N/l influent

	A	0.6993
	B	-9.3958
	C	67.010
Optimal a-recycle ratio	a_{opt}	18.59
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00 set = a_{opt} for balanced UCT
		recycle limited

Effluent Nitrate if recycle limited		4.18 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-7.10 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{NH}	4.18 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₂)	$N_{NH} + N_{NH}$	5.52 mgN/l
N removal		88.5%

Alkalinity consumed by nitrification		260 mg CaCO ₃
Alkalinity recovered by denitrification		115 mg CaCO ₃
Total Alkalinity consumption		145 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{BVL,A}$	0 mgCOD/l
FBSO COD	S_{BVL}	75 mgCOD/l
BSO COD	S_{BVL}	75 mgCOD/l
BO COD	S_{BVL}	554 mgCOD/l

S_{F1} reduction due to O ₂ & NO ₃		38.7 mgCOD/l
Reduced FBSO concentration	$S_{F1,COMP}$	36.3 mgCOD/l

	k_{F120}	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	k_{F1T}	0.0535 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	S_{BVLN}	MX_{BVL}/Q_L	S_{BVLN}	
Trial 1	0.00	917	754	4.56
Trial 2	4.56	933	766	4.48
Trial 3	4.48	933	766	4.48
Trial 4	4.48	933	766	4.48

Flux BO COD obtained by OHO's	95%	13164 kgCOD/d
Flux BO COD obtained by PAO's	5%	683 kgCOD/d
Check total BO COD		13848 kgCOD/d

correct
13848

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{G20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{GT}	0.0357 /d

Activated Sludge Masses

<u>OHO VSS</u>		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	23316 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	24956 kgVSS
<u>PAO VSS</u>		
Polyphosphate Acc Organisms VSS	MX_{PAO}	4063 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	906 kgVSS
Unbiodegradable Organic VSS	MX_{UO}	12112 kgVSS
Total VSS	MX_V	65353 kgVSS
ISS from influent		32131 kgISS
ISS of OHO's		3497 kgISS
ISS of PAO's		5349 kgISS
ISS	MX_{DO}	40977 kgISS
TSS	MX_T	106330 kgTSS
VSS/TSS ratio		0.615 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.380 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.31 mgP/l
biomass P-content	ΔP_{OHO}	2.61 mgP/l
Potential P-removal		4.92 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.31 mgP/l
biomass P-content	ΔP_{OHO}	2.61 mgP/l
Total Actual P-removal		4.92 mgP/l

TP effluent

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	10305 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	389 kgO/d
Carbonaceous Oxygen flux	FO_L	10693 kgO/d
Nitrogenous Oxygen flux	FO_N	4159 kgO/d
Oxygen dmdnd recover by denitrification	FO_D	2304 kgO/d
Total Oxygen Demand (FO _C + FO _N - FO _D)	FO_T	12548 kgO/d
Oxygen utilisation rate	O_T	71.4 mgO/L/h

Influent TKN	N_0	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_L	247 kgN/d
Equiv conc in influent	N_i	9.88 mgN/l
Effluent Sol Unbiode Org N	N_{unb}	0.90 mgN/l
Effluent ammonia	N_{NH}	0.36 mgFSA-N/l
TKN in effluent	N_{eff}	1.26 mgTKN-N/l
Nitrification capacity	N_c	37.07 mgN/l influent

Denitrification potential BSO (K1)	D_{BBSO}	1.0 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BBSO}	71.85 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{d1}	72.86 mgNO ₂ -N/l influent

	A	0.6993
	B	-33.2967
	C	132.464
Optimal a-recycle ratio	a_{opt}	51.31
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00
		recycle limited

Effluent Nitrate if recycle limited		4.26 mgNO ₂ -N/l
Effluent Nitrate if kinetics limited		-31.00 mgNO ₂ -N/l
Actual Effluent Nitrate	N_{NH}	4.26 mgNO ₂ -N/l influent

Effluent total N (TKN + NO ₂)	$N_{NH} + N_{NH}$	5.51 mgN/l
N removal		88.6%

Alkalinity consumed by nitrification		265 mg CaCO ₃
Alkalinity recovered by denitrification		117 mg CaCO ₃
Total Alkalinity consumption		148 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{BVL,A}$	0 mgCOD/l
FBSO COD	S_{BVL}	75 mgCOD/l
BSO COD	S_{BVL}	75 mgCOD/l
BO COD	S_{BVL}	554 mgCOD/l

S_{F1} reduction due to O ₂ & NO ₃		38.7 mgCOD/l
Reduced FBSO concentration	$S_{F1,COMP}$	36.3 mgCOD/l

	k_{F120}	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	k_{F1T}	0.0673 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	S_{BVLN}	MX_{BVL}/Q_L	S_{BVLN}	
Trial 1	0.00	754	754	4.41
Trial 2	4.41	766	766	4.34
Trial 3	4.34	766	766	4.34
Trial 4	4.34	766	766	4.34

Flux BO COD obtained by OHO's	95%	13157 kgCOD/d
Flux BO COD obtained by PAO's	5%	690 kgCOD/d
Check total BO COD		13848 kgCOD/d

correct

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{G20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{GT}	0.0448 /d

Activated Sludge Masses

<u>OHO VSS</u>		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	19156 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	25772 kgVSS
<u>PAO VSS</u>		
Polyphosphate Acc Organisms VSS	MX_{PAO}	3662 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	1026 kgVSS
Unbiodegradable Organic VSS	MX_{UO}	12112 kgVSS
Total VSS	MX_V	61728 kgVSS
ISS from influent		32131 kgISS
ISS of OHO's		2873 kgISS
ISS of PAO's		4821 kgISS
ISS	MX_{DO}	39825 kgISS
TSS	MX_T	101554 kgTSS
VSS/TSS ratio		0.608 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.38 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.08 mgP/l
biomass P-content	ΔP_{OHO}	2.47 mgP/l
Potential P-removal		4.55 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.08 mgP/l
biomass P-content	ΔP_{OHO}	2.47 mgP/l
Total Actual P-removal		4.55 mgP/l

TP effluent

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	10495 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	413 kgO/d
Carbonaceous Oxygen flux	FO_L	10908 kgO/d
Nitrogenous Oxygen flux	FO_N	4235 kgO/d
Oxygen dmdnd recover by denitrification	FO_D	2346 kgO/d
Total Oxygen Demand (FO _C + FO _N - FO _D)	FO_T	12797 kgO/d
Oxygen utilisation rate	O_T	72.8 mgO/L/h

UCT Reactor @ 25 Days SRT

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Check	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	8621	28738	68971	106330
Concentration TSS (kgTSS/m ³)	4.71	9.42	9.42	8.716
Volume (m ³)	1830	3050	7320	12200
Volume fraction	15%	25%	60%	100%
Concentration VSS (kgVSS/m ³)	2.90	5.79	5.79	5.36
UPO VSS Concentration (kgUPOVSS/m ³)	0.537	1.073	1.073	0.993

Mass TSS wasted per day 4253.2 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 451.4 m³/d

COD mass balance	
COD in (influent)	15472.5 kgCOD/d
COD out	15472.5 kgCOD/d
$Q_s S_{10} + Q_w S_{10}$	907.5 kgCOD/d
$Q_w X_{10} f_{10}$ or $f_{10} MX_{10}/Rs$	3871.5 kgCOD/d
FO_L	10693.5 kgO/d

N Mass balance	
TKN in (influent)	1205.00 kgN/d
TKN out	1205.00 kgN/d
N_{10}	135.51 kgN/d
N_{waste}	263.9 kgN/d
$N_{denitrified}$	805.6 kgN/d

TOD balance	
TOD in (influent)	20979.35 kgTOD/d
TOD out	20979.35 kgTOD/d
$TOD_{effluent}$	1041.58 kgTOD/d
TOD_{waste}	5085.33 kgTOD/d
TOD_{N_2-gas}	2303.96 kgTOD/d
FO_L	12548.48 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S_{100}	36.30	75	30 mgCOD/l
Unbiol Sol Org N	N_{100}	0.90	-	- mgN/l
FSA-N	N_{90}	0.44	6	2 mgFSA-N/l
TKN-N	N_{10}	1.34	-	- mgTKN-N/l
Nitrate	N_{10}	4.18	15	1.5 mgNO ₃ -N/l
Unbiol Sol Org P	P_{100}	0.60	-	- mgP/l
Ortho P as P	P_{90}	10.58	10	2.5 mgP/l
TP	P_{10}	11.18	-	- mgP/l

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	8234	27447	65873	101554
Concentration TSS (kgTSS/m ³)	4.50	9.00	9.00	8.324
Volume (m ³)	1830	3050	7320	12200
	8234			
Concentration VSS (kgVSS/m ³)	2.73	5.47	5.47	5.06
UPO VSS Concentration (kgUPOVSS/m ³)	0.537	1.073	1.073	0.993

Mass TSS wasted per day 4062.1 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 451.4 m³/d

COD mass balance	
COD in (influent)	15472.5 kgCOD/d
COD out	15472.5 kgCOD/d
$Q_s S_{10} + Q_w S_{10}$	907.5 kgCOD/d
$Q_w X_{10} f_{10}$ or $f_{10} MX_{10}/Rs$	3656.8 kgCOD/d
FO_L	10908.2 kgO/d

N Mass balance	
TKN in (influent)	1205.00 kgN/d
TKN out	1205.00 kgN/d
N_{10}	135.29 kgN/d
N_{waste}	249.4 kgN/d
$N_{denitrified}$	820.3 kgN/d

TOD balance	
TOD in (influent)	20979.35 kgTOD/d
TOD out	20979.35 kgTOD/d
$TOD_{effluent}$	1031.99 kgTOD/d
TOD_{waste}	4804.16 kgTOD/d
TOD_{N_2-gas}	2346.08 kgTOD/d
FO_L	12797.12 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S_{100}	36.30	75	30 mgCOD/l
Unbiol Sol Org N	N_{100}	0.90	-	- mgN/l
FSA-N	N_{90}	0.36	6	2 mgFSA-N/l
TKN-N	N_{10}	1.26	-	- mgTKN-N/l
Nitrate	N_{10}	4.26	15	1.5 mgNO ₃ -N/l
Unbiol Sol Org P	P_{100}	0.60	-	- mgP/l
Ortho P as P	P_{90}	10.95	10	2.5 mgP/l
TP	P_{10}	11.55	-	- mgP/l

UCT Reactor @ 30 Days SRT

TEMPERATURE	T	16 °C
Influent Flow Rate	Q _i	25.00 Ml/d
Sludge Age	SRT	30.0 days
Reactor TSS concentration	X _T	10875.69 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti	619 15473
BPO COD	Sbpi	479 11973
UPO COD	Supi	29 718
	fs'up	0.046
VFA COD	Sbsi,a	0 0
FBSO COD	Sbsfi	75 1875
BSO COD	Sbsi	75 1875
USO COD	Susi	36.3 908
	fs'us	0.059
BO COD	Sbi	554 13848
UO COD	Sui	65 1625
TSS		241 6018
ISS		51.4 1285
VSS		189 4733
UPO VSS		19.4 484
BPO VSS		170 4248
TKN	Nti	48.2 1205
Org N	Noi	13.8 345
FSA	Nai	34.4 860
BSO	Nobsi	2.90 73
USO	Nousi	0.90 23
BPO	Nobpi	8.70 218
UPO	Noupi	1.30 33
Total P	Pti	15.50 388
OP	Pai	12.80 320
Org P	Poi	2.70 68
BSO	Pobsi	0.70 18
USO	Pousi	0.60 15
BPO	Pobpi	0.78 19
UPO	Poupi	0.62 16

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _{oh}	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{ohv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.10 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,fbs0}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso0}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,u0}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,u0}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,u0}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	16 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate heterotrophs	b _{hT}	0.2141 /d
	μ _{h,m20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{amT}	0.2829 /d
	b _{h20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{aT}	0.0357 /d
	K _{s20}	1.0 mgFSA/l
Nitrification	θ	1.123
Half Saturation Coefficient	K _{sT}	0.6288 mgFSA/l
	K _{s(p0)}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{sT}	0.3472
	K _{s(p0)}	0.101
Denitrification	θ	1.08
for ND system	K _{sT}	0.0742
Half Saturation Coefficient	K ¹⁰ _{s20(p)}	0.255
Denitrification	θ	1.08
primary anoxic of NDBPER system	K ¹⁰ _{s2T}	0.1874
Half Saturation Coefficient		

Factor of safety reducing μ _{amT}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _m	6.76 days
SRT _m (with safety factor)	SRT _m	8.45 Nitrifies!

Max unaerated sludge mass fraction	f _{xm}	0.70
Total unaerated sludge mass fraction	f _{xt}	0.35
Anoxic mass fraction primary anox 2	f _{x prim anox 2}	0.27
Anaerobic mass fraction	f _{anoxaer}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments 2

r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N _{br}	4.6 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{O2,L}	0.0 mgO/l

influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	1.71 :1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)	f _{Sb/s}	0.135

TEMPERATURE	T	24 °C
Influent Flow Rate	Q _i	25.00 Ml/d
Sludge Age	SRT	30.0 days
Reactor TSS concentration	X _T	10421 mgTSS/l

Influent Characteristics	Concentration mg/l	Flux kg/d
Total COD	Sti	619 15473
BPO COD	Sbpi	479 11973
UPO COD	Supi	29 718
	fs'up	0.046
VFA COD	Sbsi,a	0 0
FBSO COD	Sbsfi	75 1875
BSO COD	Sbsi	75 1875
USO COD	Susi	36 908
	fs'us	0.059
BO COD	Sbi	554 13848
UO COD	Sui	65 1625
TSS		241 6018
ISS		51 1285
VSS		189 4733
UPO VSS		19 484
BPO VSS		170 4248
TKN	Nti	48 1205
Org N	Noi	14 345
FSA	Nai	34 860
BSO	Nobsi	2.90 73
USO	Nousi	0.90 23
BPO	Nobpi	8.70 218
UPO	Noupi	1.30 33
Total P	Pti	15.50 388
OP	Pai	12.80 320
Org P	Poi	2.70 68
BSO	Pobsi	0.70 18
USO	Pousi	0.60 15
BPO	Pobpi	0.78 19
UPO	Poupi	0.62 16

Constants		
COD/VSS ratio	f _{co}	1.481 mgCOD/mgVSS
Yield coefficient of OHO's	Y _{oh}	0.67 mgCOD/mgCOD
Yield coefficient of OHO's	Y _{ohv}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f _{de}	0.2
ISS content of OHO's	f _{iOHO}	0.15
Yield coefficient of ANO's	Y _A	0.1 mgVSS/mgFSA
COD per mass fraction of FBSO	f _{cm,fbs0}	1.42 mgCOD/mg
COD per mass fraction of USO	f _{cm,uso0}	1.493 mgCOD/mg
N Content of UPO and biomass VSS	f _{n,u0}	0.1 mgN/mgVSS
P Content of UPO and biomass VSS	f _{p,u0}	0.025 mgP/mgVSS
C Content of UPO and biomass VSS	f _{c,u0}	0.518 mgC/mgVSS

Temperature dependant coefficients	T	24 °C
	b _{h20}	0.24 /d
	θ	1.029
Endogenous respiration rate OHO	b _{hT}	0.2691 /d
	μ _{h,m20}	0.45 /d
	θ	1.123
nitrifiers max spec. growth rate	μ _{amT}	0.7157 /d
	b _{h20}	0.0400 /d
	θ	1.029
Endogenous respiration rate autotrophs	b _{aT}	0.0448 /d
	K _{s20}	1.0
Nitrification	θ	1.123
Half Saturation Coefficient	K _{sT}	1.5904
	K _{s(p0)}	0.72
Denitrification	θ	1.2
Half Saturation Coefficient	K _{sT}	1.4930
	K _{s(p0)}	0.101
Denitrification	θ	1.08
for ND system	K _{sT}	0.1374
Half Saturation Coefficient	K ¹⁰ _{s20(p)}	0.255
Denitrification	θ	1.08
primary anoxic of NDBPER system	K ¹⁰ _{s2T}	0.3469
Half Saturation Coefficient		

Factor of safety reducing μ _{amT}	Sf	1.25
total unaerated mass fraction	f _{xt}	0.351
Minimum sludge age for nitrification	SRT _m	2.38 days
SRT _m (with safety factor)	SRT _m	2.98 Nitrifies!

Max unaerated sludge mass fraction	f _{xm}	0.86
Total unaerated sludge mass fraction	f _{xt}	0.35
Anoxic mass fraction primary anox 2	f _{x prim anox 2}	0.27
Anaerobic mass fraction	f _{anoxaer}	0.08
Aerobic mass fraction	f _{aer}	0.65

Nr of equal size compartments 2

r-recycle ratio	r	1.0 :1
r-recycle NO ₃ concentration	N _{br}	4.6 mgNO ₃ -N/l
r-recycle O ₂ concentration	S _{O2,L}	0.0 mgO/l

influent NO ₃ concentration	S _{NO3,i}	0.0 mgNO ₃ -N/l
influent DO concentration	O _i	0.0 mgO/l

s-recycle ratio	s	1.7 :1
s-recycle DO concentration	O _s	1.0 mgO/l

a-recycle DO concentration	O _a	2.0 mgO/l

Influent RBCOD fraction (Sbsi/Sbi)	f _{Sb/s}	0.135

UCT Reactor @ 30 Days SRT

Influent TKN	N_0	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_L	249 kgN/d
Equiv conc in influent	N_i	9.98 mgN/l
Effluent Sol Unbiode Org N	N_{unb}	0.90 mgN/l
Effluent ammonia	N_{NH}	0.38 mgFSA-N/l
TKN in effluent	N_{de}	1.28 mgTKN-N/l
Nitrification capacity	N_L	36.94 mgN/l influent

Denitrification potential BSO (K1)	D_{BPO}	1.0 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BPO}	48.57 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{d1}	49.56 mgNO ₂ -N/l influent

	A	0.6993
	B	-10.1181
	C	69.510
Optimal a-recycle ratio	a_{opt}	19.55
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00
set = a_{opt} for balanced UCT recycle limited		

Effluent Nitrate if recycle limited		4.24 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		-7.82 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{NH}	4.24 mgNO ₃ -N/l influent

Effluent total N (TKN + NO ₃)	$N_{NH} + N_{de}$	5.52 mgN/l
N removal		88.5%

Alkalinity consumed by nitrification		264 mg CaCO ₃
Alkalinity recovered by denitrification		117 mg CaCO ₃
Total Alkalinity consumption		147 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{bi,a}$	0 mgCOD/l
FBSO COD	S_{bi}	75 mgCOD/l
BSO COD	S_{bi}	75 mgCOD/l
BO COD	S_{bi}	554 mgCOD/l

S_{F_j} reduction due to O ₂ & NO ₃		39.71498628 mgCOD/l
Reduced FBSO concentration	$S_{F_j,LOHv}$	35.28501372 mgCOD/l

	$k_{r,120}$	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	$k_{r,T}$	0.0535 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	$S_{bi/N}$	MX_{bi}/Q_r	$S_{bi/N}$	
Trial 1	0.00	943		4.31
Trial 2	4.31	959		4.24
Trial 3	4.24	959		4.24
Trial 4	4.24	959		4.24

Flux BO COD obtained by OHO's	95%	13177 kgCOD/d
Flux BO COD obtained by PAO's	5%	670 kgCOD/d
Check total BO COD		13848 kgCOD/d

correct
13848

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{G20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{GT}	0.0357 /d

Activated Sludge Masses

<u>OHO VSS</u>		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	23968 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	30785 kgVSS

<u>PAO VSS</u>		
Polyphosphate Acc Organisms VSS	MX_{PAO}	4370 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	1169 kgVSS

Unbiodegradable Organic VSS	MX_{iu}	14534 kgVSS
Total VSS	MX_v	74827 kgVSS

ISS from influent		38557 kgISS
ISS of OHO's		3595 kgISS
ISS of PAO's		5753 kgISS
ISS	MX_{DO}	47905 kgISS
TSS	MX_t	122732 kgTSS
VSS/TSS ratio		0.610 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.380 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.07 mgP/l
biomass P-content	ΔP_{OHO}	2.49 mgP/l
Potential P-removal		4.56 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	2.07 mgP/l
biomass P-content	ΔP_{OHO}	2.49 mgP/l
Total Actual P-removal		4.56 mgP/l

TP effluent P_{le} 10.94 mgP/l

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	10474 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	397 kgO/d
Carbonaceous Oxygen flux	FO_L	10871 kgO/d
Nitrogenous Oxygen flux	FO_N	4221 kgO/d
Oxygen dmdnd recover by denitrification	FO_D	2338 kgO/d
Total Oxygen Demand ($FO_L + FO_N + FO_D$)	FO_T	12754 kgO/d
Oxygen utilisation rate	O_r	72.6 mgO/l/h

Influent TKN	N_0	48.2 mgTKN-N/l
Flux of N in waste VSS	FN_L	237 kgN/d
Equiv conc in influent	N_i	9.46 mgN/l
Effluent Sol Unbiode Org N	N_{unb}	0.90 mgN/l
Effluent ammonia	N_{NH}	0.32 mgFSA-N/l
TKN in effluent	N_{de}	1.22 mgTKN-N/l
Nitrification capacity	N_L	37.51 mgN/l influent

Denitrification potential BSO (K1)	D_{BPO}	1.0 mgNO ₂ -N/l influent
Denitrification potential BPO (K2)	D_{BPO}	73.51 mgNO ₂ -N/l influent
Denitr potential primary anoxic tank	D_{d1}	74.47 mgNO ₂ -N/l influent

	A	0.6993
	B	-34.4631
	C	136.073
Optimal a-recycle ratio	a_{opt}	52.96
Maximum practical a-recycle ratio	a_{max}	6
chosen a-recycle ratio	a	6.00
recycle limited		

Effluent Nitrate if recycle limited		4.31 mgNO ₃ -N/l
Effluent Nitrate if kinetics limited		-32.16 mgNO ₃ -N/l
Actual Effluent Nitrate	N_{NH}	4.31 mgNO ₃ -N/l influent

Effluent total N (TKN + NO ₃)	$N_{NH} + N_{de}$	5.53 mgN/l
N removal		88.5%

Alkalinity consumed by nitrification		268 mg CaCO ₃
Alkalinity recovered by denitrification		119 mg CaCO ₃
Total Alkalinity consumption		149 mg CaCO ₃

ANAEROBIC REACTOR

VFA COD	$S_{bi,a}$	0 mgCOD/l
FBSO COD	S_{bi}	75 mgCOD/l
BSO COD	S_{bi}	75 mgCOD/l
BO COD	S_{bi}	554 mgCOD/l

S_{F_j} reduction due to O ₂ & NO ₃		39.71498628 mgCOD/l
Reduced FBSO concentration	$S_{F_j,LOHv}$	35.28501372 mgCOD/l

	$k_{r,120}$	0.06 m ³ /gVSS.d
	θ	1.029
Fermentation rate	$k_{r,T}$	0.0673 m ³ /gVSS.d

PAO's get all VFA's + FBSO converted to VFA
OHO's get BPO and remaining FBSO

	$S_{bi/N}$	MX_{bi}/Q_r	$S_{bi/N}$	
Trial 1	0.00	772		4.19
Trial 2	4.19	784		4.12
Trial 3	4.12	784		4.12
Trial 4	4.12	784		4.12

Flux BO COD obtained by OHO's	95%	13171 kgCOD/d
Flux BO COD obtained by PAO's	5%	676 kgCOD/d
Check total BO COD		13848 kgCOD/d

correct

Yield coefficient of PAO's	Y_G	0.67 mgCOD/mgCOD
Yield coefficient of PAO's	Y_{GV}	0.45 mgVSS/mgCOD
Endogenous residue fraction	f_G	0.25
ISS content of PAO's	f_{PAO}	0.15

	b_{G20}	0.04 /d
	θ	1.029
Endogenous respiration rate PAO's	b_{GT}	0.0448 /d

Activated Sludge Masses

<u>OHO VSS</u>		
Ordinary Heterotrophic Organisms VSS	MX_{OHO}	19600 kgVSS
Endogenous Residue VSS OHO	$MX_{E,OHO}$	31643 kgVSS

<u>PAO VSS</u>		
Polyphosphate Acc Organisms VSS	MX_{PAO}	3891 kgVSS
Endogenous Residue VSS PAO	$MX_{E,PAO}$	1309 kgVSS

Unbiodegradable Organic VSS	MX_{iu}	14534 kgVSS
Total VSS	MX_v	70977 kgVSS

ISS from influent		38557 kgISS
ISS of OHO's		2940 kgISS
ISS of PAO's		5123 kgISS
ISS	MX_{DO}	46620 kgISS
TSS	MX_t	117597 kgTSS
VSS/TSS ratio		0.604 kgVSS/kgTSS

PAO biomass P-content		0.025 mgP/mgPAOVSS
Max PAO polyphosphate P-content	$f_{PB,PAO}$	0.355 mgP/mgPAOVSS
		0.38 mgP/mgPAOVSS

Potential P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	1.84 mgP/l
biomass P-content	ΔP_{OHO}	2.37 mgP/l
Potential P-removal		4.21 mgP/l

Max P removal		15.5 mgP/l
Revised PAO poly-P-content	$f_{PB,PAO}$	0.3550 mgP/mgPAOVSS

Actual P removal through:

PAO polyphosphate P-content	$\Delta P_{PAO,2}$	1.84 mgP/l
biomass P-content	ΔP_{OHO}	2.37 mgP/l
Total Actual P-removal		4.21 mgP/l

TP effluent P_{le} 11.29 mgP/l

Note: Add P content of TSS in effluent

Carbonaceous Oxygen flux OHO's	FO_{OHO}	10642 kgO/d
Carbonaceous Oxygen flux PAO's	FO_{PAO}	419 kgO/d
Carbonaceous Oxygen flux	FO_L	11061 kgO/d
Nitrogenous Oxygen flux	FO_N	4286 kgO/d
Oxygen dmdnd recover by denitrification	FO_D	2374 kgO/d
Total Oxygen Demand ($FO_L + FO_N + FO_D$)	FO_T	12973 kgO/d
Oxygen utilisation rate	O_r	73.8 mgO/l/h

UCT Reactor @ 30 Days SRT

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Check	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	9951	33171	79610	122732
Concentration TSS (kgTSS/m ³)	5.44	10.88	10.88	10.060
Volume (m ³)	1830	3050	7320	12200
Volume fraction	15%	25%	60%	100%
Concentration VSS (kgVSS/m ³)	3.32	6.63	6.63	6.13
UPO VSS Concentration (kgUPOVSS/m ³)	0.644	1.288	1.288	1.191

Mass TSS wasted per day 4091.1 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 376.2 m³/d

COD mass balance	
COD in (influent)	15472.5 kgCOD/d
COD out	15472.5 kgCOD/d
$Q_a S_{10} + Q_w S_{10}$	907.5 kgCOD/d
$Q_w X_a f_{cv}$ or $f_{cv} MX_w/Rs$	3694.0 kgCOD/d
FO_L	10871.0 kgO/d

N Mass balance	
TKN in (influent)	1205.00 kgN/d
TKN out	1205.00 kgN/d
N_{10}	135.93 kgN/d
N_{waste}	251.5 kgN/d
$N_{denitrified}$	817.6 kgN/d

TOD balance	
TOD in (influent)	20979.35 kgTOD/d
TOD out	20979.35 kgTOD/d
$TOD_{effluent}$	1037.76 kgTOD/d
TOD_{waste}	4849.67 kgTOD/d
TOD_{N_2-gas}	2338.26 kgTOD/d
FO_L	12753.66 kgTOD/d

Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S_{100}	36.30	75	30 mgCOD/l
Undiol Sol Org N	N_{1000}	0.90	-	mgN/l
FSA-N	N_{10}	0.38	6	2 mgFSA-N/l
TKN-N	N_{10}	1.28	-	mgTKN-N/l
Nitrate	N_{10}	4.24	15	1.5 mgNO ₃ -N/l
Undiol Sol Org P	P_{1000}	0.60	-	mgP/l
Ortho P as P	P_{10}	10.94	10	2.5 mgP/l
TP	P_{10}	11.54	-	mgP/l

	Anaerobic	Anoxic	Aerobic	Total
Sludge mass fraction	0.08	0.27	0.65	1.000
Sludge mass (kgTSS)	9535	31783	76279	117597
Concentration TSS (kgTSS/m ³)	5.21	10.42	10.42	9.639
Volume (m ³)	1830	3050	7320	12200
	9535			
Concentration VSS (kgVSS/m ³)	3.14	6.29	6.29	5.82
UPO VSS Concentration (kgUPOVSS/m ³)	0.644	1.288	1.288	1.191

Mass TSS wasted per day 3919.9 kgTSS/d
Waste Flow Rate (note not V/Rs) Q_w 376.2 m³/d

COD mass balance	
COD in (influent)	15472.5 kgCOD/d
COD out	15472.5 kgCOD/d
$Q_a S_{10} + Q_w S_{10}$	907.5 kgCOD/d
$Q_w X_a f_{cv}$ or $f_{cv} MX_w/Rs$	3503.9 kgCOD/d
FO_L	11061.1 kgO/d

N Mass balance	
TKN in (influent)	1205.00 kgN/d
TKN out	1205.00 kgN/d
N_{10}	136.14 kgN/d
N_{waste}	238.7 kgN/d
$N_{denitrified}$	830.2 kgN/d

TOD balance	
TOD in (influent)	20979.35 kgTOD/d
TOD out	20979.35 kgTOD/d
$TOD_{effluent}$	1031.37 kgTOD/d
TOD_{waste}	4600.88 kgTOD/d
TOD_{N_2-gas}	2374.35 kgTOD/d
FO_L	12972.76 kgTOD/d

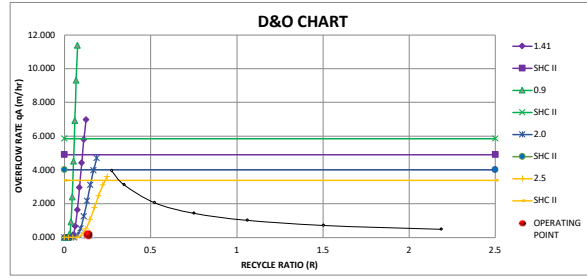
Effluent Concentrations		General	Special	Unit
Unbiol Sol COD	S_{100}	36.30	75	30 mgCOD/l
Undiol Sol Org N	N_{1000}	0.90	-	mgN/l
FSA-N	N_{10}	0.32	6	2 mgFSA-N/l
TKN-N	N_{10}	1.22	-	mgTKN-N/l
Nitrate	N_{10}	4.31	15	1.5 mgNO ₃ -N/l
Undiol Sol Org P	P_{1000}	0.60	-	mgP/l
Ortho P as P	P_{10}	11.29	10	2.5 mgP/l
TP	P_{10}	11.89	-	mgP/l

Annexure B – SST Capacity Check

**Annexure B1 – SST Capacity Check for Influent
Flow of 20 ML/d**

SST's - MLE Process @ 10 Days SRT

DSVI	100 ml/g	(Range 50-200ml/g, >150ml/g = bulking sludge)
SSVI	67 ml/g	
V_0/n	23.24 kgTSS/(m ² ·h)	
V_0	7.974 m ³ /h	
n	0.343 m ³ /kgTSS	
f_n	1.8432	
ADWF	370 m ³ /h	8.9 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	683 m ³ /h	16.4 Ml/d
$Q_{applied}$	370 m ³ /h	8.9 Ml/d
Flux Rating	0.8	
SST Area	1963 m ²	0% added to area for non-idealities
SST diameter	25	1963 m ²
No. of SST's	4.0	
OPERATING POINT		
q_A	0.189 m ³ /h	
q_R	0.026 m ³ /h	
R	0.138 [Q_A/Q_R]	

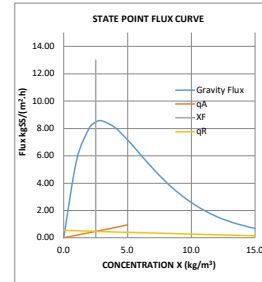
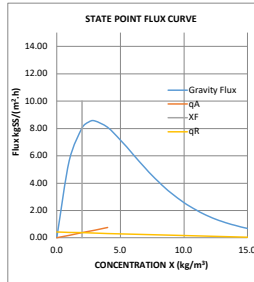
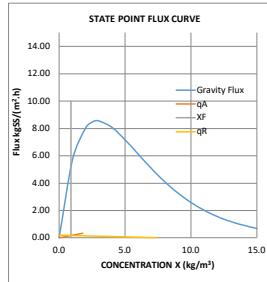
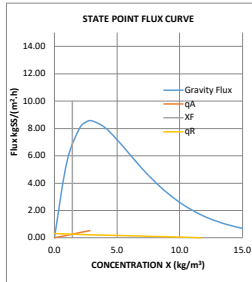


X_c	1.41 kg/m ³
SST min Area:	SAFE 75 m ²
SHC I	
R	α q_A (m ³ /hr)
0	1.000 0.000
0.013	0.948 0.000
0.025	0.893 0.000
0.038	0.837 0.011
0.050	0.778 0.153
0.063	0.716 0.665
0.075	0.650 1.643
0.088	0.578 2.964
0.100	0.498 4.414
0.113	0.404 5.798
0.126	0.284 6.972
R_{crit}	0.138 7.817
X	
0.000	0.000 0.304 kgSS/(m ² ·h)
1.414	0.267 0.267 kgSS/(m ² ·h)
2.829	0.534 0.230 kgSS/(m ² ·h)
X_c	11.660 2.199 0.000 kgSS/(m ² ·h)

X_c	0.9 kg/m ³
SST min Area:	SAFE 63 m ²
SHC I	
R	α q_A (m ³ /hr)
0	1.000 0.000
0.008	0.950 0.000
0.015	0.898 0.000
0.023	0.843 0.012
0.030	0.786 0.192
0.038	0.725 0.915
0.046	0.659 2.401
0.053	0.588 4.517
0.061	0.507 6.932
0.068	0.413 9.309
0.076	0.291 11.378
R_{crit}	0.084 0.000 12.902
X	
0.000	0.000 0.193 kgSS/(m ² ·h)
0.900	0.170 0.170 kgSS/(m ² ·h)
1.800	0.340 0.146 kgSS/(m ² ·h)
X_c	7.419 1.399 0.000 kgSS/(m ² ·h)

X_c	2.0 kg/m ³
SST min Area:	SAFE 149 m ²
SHC I	
R	α q_A (m ³ /hr)
0	1.000 0.000
0.019	0.945 0.000
0.038	0.888 0.000
0.056	0.830 0.012
0.075	0.769 0.140
0.094	0.706 0.545
0.113	0.639 1.257
0.132	0.567 2.163
0.151	0.487 3.114
0.169	0.394 3.989
0.188	0.277 4.710
R_{crit}	0.207 0.000 5.212
X	
0.000	0.000 0.429 kgSS/(m ² ·h)
2.000	0.377 0.377 kgSS/(m ² ·h)
4.000	0.755 0.325 kgSS/(m ² ·h)
X_c	16.487 3.110 0.000 kgSS/(m ² ·h)

X_c	2.5 kg/m ³
SST min Area:	SAFE 464 m ²
SHC I	
R	α q_A (m ³ /hr)
0	1.000 0.000
0.025	0.942 0.000
0.050	0.883 0.000
0.074	0.823 0.014
0.099	0.761 0.138
0.124	0.697 0.493
0.149	0.629 1.072
0.174	0.557 1.771
0.198	0.477 2.477
0.223	0.386 3.107
0.248	0.270 3.612
R_{crit}	0.273 0.000 3.954
X	
0.000	0.000 0.537 kgSS/(m ² ·h)
2.500	0.472 0.472 kgSS/(m ² ·h)
5.000	0.943 0.406 kgSS/(m ² ·h)
X_c	20.609 3.887 0.000 kgSS/(m ² ·h)



SHC II	
R	q_{Amax} (m ³ /hr)
0	4.908
2.5	4.908

APPLIED FLUX (SLR) 0.27 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m ³ /hr)
0	5.856
2.5	5.856

APPLIED FLUX (SLR) 0.17 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m ³ /hr)
0	4.015
2.5	4.015

APPLIED FLUX (SLR) 0.38 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m ³ /hr)
0	3.382
2.5	3.382

APPLIED FLUX (SLR) 0.47 kgTSS/(m²·h)

SHC I

$$q_A = \frac{F_g (1 + \alpha)}{R (1 - \alpha)} \exp \left[\frac{-n(1+R)X_p(1+\alpha)}{2R} \right]$$

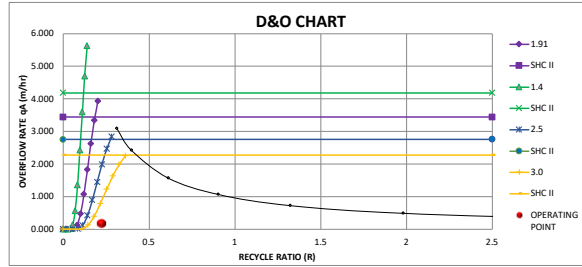
where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_p}}$

SHC II

$$q_{AmaxSHC II} = F_g e^{-nX_p}$$

SST's - MLE Process @ 15 Days SRT

DSVI	120 ml/g	(Range 50-200ml/g, >150ml/g = bulking sludge)
SSVI	80.4 ml/g	
V_0/n	18.76 kgTSS/(m ² ·h)	
V_0	7.121 m/h	
n	0.380 m ³ /kgTSS	
f_n	1.8432	
ADWF	370 m ³ /h	8.9 Ml/d
PWWF	m ³ /h	Ml/d
PWWF	683 m ³ /h	16.4 Ml/d
$Q_{applied}$	370 m ³ /h	8.9 Ml/d
Flux Rating	0.8	
SST Area	1963 m ²	0% added to area for non-idealities
SST diameter	25	1963 m ²
No. of SST's	4.0	
OPERATING POINT		
q_A	0.189 m/h	
q_R	0.042 m/h	
R	0.222 [Q_A/Q_R]	

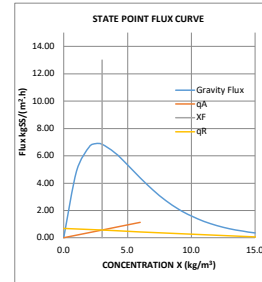
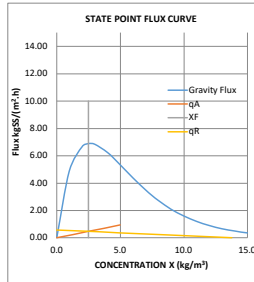
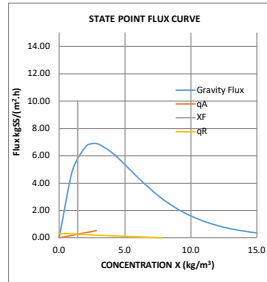
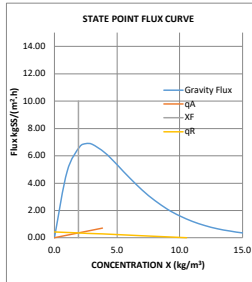


X_c	1.91	kg/m ³
	SAFE	
SST min Area:	108 m ²	
		4.341
SHC I		
R	α	q_A (m/hr)
	0	1.000
		#DIV/0!
	0.020	0.944
	0.040	0.897
	0.061	0.828
	0.081	0.767
	0.101	0.704
	0.121	0.637
	0.141	0.564
	0.161	0.485
	0.182	0.392
	0.202	0.275
R_{crit}	0.222	0.000
		4.341
X	q_A	q_R
	0.000	0.000
	1.914	0.361
	3.829	0.722
X_c	10.536	1.987

X_p		1.4 kg/m ³
	SAFE	
SST min Area:		88 m ²
	#DIV/0!	#DIV/0!
SHC I		
R	α	q_A (m/hr)
	1.000	#DIV/0!
	0.014	0.947
	0.028	0.892
	0.042	0.836
	0.056	0.776
	0.070	0.714
	0.084	0.648
	0.098	0.576
	0.111	0.495
	0.125	0.402
	0.139	0.282
R_{crit}	0.153	0.000
X	q_A	q_R
	0.000	0.000
	1.400	0.264
	2.800	0.528
X_c	7.706	1.453

X_c	2.5 kg/m ³	
SAFE	SAFE	
SST min Area:	194 m ²	
SHC I	(0.48) (0.912)	
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.028	0.940	0.000
0.057	0.880	0.000
0.085	0.819	0.014
0.113	0.756	0.124
0.141	0.691	0.424
0.170	0.623	0.894
0.198	0.551	1.445
0.226	0.472	1.991
0.255	0.381	2.469
0.283	0.266	2.846
R_{crit}	0.311	0.000
	0.3098	
X	q_A	q_R
0.000	0.000	0.576
2.500	0.472	0.472
5.000	0.943	0.367
X_c	13.760	2.596

X_c	3.0 kg/m ³	
SAFE		
SST min Area:	435 m ²	(0.602) (0.812)
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.036	0.937	0.000
0.072	0.873	0.000
0.109	0.810	0.017
0.145	0.746	0.130
0.181	0.680	0.401
0.217	0.611	0.794
0.253	0.539	1.228
0.290	0.460	1.639
0.326	0.370	1.986
0.362	0.258	2.251
R_{crit}	0.398	0.000
X	q_A	q_R
0.000	0.000	0.692
3.000	0.566	0.566
6.000	1.132	0.440
X_c	16.512	3.115



SHC II	
R	q_{Amax} (m/hr)
0	3.443
2.5	3.443

APPLIED FLUX (SLR) 0.36 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	4.185
2.5	4.185

APPLIED FLUX (SLR) 0.26 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	2.757
2.5	2.757

APPLIED FLUX (SLR) 0.47 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	2.280
2.5	2.280

APPLIED FLUX (SLR) 0.57 kgTSS/(m²·h)

SHC I

$$q_A = \frac{F_g (1 + \alpha)}{R (1 - \alpha)} \exp \left[\frac{-n(1+R)X_p(1+\alpha)}{2R} \right]$$

where

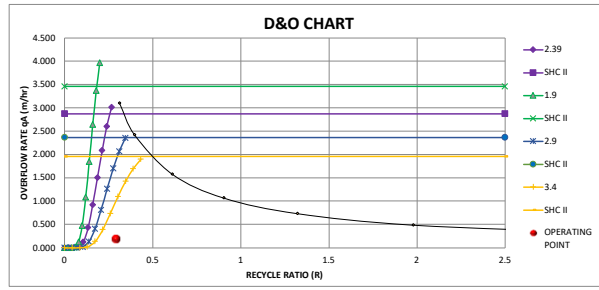
$$\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_p}}$$

SHC II

$$q_{AmaxSHC II} = F_g e^{-nX_p}$$

SST's - MLE Process @ 20 Days SRT

DSVI	120 ml/g	(Range 50-200ml/g, >150ml/g = bulking sludge)
SSVI	80.4 ml/g	
V_0/n	18.76 kgTSS/(m ² ·h)	
V_0	7.121 m/h	
n	0.380 m ³ /kgTSS	
f_n	1.8432	
ADWF	370 m ³ /h	8.9 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	683 m ³ /h	16.4 Ml/d
$Q_{applied}$	370 m ³ /h	8.9 Ml/d
Flux Rating	0.8	
SST Area	1963 m ²	0% added to area for non-idealities
SST diameter	25	1963 m ²
No. of SST's	4.0	
OPERATING POINT		
q_A	0.189 m/h	
q_R	0.055 m/h	
R	0.293 [Q_R/Q_A]	



X_c	2.39	kg/m ³
	SAFE	
SST min Area:	129 m ²	
	0.000	3.289
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.027	0.941	0.000
0.053	0.881	0.000
0.080	0.821	0.013
0.107	0.758	0.124
0.133	0.694	0.431
0.160	0.626	0.922
0.186	0.554	1.506
0.213	0.474	2.088
0.240	0.383	2.604
0.266	0.268	3.013
R_{crit}	0.293	3.289

X	q_A	q_R
0.000	0.000	0.582 kgSS/(m ² ·h)
2.388	0.450	0.450 kgSS/(m ² ·h)
4.776	0.901	0.318 kgSS/(m ² ·h)
X_c	10.536	1.987 0.000 kgSS/(m ² ·h)

X_c	1.9	kg/m ³
SAFE		
SST min Area:	107	m ²
		#NUM! #NUM!
SHC I		
R	α	q_s (m/hr)
0	1.000	#DIV/0!
0.020	0.944	0.000
0.040	0.887	0.000
0.060	0.828	0.011
0.080	0.768	0.124
0.100	0.704	0.475
0.120	0.637	1.082
0.140	0.565	1.847
0.160	0.485	2.643
0.180	0.393	3.371
0.200	0.275	3.967
R_{crit}	0.220	4.381

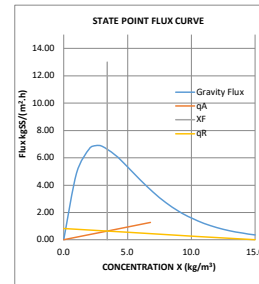
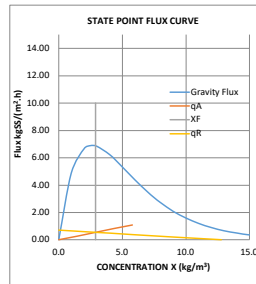
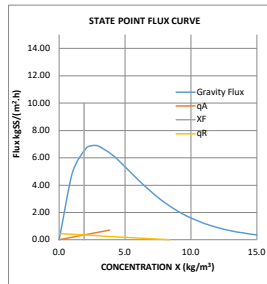
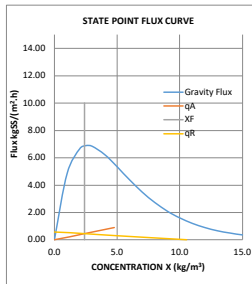
X	q_A	q_R
0.000	0.000	0.463 kgSS/(m ² ·h)
1.900	0.358	0.358 kgSS/(m ² ·h)
3.800	0.717	0.253 kgSS/(m ² ·h)
X_c	8.383	1.581 0.000 kgSS/(m ² ·h)

X_f	2.9	kg/m ³
	SAFE	
SST min Area:	196	m ²
	0.420	1.89
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.035	0.937	0.000
0.069	0.875	0.000
0.104	0.812	0.010
0.138	0.748	0.120
0.173	0.682	0.400
0.207	0.614	0.810
0.242	0.541	1.260
0.276	0.462	1.700
0.311	0.372	2.070
0.345	0.260	2.350
R_{crit}	0.380	2.530

X	q_A	q_R
0.000	0.000	0.707 kgSS/(m ² ·h)
2.900	0.547	0.547 kgSS/(m ² ·h)
5.800	1.094	0.387 kgSS/(m ² ·h)
X_c	12.796	2.414 0.000 kgSS/(m ² ·h)

X_c	3.4	kg/m ³
SAFE		
SST min Area:	365	m ²
	0.546	1.014
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.043	0.933	0.000
0.087	0.868	0.000
0.130	0.802	0.020
0.173	0.736	0.137
0.217	0.670	0.391
0.260	0.601	0.734
0.303	0.528	1.097
0.346	0.450	1.427
0.390	0.362	1.698
0.433	0.252	1.899
R_{crit}	0.476	2.023

X	q_A	q_R
0.000	0.000	0.829 kgSS/(m ² ·h)
3.400	0.641	0.641 kgSS/(m ² ·h)
6.800	1.283	0.453 kgSS/(m ² ·h)
X_c	15.002	2.830 0.000 kgSS/(m ² ·h)



SHC II	
R	q_{Amax} (m/hr)
0	2.876
2.5	2.876

APPLIED FLUX (SLR) 0.45 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	3.462
2.5	3.462

APPLIED FLUX (SLR) 0.36 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	2.368
2.5	2.368

APPLIED FLUX (SLR) 0.55 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	1.959
2.5	1.959

APPLIED FLUX (SLR) 0.64 kgTSS/(m²·h)

SHC I

$$q_A = \frac{V_0}{R} \frac{(1+\alpha)}{(1-\alpha)} \exp \left[\frac{-n(1+R)X_p(1+\alpha)}{2R} \right]$$

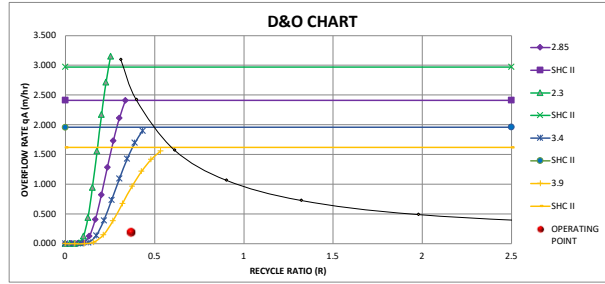
where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_p}}$

SHC II

$$q_{AmaxSHC II} = V_0 e^{-nX_p}$$

SST's - MLE Process @ 25 Days SRT

DSVI	120 ml/g	(Range 50-200ml/g, >150ml/g = bulking sludge)
SSVI	80.4 ml/g	
V_0/n	18.76 kgTSS/(m ² ·h)	
V_0	7.121 m/h	
n	0.380 m ³ /kgTSS	
f_n	1.8432	
ADWF	370 m ³ /h	8.9 Ml/d
PWWF	m ³ /h	Ml/d
PWWF	683 m ³ /h	16.4 Ml/d
$Q_{applied}$	370 m ³ /h	8.9 Ml/d
Flux Rating	0.8	
SST Area	1963 m ²	0% added to area for non-idealities
SST diameter	25	1963 m ²
No. of SST's	4.0	
OPERATING POINT		
q_A	0.189 m/h	
q_R	0.070 m/h	
R	0.371 [Q_A/Q_R]	

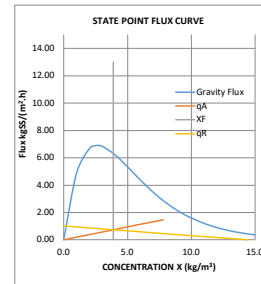
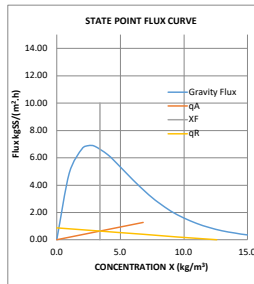
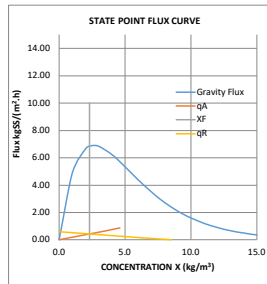
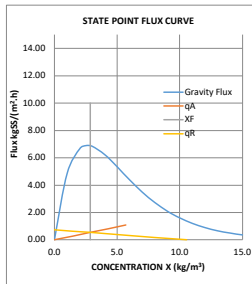


X_c	2.85	kg/m ³
	SAFE	
SST min Area:	153 m ²	
	0.000	2.601
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.034	0.938	0.000
0.067	0.876	0.000
0.101	0.813	0.016
0.135	0.749	0.128
0.168	0.683	0.407
0.202	0.615	0.820
0.236	0.542	1.287
0.269	0.463	1.733
0.303	0.374	2.115
0.337	0.261	2.410
R_{min}	0.371	2.601
X	q_A	q_R
0.000	0.000	0.736
2.849	0.537	0.537
5.697	1.075	0.338
X_c	10.536	1.987

X_c	2.3	kg/m ³
SAFE		
SST min Area:	125	m ²
R(IN)/N(I)		R(IN)/N(I)
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.025	0.942	0.000
0.051	0.882	0.000
0.076	0.822	0.013
0.102	0.760	0.123
0.127	0.696	0.437
0.152	0.628	0.946
0.178	0.556	1.557
0.203	0.476	2.172
0.228	0.385	2.718
0.254	0.269	3.156
R_{min}	0.279	3.451
X		
	q_A	q_R
0.000	0.000	0.595
2.300	0.434	0.434
4.600	0.868	0.273
X_c	8.507	1.605

X_c	3.4 kg/m ³	
SAFE		
SST min Area:	234 m ²	
SHC I	(0.403) 1.586	
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.043	0.933	0.000
0.087	0.868	0.000
0.130	0.802	0.020
0.173	0.736	0.137
0.217	0.670	0.391
0.260	0.601	0.734
0.303	0.528	1.097
0.346	0.450	1.427
0.390	0.362	1.698
0.433	0.252	1.899
R_{min}	0.476	2.000
2.023		
X	q_A	q_R
0.000	0.000	0.879
3.400	0.641	0.641
6.800	1.283	0.404
X_c	12.575	2.372

X_c	3.9	kg/m ³
SAFE		
SST min Area:	391	m ²
	0.519	0.940
SHC I		
R	α	q_A (m/hr)
	1.000	#DIV/0!
0.053	0.929	0.000
0.107	0.860	0.001
0.160	0.792	0.026
0.214	0.724	0.148
0.267	0.656	0.383
0.321	0.587	0.675
0.374	0.514	0.966
0.427	0.437	1.218
0.481	0.350	1.417
0.534	0.243	1.558
R_{min}	0.588	1.640
X	q_A	q_R
0.000	0.000	1.008 kgSS/(m ² ·h)
3.900	0.736	0.736 kgSS/(m ² ·h)
7.800	1.471	0.463 kgSS/(m ² ·h)
X_c	14.425	2.721 0.000 kgSS/(m ² ·h)



SHC II	
R	q_{Amax} (m/hr)
0	2.415
2.5	2.415

APPLIED FLUX (SLR) 0.54 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	2.974
2.5	2.974

APPLIED FLUX (SLR) 0.43 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	1.959
2.5	1.959

APPLIED FLUX (SLR) 0.64 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	1.620
2.5	1.620

APPLIED FLUX (SLR) 0.74 kgTSS/(m²·h)

SHC I

$$q_A = \frac{V_g (1 + \alpha)}{R (1 - \alpha)} \exp \left[\frac{-n(1+R)X_p(1+\alpha)}{2R} \right]$$

where

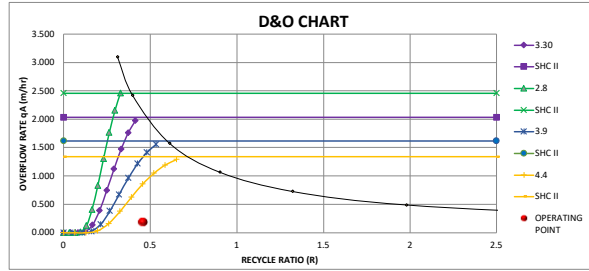
$$\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_p}}$$

SHC II

$$q_{AmaxSHC II} = V_g e^{-nX_p}$$

SST's - MLE Process @ 30 Days SRT

DSVI	120 ml/g	(Range 50-200ml/g, >150ml/g = bulking sludge)
SSVI	80.4 ml/g	
V_0/n	18.76 kgTSS/(m ² ·h)	
V_0	7.121 m/h	
n	0.380 m ³ /kgTSS	
f_n	1.8432	
ADWF	370 m ³ /h	8.9 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	683 m ³ /h	16.4 Ml/d
$Q_{applied}$	370 m ³ /h	8.9 Ml/d
Flux Rating	0.8	
SST Area	1963 m ²	0% added to area for non-idealities
SST diameter	25	1963 m ²
No. of SST's	4.0	
OPERATING POINT		
q_A	0.189 m/h	
q_R	0.086 m/h	
R	0.456 [Q_R/Q_A]	

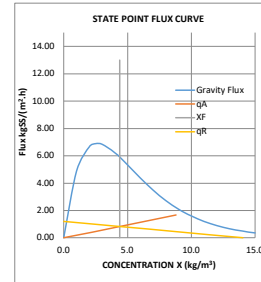
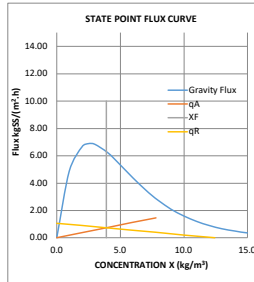
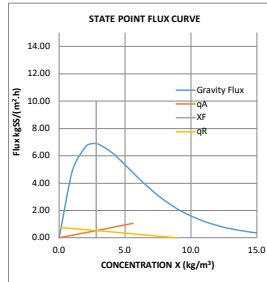
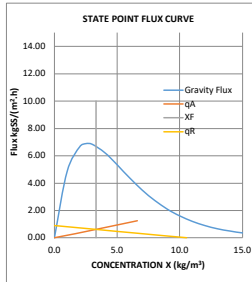


X_c	3.30 kg/m ³	
	SAFE	
SST min Area:	182 m ²	
	0.000 2.111	
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.041	0.934	0.000
0.083	0.869	0.000
0.124	0.804	0.019
0.166	0.739	0.135
0.207	0.672	0.393
0.249	0.603	0.747
0.290	0.531	1.126
0.332	0.453	1.475
0.373	0.364	1.763
0.415	0.253	1.978
R_{crit}	0.456	2.111
X		
	q_A	q_R
0.000	0.000	0.907 kgSS/(m ² ·h)
3.302	0.623	0.623 kgSS/(m ² ·h)
6.604	1.246	0.339 kgSS/(m ² ·h)
X_c	10.536	1.987 0.000 kgSS/(m ² ·h)

X_c	2.8 kg/m ³	
	SAFE	
SST min Area:	151 m ²	
	#NUM! #NUM!	
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.033	0.938	0.000
0.066	0.876	0.000
0.099	0.814	0.015
0.132	0.750	0.127
0.165	0.684	0.409
0.197	0.616	0.829
0.230	0.544	1.307
0.263	0.465	1.766
0.296	0.375	2.159
0.329	0.262	2.464
R_{crit}	0.362	2.663
X		
	q_A	q_R
0.000	0.000	0.769 kgSS/(m ² ·h)
2.800	0.528	0.528 kgSS/(m ² ·h)
5.600	1.056	0.287 kgSS/(m ² ·h)
X_c	8.934	1.685 0.000 kgSS/(m ² ·h)

X_c	3.9 kg/m ³	
	SAFE	
SST min Area:	278 m ²	
	0.320 1.333	
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.053	0.929	0.000
0.107	0.860	0.001
0.160	0.792	0.026
0.214	0.724	0.148
0.267	0.656	0.383
0.321	0.587	0.675
0.374	0.514	0.966
0.427	0.437	1.218
0.481	0.350	1.417
0.534	0.243	1.558
R_{crit}	0.588	1.640
X		
	q_A	q_R
0.000	0.000	1.071 kgSS/(m ² ·h)
3.900	0.736	0.736 kgSS/(m ² ·h)
7.800	1.471	0.400 kgSS/(m ² ·h)
X_c	12.444	2.347 0.000 kgSS/(m ² ·h)

X_c	4.4 kg/m ³	
	SAFE	
SST min Area:	431 m ²	
	0.500 0.850	
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.065	0.924	0.000
0.130	0.851	0.001
0.196	0.780	0.033
0.261	0.710	0.161
0.326	0.641	0.378
0.391	0.572	0.627
0.456	0.500	0.859
0.521	0.423	1.051
0.587	0.339	1.195
0.652	0.235	1.292
R_{crit}	0.717	1.344
X		
	q_A	q_R
0.000	0.000	1.209 kgSS/(m ² ·h)
4.400	0.830	0.830 kgSS/(m ² ·h)
8.800	1.660	0.451 kgSS/(m ² ·h)
X_c	14.040	2.648 0.000 kgSS/(m ² ·h)



SHC II	
R	q_{Amax} (m/hr)
0	2.033
2.5	2.033

APPLIED FLUX (SLR) 0.62 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	2.460
2.5	2.460

APPLIED FLUX (SLR) 0.53 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	1.620
2.5	1.620

APPLIED FLUX (SLR) 0.74 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	1.340
2.5	1.340

APPLIED FLUX (SLR) 0.83 kgTSS/(m²·h)

SHC I

$$q_A = \frac{V_0}{R} \frac{(1+\alpha)}{(1-\alpha)} \exp \left[\frac{-n(1+R)X_p(1+\alpha)}{2R} \right]$$

where

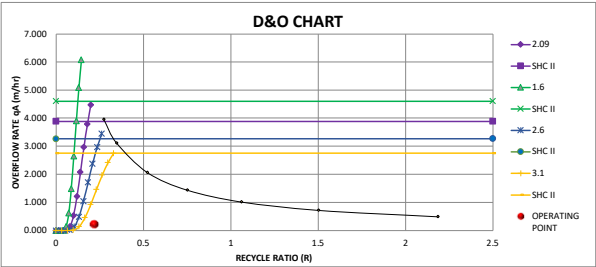
$$\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_p}}$$

SHC II

$$q_{AmaxSHC II} = V_0 e^{-nX_p}$$

SST's - UCT Process @ 10 Days SRT

DSVI	100 ml/g	(Range 50-200ml/g, >150ml/g = bulking sludge)
SSVI	67 ml/g	
V_0/n	23.24 kgTSS/(m ² ·h)	
V_0	7.974 m ³ /h	
n	0.343 m ³ /kgTSS	
fn	1.2288	
ADWF	463 m ³ /h	11.1 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	569 m ³ /h	13.7 Ml/d
$Q_{applied}$	463 m ³ /h	11.1 Ml/d
Flux Rating	0.8	25% added to area for non-idealities
SST Area	2016 m ²	2519 m ²
SST diameter	32.7	
No. of SST's	3	
OPERATING POINT		
q_A	0.230 m/h	
q_R	0.050 m/h	
R	0.219 [Q_R/Q_A]	

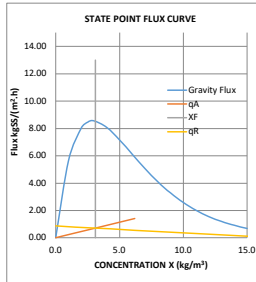
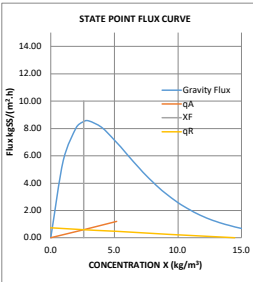
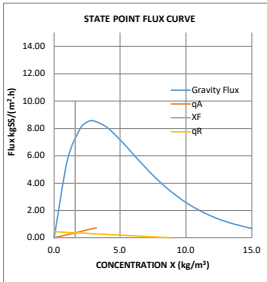
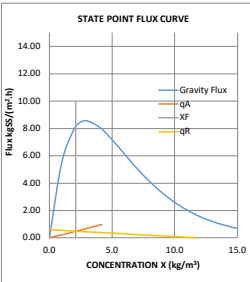


X_c	2.09 kg/m ³	SAFE
SST min Area:	119 m ²	
	0.000 4.933	
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.020	0.944	0.000
0.040	0.887	0.000
0.060	0.828	0.012
0.080	0.768	0.139
0.099	0.704	0.533
0.119	0.637	1.216
0.139	0.565	2.077
0.159	0.485	2.973
0.179	0.393	3.794
0.199	0.275	4.467
R_{crit}	0.219	4.933
X		
	q_A	q_R
0.000	0.000	0.586 kgSS/(m ² ·h)
2.093	0.481	0.481 kgSS/(m ² ·h)
4.186	0.961	0.376 kgSS/(m ² ·h)
X_c	11.660	2.678 0.000 kgSS/(m ² ·h)

X_c	1.6 kg/m ³	SAFE
SST min Area:	101 m ²	
	#NUM! #NUM!	
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.014	0.947	0.000
0.029	0.892	0.000
0.043	0.835	0.011
0.058	0.776	0.147
0.072	0.713	0.617
0.087	0.647	1.490
0.101	0.575	2.648
0.116	0.494	3.901
0.130	0.401	5.083
0.145	0.282	6.077
R_{crit}	0.159	6.785
X		
	q_A	q_R
0.000	0.000	0.448 kgSS/(m ² ·h)
1.600	0.368	0.368 kgSS/(m ² ·h)
3.200	0.735	0.287 kgSS/(m ² ·h)
X_c	8.915	2.048 0.000 kgSS/(m ² ·h)

X_c	2.6 kg/m ³	SAFE
SST min Area:	177 m ²	
	0.484 2.618	
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.026	0.941	0.000
0.052	0.882	0.000
0.078	0.821	0.014
0.104	0.759	0.138
0.130	0.695	0.485
0.157	0.627	1.043
0.183	0.555	1.711
0.209	0.475	2.378
0.235	0.384	2.971
0.261	0.269	3.443
R_{crit}	0.287	3.760
X		
	q_A	q_R
0.000	0.000	0.728 kgSS/(m ² ·h)
2.600	0.597	0.597 kgSS/(m ² ·h)
5.200	1.194	0.467 kgSS/(m ² ·h)
X_c	14.487	3.327 0.000 kgSS/(m ² ·h)

X_c	3.1 kg/m ³	SAFE
SST min Area:	364 m ²	
	0.570 1.371	
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.033	0.938	0.000
0.066	0.876	0.000
0.099	0.814	0.017
0.132	0.750	0.143
0.165	0.684	0.458
0.198	0.616	0.928
0.230	0.544	1.462
0.263	0.465	1.976
0.296	0.375	2.417
0.329	0.262	2.758
R_{crit}	0.362	2.980
X		
	q_A	q_R
0.000	0.000	0.868 kgSS/(m ² ·h)
3.100	0.712	0.712 kgSS/(m ² ·h)
6.200	1.424	0.556 kgSS/(m ² ·h)
X_c	17.272	3.967 0.000 kgSS/(m ² ·h)



SHC II	
R	q_{Amax} (m/hr)
0	3.889
2.5	3.889

APPLIED FLUX (SLR) 0.48 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	4.606
2.5	4.606

APPLIED FLUX (SLR) 0.37 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	3.268
2.5	3.268

APPLIED FLUX (SLR) 0.60 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	2.753
2.5	2.753

APPLIED FLUX (SLR) 0.71 kgTSS/(m²·h)

SHC I

$$q_A = \frac{F_g (1 + \alpha)}{R (1 - \alpha)} \exp \left[\frac{-n(1+R)X_p(1+\alpha)}{2R} \right]$$

where

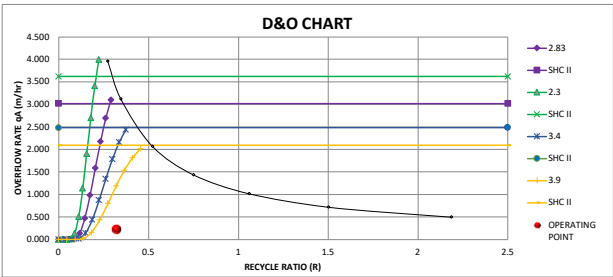
$$\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_p}}$$

SHC II

$$q_{AmaxSHC II} = F_g e^{-nX_p}$$

SST's - UCT Process @ 15 Days SRT

DSVI	100	ml/g	(Range 50-200ml/g, >150ml/g = bulking sludge)
SSVI	67	ml/g	
V_0/n	23.24	kgTSS/(m ² ·h)	
V_0	7.974	m ³ /h	
n	0.343	m ³ /kgTSS	
fn	1.2288		
ADWF	463	m ³ /h	11.1 Ml/d
PWWF	569	m ³ /h	13.7 Ml/d
$Q_{applied}$	463	m ³ /h	11.1 Ml/d
Flux Rating	0.8		25% added to area for non-idealities
SST Area	2016	m ²	2519 m ²
SST diameter	32.7		
No. of SST's	3		
OPERATING POINT			
q_A	0.230	m/h	
q_R	0.074	m/h	
R	0.320	$[Q_R/Q_A]$	

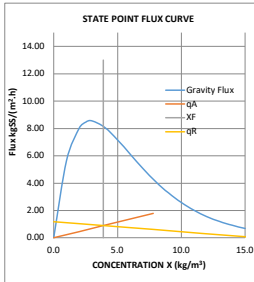
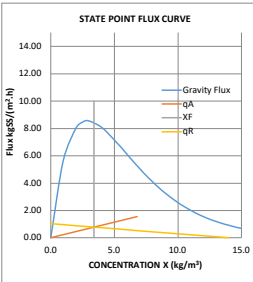
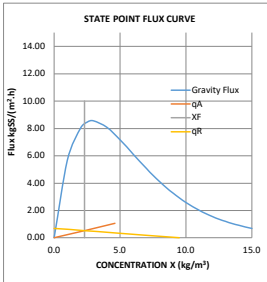
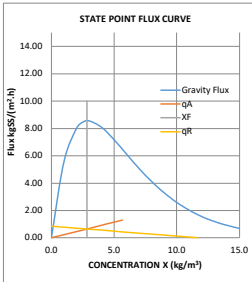


X_c	2.83	kg/m ³
SAFE		
SST min Area:	153	m ²
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.029	0.940	0.000
0.058	0.879	0.000
0.087	0.818	0.016
0.117	0.755	0.140
0.146	0.690	0.471
0.175	0.622	0.986
0.204	0.550	1.586
0.233	0.470	2.177
0.262	0.380	2.693
0.291	0.265	3.098
R_{crit}	0.320	3.368
X		
0.000	0.000	0.858 kgSS/(m ² ·h)
2.830	0.650	0.650 kgSS/(m ² ·h)
5.659	1.300	0.442 kgSS/(m ² ·h)
X_c	11.660	2.678 kgSS/(m ² ·h)

X_c	2.3	kg/m ³
SAFE		
SST min Area:	128	m ²
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.022	0.943	0.000
0.045	0.885	0.000
0.067	0.826	0.013
0.089	0.764	0.138
0.112	0.700	0.510
0.134	0.633	1.136
0.156	0.561	1.908
0.179	0.481	2.700
0.201	0.389	3.415
0.223	0.273	3.994
R_{crit}	0.246	4.392
X		
0.000	0.000	0.698 kgSS/(m ² ·h)
2.300	0.528	0.528 kgSS/(m ² ·h)
4.600	1.057	0.359 kgSS/(m ² ·h)
X_c	9.478	2.177 kgSS/(m ² ·h)

X_c	3.4	kg/m ³
SAFE		
SST min Area:	231	m ²
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.037	0.936	0.000
0.075	0.872	0.000
0.112	0.809	0.019
0.150	0.744	0.147
0.187	0.678	0.447
0.225	0.609	0.875
0.262	0.537	1.346
0.299	0.458	1.788
0.337	0.369	2.160
0.374	0.257	2.442
R_{crit}	0.412	2.622
X		
0.000	0.000	1.031 kgSS/(m ² ·h)
3.400	0.781	0.781 kgSS/(m ² ·h)
6.800	1.562	0.531 kgSS/(m ² ·h)
X_c	14.010	3.218 kgSS/(m ² ·h)

X_c	3.9	kg/m ³
SAFE		
SST min Area:	388	m ²
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.046	0.932	0.000
0.091	0.866	0.000
0.137	0.800	0.024
0.183	0.734	0.156
0.228	0.666	0.435
0.274	0.597	0.804
0.320	0.525	1.188
0.365	0.447	1.535
0.411	0.359	1.815
0.457	0.250	2.022
R_{crit}	0.503	2.147
X		
0.000	0.000	1.183 kgSS/(m ² ·h)
3.900	0.896	0.896 kgSS/(m ² ·h)
7.800	1.792	0.609 kgSS/(m ² ·h)
X_c	16.071	3.691 kgSS/(m ² ·h)



SHC II	
R	q_{Amax} (m/hr)
0	3.021
2.5	3.021

APPLIED FLUX (SLR) 0.65 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	3.622
2.5	3.622

APPLIED FLUX (SLR) 0.53 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	2.484
2.5	2.484

APPLIED FLUX (SLR) 0.78 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	2.092
2.5	2.092

APPLIED FLUX (SLR) 0.90 kgTSS/(m²·h)

SHC I

$$q_A = \frac{V_g (1 + \alpha)}{R (1 - \alpha)} \exp \left[\frac{-n(1+R)X_p(1+\alpha)}{2R} \right]$$

where

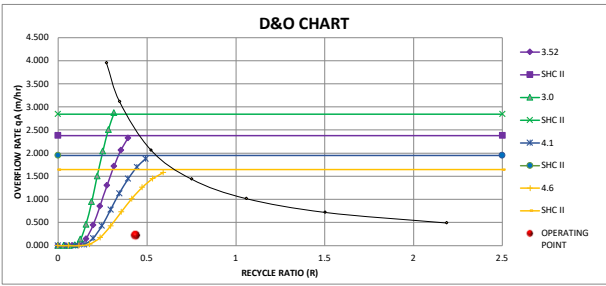
$$\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_p}}$$

SHC II

$$q_{AmaxSHC II} = V_g e^{-nX_p}$$

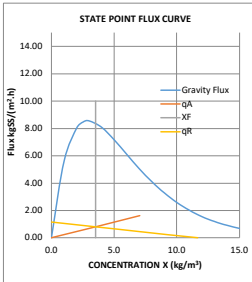
SST's - UCT Process @ 20 Days SRT

DSVI	100	ml/g	(Range 50-200ml/g, >150ml/g = bulking sludge)
SSVI	67	ml/g	
V_0/n	23.24	kgTSS/(m ² ·h)	
V_0	7.974	m ³ /h	
n	0.343	m ³ /kgTSS	
fn	1.2288		
ADWF	463	m ³ /h	11.1 MI/d
PWWF		m ³ /h	MI/d
PWWF	569	m ³ /h	13.7 MI/d
$Q_{applied}$	463	m ³ /h	11.1 MI/d
Flux Rating	0.8		
SST Area	2016	m ²	25% added to area for non-idealities
SST diameter	32.7		2519 m ²
No. of SST's	3		
OPERATING POINT			
q_A	0.230	m/h	
q_R	0.099	m/h	
R	0.433	$[Q_A/Q_R]$	



X_c	3.52	kg/m ³
SAFE		
SST min Area:	194	m ²
	0.000	2.494
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.039	0.935	0.000
0.079	0.871	0.000
0.118	0.807	0.020
0.157	0.742	0.149
0.197	0.675	0.443
0.236	0.606	0.856
0.275	0.534	1.304
0.315	0.455	1.720
0.354	0.366	2.067
0.393	0.255	2.329
R_{crit}	0.433	0.000

X	q_A	q_R
0.000	0.000	1.159
3.522	0.809	0.809
7.044	1.618	0.459
X_c	11.660	2.678



SHC II	
R	q_{Amax} (m/hr)
0	2.382
2.5	2.382

APPLIED FLUX (SLR) 0.81 kgTSS/(m²·h)

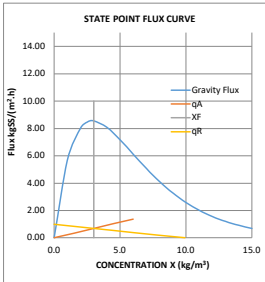
SHC I

$$q_A = \frac{V_0}{R} \frac{(1+\alpha)}{(1-\alpha)} \exp \left[\frac{-n(1+R)X_p(1+\alpha)}{2R} \right]$$

where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_p}}$

X_c	3.0	kg/m ³
SAFE		
SST min Area:	162	m ²
	#NUM!	#NUM!
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.031	0.939	0.000
0.063	0.877	0.000
0.094	0.815	0.017
0.126	0.752	0.142
0.157	0.686	0.462
0.189	0.618	0.948
0.220	0.546	1.506
0.252	0.467	2.046
0.283	0.376	2.513
0.315	0.263	2.877
R_{crit}	0.346	0.000

X	q_A	q_R
0.000	0.000	0.987
3.000	0.689	0.689
6.000	1.378	0.391
X_c	9.933	2.281



SHC II	
R	q_{Amax} (m/hr)
0	2.849
2.5	2.849

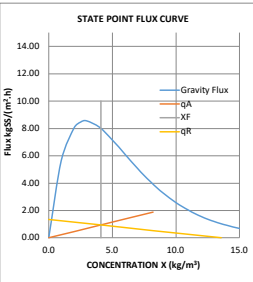
APPLIED FLUX (SLR) 0.69 kgTSS/(m²·h)

SHC II

$$q_{AmaxSHC II} = V_0 e^{-nX_p}$$

X_c	4.1	kg/m ³
SAFE		
SST min Area:	281	m ²
	0.370	1.650
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.049	0.931	0.000
0.099	0.863	0.001
0.148	0.796	0.026
0.197	0.729	0.161
0.247	0.662	0.431
0.296	0.592	0.780
0.345	0.520	1.135
0.394	0.442	1.449
0.444	0.355	1.700
0.493	0.247	1.882
R_{crit}	0.542	0.000

X	q_A	q_R
0.000	0.000	1.349
4.100	0.942	0.942
8.200	1.883	0.534
X_c	13.575	3.118

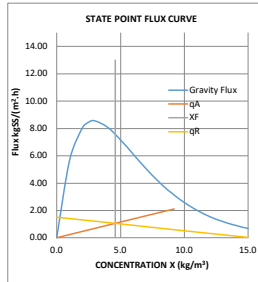


SHC II	
R	q_{Amax} (m/hr)
0	1.954
2.5	1.954

APPLIED FLUX (SLR) 0.94 kgTSS/(m²·h)

X_c	4.6	kg/m ³
SAFE		
SST min Area:	422	m ²
	0.480	1.000
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.059	0.926	0.000
0.118	0.855	0.001
0.178	0.786	0.033
0.237	0.717	0.173
0.296	0.649	0.426
0.355	0.579	0.727
0.415	0.507	1.017
0.474	0.430	1.263
0.533	0.344	1.452
0.592	0.239	1.583
R_{crit}	0.652	0.000

X	q_A	q_R
0.000	0.000	1.514
4.600	1.057	1.057
9.200	2.113	0.599
X_c	15.230	3.498

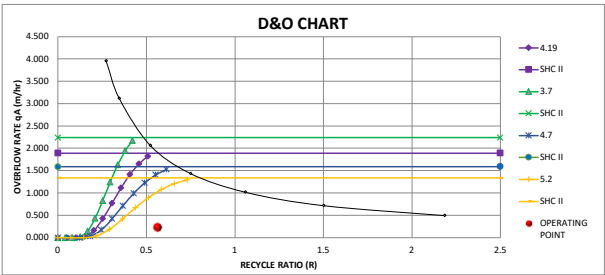


SHC II	
R	q_{Amax} (m/hr)
0	1.646
2.5	1.646

APPLIED FLUX (SLR) 1.06 kgTSS/(m²·h)

SST's - UCT Process @ 25 Days SRT

DSVI	100	ml/g	(Range 50-200ml/g, >150ml/g = bulking sludge)	
SSVI	67	ml/g		
V_0/n	23.24	kgTSS/(m ² ·h)		
V_0	7.974	m ³ /h		
n	0.343	m ³ /kgTSS		
fn	1.2288			
ADWF	463	m ³ /h	11.1	MI/d
PDPWF		m ³ /h		MI/d
PWWF	569	m ³ /h	13.7	MI/d
$Q_{applied}$	463	m ³ /h	11.1	MI/d
			0.560	259.4
			0.456	
			0.560	259.4
Flux Rating	0.8		25% added to area for non-idealities	
SST Area	2016	m ²	2519 m ²	
SST diameter	32.7			
No. of SST's	3			
OPERATING POINT				
q_A	0.230	m/h		
q_R	0.129	m/h		
R	0.560	$[Q_A/Q_R]$		

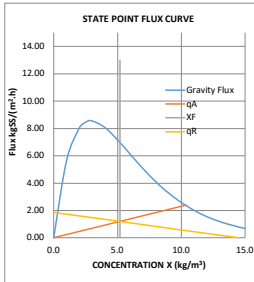
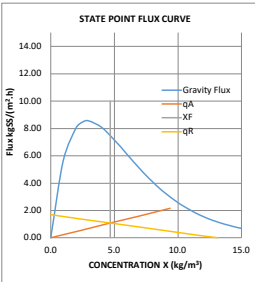
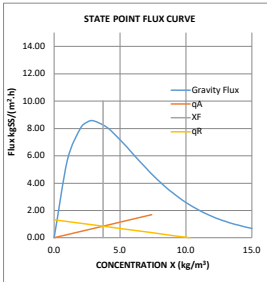
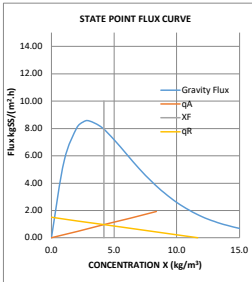


X_c	4.19	kg/m ³
SAFE		
SST min Area:	244	m ²
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.051	0.930	0.000
0.102	0.862	0.001
0.153	0.794	0.027
0.204	0.727	0.163
0.255	0.659	0.430
0.306	0.590	0.770
0.357	0.518	1.113
0.408	0.440	1.413
0.459	0.353	1.652
0.509	0.245	1.824
R_{crit}	0.560	0.000
X		
0.000	0.000	1.501
4.188	0.962	0.962
8.375	1.924	0.423
X_c	11.660	2.678

X_c	3.7	kg/m ³
SAFE		
SST min Area:	207	m ²
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.042	0.934	0.000
0.085	0.869	0.000
0.127	0.803	0.022
0.169	0.738	0.152
0.211	0.671	0.439
0.254	0.602	0.830
0.296	0.530	1.247
0.338	0.451	1.629
0.380	0.363	1.943
0.423	0.253	2.177
R_{crit}	0.465	0.000
X		
0.000	0.000	1.326
3.700	0.850	0.850
7.400	1.700	0.374
X_c	10.302	2.366

X_c	4.7	kg/m ³
SAFE		
SST min Area:	324	m ²
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.061	0.925	0.000
0.123	0.854	0.001
0.184	0.784	0.034
0.246	0.715	0.176
0.307	0.646	0.425
0.368	0.576	0.717
0.430	0.504	0.996
0.491	0.428	1.230
0.552	0.342	1.408
0.614	0.237	1.531
R_{crit}	0.675	0.000
X		
0.000	0.000	1.685
4.700	1.080	1.080
9.400	2.159	0.475
X_c	13.087	3.006

X_c	5.2	kg/m ³
SAFE		
SST min Area:	452	m ²
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.073	0.920	0.000
0.146	0.845	0.002
0.220	0.772	0.043
0.293	0.702	0.191
0.366	0.632	0.422
0.439	0.562	0.673
0.512	0.490	0.899
0.585	0.415	1.080
0.659	0.331	1.212
0.732	0.229	1.298
R_{crit}	0.805	0.000
X		
0.000	0.000	1.864
5.200	1.194	1.194
10.400	2.389	0.525
X_c	14.479	3.326



SHC II	
R	q_{Amax} (m/hr)
0	1.896
2.5	1.896

APPLIED FLUX (SLR) 0.96 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	2.241
2.5	2.241

APPLIED FLUX (SLR) 0.85 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	1.590
2.5	1.590

APPLIED FLUX (SLR) 1.08 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	1.340
2.5	1.340

APPLIED FLUX (SLR) 1.19 kgTSS/(m²·h)

SHC I

$$q_A = \frac{V_0}{R} \frac{(1+\alpha)}{(1-\alpha)} \exp \left[\frac{-n(1+R)X_p(1+\alpha)}{2R} \right]$$

where

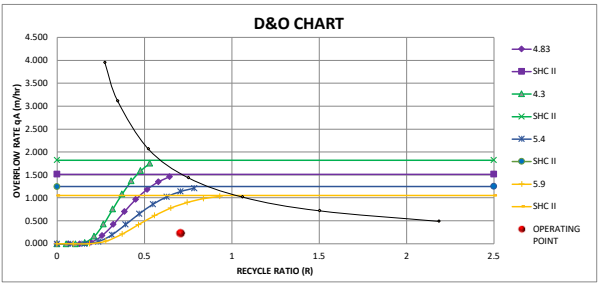
$$\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_p}}$$

SHC II

$$q_{AmaxSHC II} = V_0 e^{-nX_p}$$

SST's - UCT Process @ 30 Days SRT

DSVI	100	ml/g	(Range 50-200ml/g, >150ml/g = bulking sludge)		
SSVI	67	ml/g			
V_0/n	23.24	kgTSS/(m ² ·h)			
V_0	7.974	m/h			
n	0.343	m ³ /kgTSS			
fn	2				
ADWF	463	m ³ /h	11.1	ML/d	
PWWF		m ³ /h		ML/d	
PWWF	926	m ³ /h	22.2	ML/d	
$Q_{applied}$	463	m ³ /h	11.1	ML/d	



X_c	4.83	kg/m ³
SAFE		
SST min Area:	305	m ²
	0.000	1.524
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.064	0.924	0.000
0.129	0.851	0.001
0.193	0.781	0.037
0.257	0.711	0.180
0.322	0.642	0.424
0.386	0.573	0.705
0.451	0.501	0.969
0.515	0.424	1.187
0.579	0.339	1.352
0.644	0.235	1.464
R_{crit}	0.708	0.000

X	q_A	q_R
0.000	0.000	1.896
4.834	1.110	1.110
9.667	2.221	0.324
X_c	11.660	2.678

X_c	4.3	kg/m ³
SAFE		
SST min Area:	254	m ²
	#NUM!	#NUM!
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.053	0.929	0.000
0.106	0.860	0.001
0.159	0.792	0.029
0.212	0.724	0.165
0.266	0.657	0.429
0.319	0.587	0.758
0.372	0.515	1.085
0.425	0.437	1.370
0.478	0.351	1.594
0.531	0.244	1.754
R_{crit}	0.584	0.000

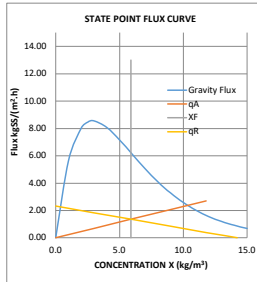
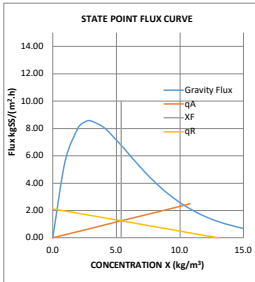
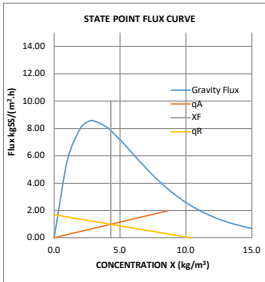
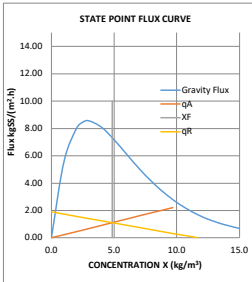
X	q_A	q_R
0.000	0.000	1.687
4.300	0.988	0.988
8.600	1.975	0.288
X_c	10.373	2.383

X_c	5.4	kg/m ³
SAFE		
SST min Area:	404	m ²
	0.324	1.345
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.078	0.918	0.000
0.157	0.841	0.002
0.235	0.767	0.048
0.314	0.696	0.197
0.392	0.626	0.421
0.470	0.556	0.657
0.549	0.485	0.864
0.627	0.409	1.026
0.706	0.326	1.142
0.784	0.226	1.216
R_{crit}	0.863	0.000

X	q_A	q_R
0.000	0.000	2.119
5.400	1.240	1.240
10.800	2.481	0.362
X_c	13.027	2.992

X_c	5.9	kg/m ³
SAFE		
SST min Area:	538	m ²
	0.422	0.901
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.093	0.912	0.000
0.186	0.831	0.003
0.279	0.754	0.060
0.372	0.681	0.214
0.466	0.610	0.419
0.559	0.540	0.618
0.652	0.469	0.782
0.745	0.395	0.904
0.838	0.315	0.986
0.931	0.217	1.035
R_{crit}	1.024	0.000

X	q_A	q_R
0.000	0.000	2.315
5.900	1.355	1.355
11.800	2.710	0.396
X_c	14.233	3.269



SHC II	
R	q_{Amax} (m/hr)
0	1.519
2.5	1.519

APPLIED FLUX (SLR) 1.11 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	1.824
2.5	1.824

APPLIED FLUX (SLR) 0.99 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	1.251
2.5	1.251

APPLIED FLUX (SLR) 1.24 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	1.054
2.5	1.054

APPLIED FLUX (SLR) 1.36 kgTSS/(m²·h)

SHC I

$$q_A = \frac{V_0}{R} \frac{(1+\alpha)}{(1-\alpha)} \exp \left[\frac{-n(1+R)X_p(1+\alpha)}{2R} \right]$$

where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_p}}$

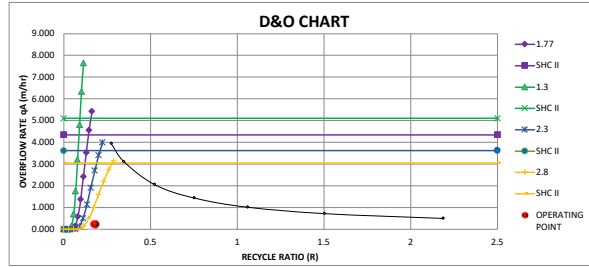
SHC II

$$q_{AmaxSHC II} = V_0 e^{-nX_p}$$

**Annexure B2 – SST Capacity Check for Influent
Flow of 25 ML/d**

SST's - MLE Process @ 10 Days SRT

DSVI	100 ml/g	(Range 50-200ml/g, >150ml/g = bulking sludge)
SSVI	67 ml/g	
V_0/n	23.24 kgTSS/(m ² ·h)	
V_0	7.974 m ³ /h	
n	0.343 m ³ /kgTSS	
f_n	1.8432	
ADWF	463 m ³ /h	11.1 Ml/d
PWWF	m ³ /h	Ml/d
PWWF	853 m ³ /h	20.5 Ml/d
$Q_{applied}$	463 m ³ /h	11.1 Ml/d
Flux Rating	0.8	0% added to area for non-idealities
SST Area	1963 m ²	1963 m ²
SST diameter	25	
No. of SST's	4.0	
OPERATING POINT		
q_A	0.236 m ³ /h	
q_R	0.042 m ³ /h	
R	0.179 [Q_R/Q_A]	

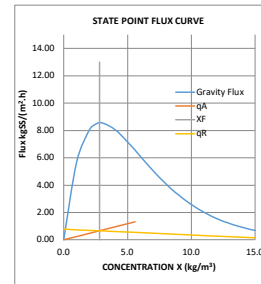
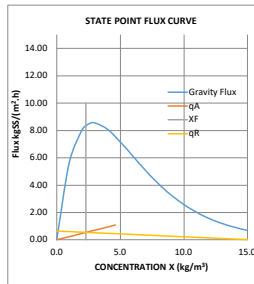
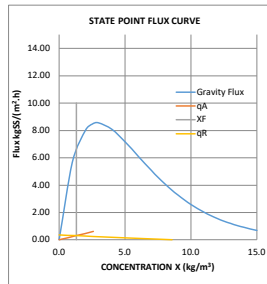
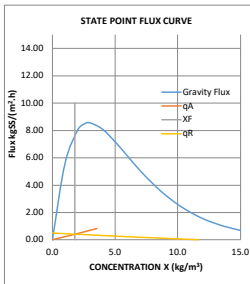


X_e	SAFE	1.77	kg/m ³
SST min Area:	106	m ²	
	0.033	6.037	
SHC I			
R	α	q_A (m ³ /hr)	
	0	1.000	#DIV/0!
	0.016	0.946	0.000
	0.032	0.890	0.000
	0.049	0.833	0.011
	0.065	0.773	0.143
	0.081	0.710	0.582
	0.097	0.644	1.379
	0.114	0.571	2.418
	0.130	0.491	3.527
	0.146	0.398	4.563
	0.162	0.280	5.427
R_{crit}	0.179	0.000	6.037
X			
	q_A	q_R	
	0.000	0.000	0.491
	1.768	0.417	0.417
	3.536	0.834	0.342
X_e	11.660	2.749	0.000

X_e	1.3 kg/m ³	
SAFE		
SST min Area:	91 m ²	
	#IN(L)/N	#IN(U)/N
SHC I		
R	α	q_A (m ³ /hr)
0	1.000	#DIV/0!
0.011	0.948	0.000
0.023	0.894	0.000
0.034	0.839	0.011
0.046	0.780	0.159
0.057	0.718	0.703
0.068	0.652	1.760
0.080	0.580	3.204
0.091	0.500	4.803
0.103	0.406	6.340
0.114	0.286	7.652
R_{crit}	0.125	8.600
X		
	q_A	q_R
0.000	0.000	0.361
1.300	0.307	0.307
2.600	0.613	0.252
X_e	8.573	2.021

X_e	2.3 kg/m ³	
SAFE		
SST min Area:	171 m ²	
	(0.48 2.70)	
SHC I		
R	α	q_A (m ³ /hr)
	1.000	#DIV/0!
	0.022	0.943 0.000
	0.045	0.885 0.000
	0.067	0.826 0.013
	0.089	0.764 0.138
	0.112	0.700 0.510
	0.134	0.633 1.136
	0.156	0.561 1.908
	0.179	0.481 2.700
	0.201	0.389 3.415
	0.223	0.273 3.994
R_{crit}	0.246	0.000 4.392
X	q_A	q_R
	0.000	0.000 0.639
	2.300	0.542 0.542
	4.600	1.085 0.445
X_e	15.168	3.576 0.000

X_e	2.8 kg/m ³	
SAFE		
SST min Area:	412 m ²	
	0.00	1.124
SHC I		
R	α	q_A (m ³ /hr)
	0	1.000 #DIV/0!
	0.029	0.940 0.000
	0.057	0.880 0.000
	0.086	0.818 0.015
	0.115	0.755 0.140
	0.144	0.691 0.473
	0.172	0.623 0.993
	0.201	0.550 1.601
	0.230	0.471 2.201
	0.259	0.380 2.726
	0.287	0.266 3.140
R_{crit}	0.316	0.380 3.415
X	q_A	q_R
	0.000	0.000 0.778
	2.800	0.660 0.660
	5.600	1.320 0.542
X_e	18.466	4.354 0.000



SHC II	
R	q_{Amax} (m ³ /hr)
0	4.347
2.5	4.347

APPLIED FLUX (SLR) 0.42 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m ³ /hr)
0	5.105
2.5	5.105

APPLIED FLUX (SLR) 0.31 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m ³ /hr)
0	3.622
2.5	3.622

APPLIED FLUX (SLR) 0.54 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m ³ /hr)
0	3.051
2.5	3.051

APPLIED FLUX (SLR) 0.66 kgTSS/(m²·h)

SHC I

$$q_A = \frac{F_g (1 + \alpha)}{R (1 - \alpha)} \exp \left[\frac{-n(1+R)X_p(1+\alpha)}{2R} \right]$$

where

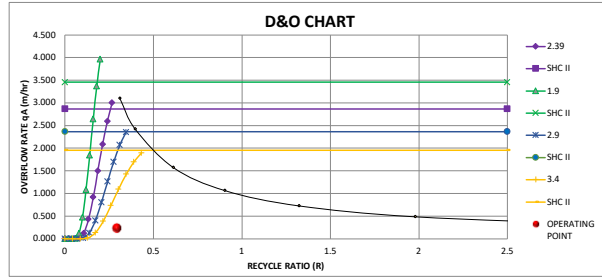
$$\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_p}}$$

SHC II

$$q_{AmaxSHC II} = F_g e^{-nX_p}$$

SST's - MLE Process @ 15 Days SRT

DSVI	120 ml/g	(Range 50-200ml/g, >150ml/g = bulking sludge)
SSVI	80.4 ml/g	
V_0/n	18.76 kgTSS/(m ² ·h)	
V_0	7.121 m/h	
n	0.380 m ³ /kgTSS	
f_n	1.8432	
ADWF	463 m ³ /h	11.1 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	853 m ³ /h	20.5 Ml/d
$Q_{applied}$	463 m ³ /h	11.1 Ml/d
Flux Rating	0.8	0% added to area for non-idealities
SST Area	1963 m ²	1963 m ²
SST diameter	25	
No. of SST's	4.0	
OPERATING POINT		
q_A	0.236 m/h	
q_R	0.069 m/h	
R	0.294 [Q_R/Q_A]	

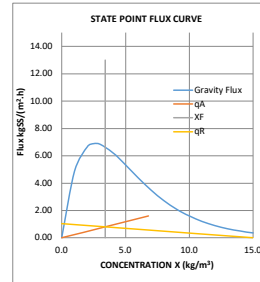
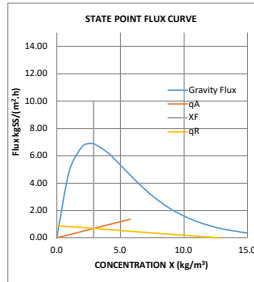
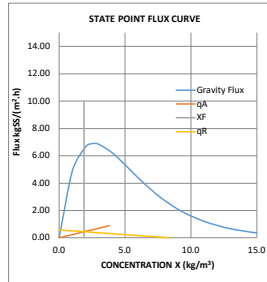
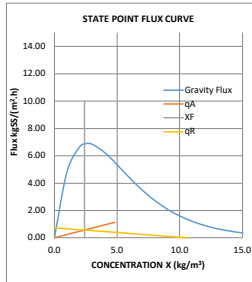


X_c	2.39	kg/m ³
	SAFE	
SST min Area:	161 m ²	
	SAFE	3.280
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.027	0.941	0.000
0.053	0.881	0.000
0.080	0.821	0.013
0.107	0.758	0.124
0.134	0.694	0.431
0.160	0.626	0.920
0.187	0.553	1.503
0.214	0.474	2.084
0.240	0.383	2.597
0.267	0.268	3.006
R_{crit}	0.294	0.000
	0.000	3.280
X	q_A	q_R
0.000	0.000	0.730
2.393	0.564	0.564
4.786	1.128	0.398
X_c	10.536	2.484

X_p	1.9	kg/m ³
SAFE	SAFE	
SST min Area:	134	m ²
	$\beta_{ENV}(M^*)$	$\beta_{ENV}(M)$
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.020	0.944	0.000
0.040	0.887	0.000
0.060	0.828	0.011
0.080	0.768	0.124
0.100	0.704	0.475
0.120	0.637	1.082
0.140	0.565	1.847
0.160	0.485	2.643
0.180	0.393	3.371
0.200	0.275	3.967
R_{crit}	0.220	0.000
	0.000	4.381
X	q_A	q_R
0.000	0.000	0.580
1.900	0.448	0.448
3.800	0.896	0.316
X_c	8.366	1.973

X_c	2.9 kg/m ³	
SAFE		
SST min Area:	244 m ²	
SHC I	(0.415 1.950)	
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.035	0.937	0.000
0.069	0.875	0.000
0.104	0.812	0.016
0.138	0.748	0.129
0.173	0.682	0.405
0.207	0.614	0.811
0.242	0.541	1.266
0.276	0.462	1.700
0.311	0.372	2.070
0.345	0.260	2.354
R_{crit}	0.380	0.000
	0.380	2.538
X	q_A	q_R
0.000	0.000	0.885
2.900	0.684	0.684
5.800	1.368	0.483
X_c	12.769	3.011

X_c	3.4 kg/m ³	
SAFE		
SST min Area:	454 m ²	
	0.544	0.020
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.043	0.933	0.000
0.087	0.868	0.000
0.130	0.802	0.020
0.173	0.736	0.137
0.217	0.670	0.391
0.260	0.601	0.734
0.303	0.528	1.097
0.346	0.450	1.427
0.390	0.362	1.698
0.433	0.252	1.899
R_{crit}	0.476	0.000
	0.000	2.023
X	q_A	q_R
0.000	0.000	1.037
3.400	0.802	0.802
6.800	1.603	0.566
X_c	14.971	3.530



SHC II	
R	q_{Amax} (m/hr)
0	2.871
2.5	2.871

APPLIED FLUX (SLR) 0.56 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	3.462
2.5	3.462

APPLIED FLUX (SLR) 0.45 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	2.368
2.5	2.368

APPLIED FLUX (SLR) 0.68 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	1.959
2.5	1.959

APPLIED FLUX (SLR) 0.80 kgTSS/(m²·h)

SHC I

$$q_A = \frac{V_0}{R} \frac{(1+\alpha)}{(1-\alpha)} \exp \left[\frac{-n(1+R)X_p(1+\alpha)}{2R} \right]$$

where

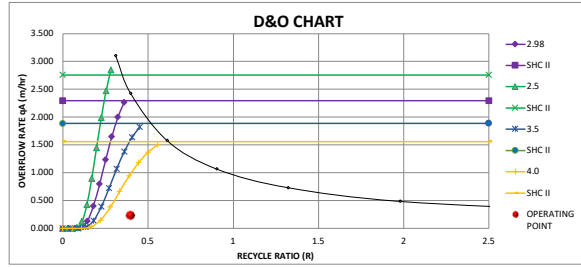
$$\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_p}}$$

SHC II

$$q_{AmaxSHC II} = V_0 e^{-nX_p}$$

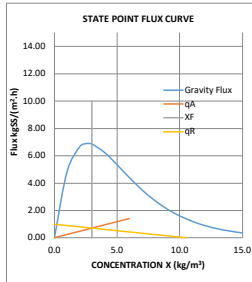
SST's - MLE Process @ 20 Days SRT

DSVI	120 ml/g	(Range 50-200ml/g, >150ml/g = bulking sludge)
SSVI	80.4 ml/g	
V_0/n	18.76 kgTSS/(m ² ·h)	
V_0	7.121 m/h	
n	0.380 m ³ /kgTSS	
f_n	1.8432	
ADWF	463 m ³ /h	11.1 Ml/d
PWWF	m ³ /h	Ml/d
PWWF	853 m ³ /h	20.5 Ml/d
$Q_{applied}$	463 m ³ /h	11.1 Ml/d
Flux Rating	0.8	0% added to area for non-idealities
SST Area	1963 m ²	1963 m ²
SST diameter	25	
No. of SST's	4.0	
OPERATING POINT		
q_A	0.236 m/h	
q_R	0.093 m/h	
R	0.395 [Q_A/Q_R]	



X_c	2.98	kg/m ³
	SAFE	
SST min Area:	202	m ²
	0.000	2.438
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.036	0.937	0.000
0.072	0.874	0.000
0.108	0.810	0.017
0.144	0.746	0.130
0.180	0.680	0.402
0.216	0.611	0.796
0.252	0.539	1.234
0.287	0.460	1.648
0.323	0.371	1.998
0.359	0.259	2.266
R_{crit}	0.000	2.438

X	q_A	q_R
0.000	0.000	0.982 kgSS/(m ² ·h)
2.985	0.704	0.704 kgSS/(m ² ·h)
5.970	1.408	0.426 kgSS/(m ² ·h)
X_c	10.536	2.484 0.000 kgSS/(m ² ·h)



SHC II		
R	q_{Amax} (m/hr)	
0	2.293	
2.5	2.293	

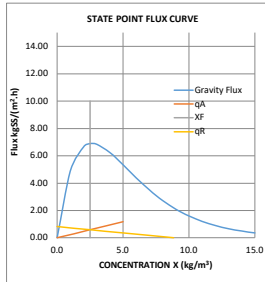
APPLIED FLUX (SLR) 0.70 kgTSS/(m²·h)

$$q_A = \frac{F_g (1 + \alpha)}{R (1 - \alpha)} \exp \left[\frac{-n(1+R)X_F(1+\alpha)}{2R} \right]$$

where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_F}}$

X_c	2.5	kg/m ³
	SAFE	
SST min Area:	168	m ²
	#NUM!	#NUM!
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.028	0.940	0.000
0.057	0.880	0.000
0.085	0.819	0.014
0.113	0.756	0.124
0.141	0.691	0.424
0.170	0.623	0.894
0.198	0.551	1.445
0.226	0.472	1.991
0.255	0.381	2.469
0.283	0.266	2.846
R_{crit}	0.311	3.098

X	q_A	q_R
0.000	0.000	0.822 kgSS/(m ² ·h)
2.500	0.589	0.589 kgSS/(m ² ·h)
5.000	1.179	0.356 kgSS/(m ² ·h)
X_c	8.825	2.081 0.000 kgSS/(m ² ·h)



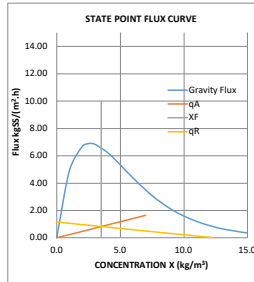
SHC II		
R	q_{Amax} (m/hr)	
0	2.757	
2.5	2.757	

APPLIED FLUX (SLR) 0.59 kgTSS/(m²·h)

$$q_{AmaxSHC II} = F_g e^{-nX_F}$$

X_e	3.5	kg/m ³
	SAFE	
SST min Area:	294	m ²
	0.384	1.57
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.045	0.933	0.000
0.090	0.866	0.000
0.136	0.800	0.021
0.181	0.734	0.139
0.226	0.667	0.389
0.271	0.598	0.721
0.317	0.526	1.068
0.362	0.448	1.381
0.407	0.359	1.636
0.452	0.250	1.823
R_{crit}	0.497	1.938

X	q_A	q_R
0.000	0.000	1.151 kgSS/(m ² ·h)
3.500	0.825	0.825 kgSS/(m ² ·h)
7.000	1.650	0.499 kgSS/(m ² ·h)
X_c	12.354	2.913 0.000 kgSS/(m ² ·h)

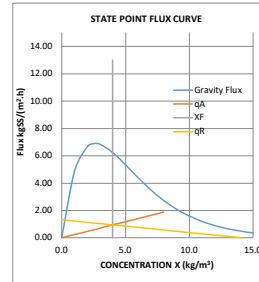


SHC II		
R	q_{Amax} (m/hr)	
0	1.886	
2.5	1.886	

APPLIED FLUX (SLR) 0.83 kgTSS/(m²·h)

X_c	4.0	kg/m ³
	SAFE	
SST min Area:	477	m ²
	0.504	0.970
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.056	0.928	0.000
0.111	0.858	0.001
0.167	0.789	0.027
0.223	0.721	0.151
0.278	0.653	0.382
0.334	0.584	0.665
0.389	0.512	0.943
0.445	0.434	1.182
0.501	0.348	1.368
0.556	0.242	1.500
R_{crit}	0.612	1.575

X	q_A	q_R
0.000	0.000	1.316 kgSS/(m ² ·h)
4.000	0.943	0.943 kgSS/(m ² ·h)
8.000	1.886	0.570 kgSS/(m ² ·h)
X_c	14.119	3.329 0.000 kgSS/(m ² ·h)

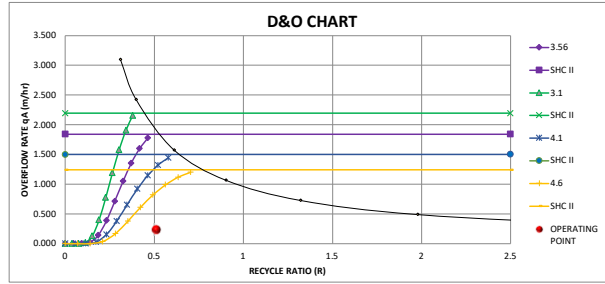


SHC II		
R	q_{Amax} (m/hr)	
0	1.560	
2.5	1.560	

APPLIED FLUX (SLR) 0.94 kgTSS/(m²·h)

SST's - MLE Process @ 25 Days SRT

DSVI	120 ml/g	(Range 50-200ml/g, >150ml/g = bulking sludge)
SSVI	80.4 ml/g	
V_0/n	18.76 kgTSS/(m ² ·h)	
V_0	7.121 m/h	
n	0.380 m ³ /kgTSS	
f_n	1.8432	
ADWF	463 m ³ /h	11.1 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	853 m ³ /h	20.5 Ml/d
$Q_{applied}$	463 m ³ /h	11.1 Ml/d
Flux Rating	0.8	0% added to area for non-idealities
SST Area	1963 m ²	1963 m ²
SST diameter	25	
No. of SST's	4.0	
OPERATING POINT		
q_A	0.236 m/h	
q_R	0.120 m/h	
R	0.510 [Q_R/Q_A]	

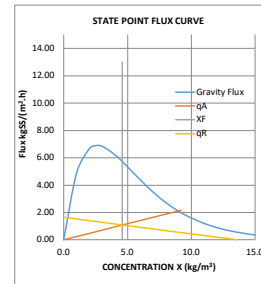
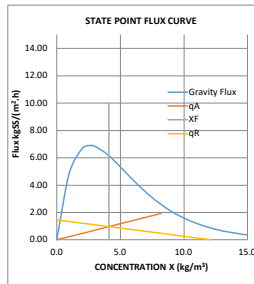
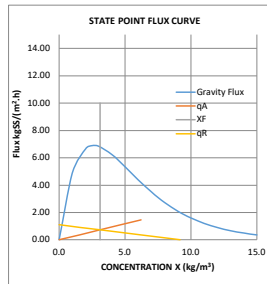
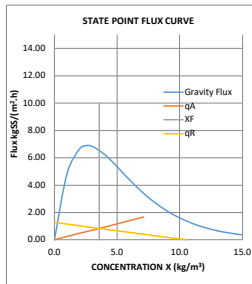


X_c	3.56	kg/m ³
	SAFE	
SST min Area:	251 m ²	
	0.000	1.888
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.046	0.932	0.000
0.093	0.865	0.000
0.139	0.799	0.022
0.186	0.733	0.140
0.232	0.665	0.387
0.278	0.596	0.714
0.325	0.524	1.051
0.371	0.446	1.354
0.418	0.358	1.600
0.464	0.249	1.779
R_{crit}	0.510	1.888
X		
	q_A	q_R
0.000	0.000	1.268
3.561	0.840	0.840
7.122	1.679	0.411
X_c	10.536	2.484

X_c	3.1	kg/m ³
SAFE		
SST min Area:	211	m ²
	#NUM!/(N)	#NUM!/(N)
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.038	0.936	0.000
0.076	0.872	0.000
0.114	0.808	0.018
0.152	0.743	0.132
0.189	0.677	0.398
0.227	0.609	0.777
0.265	0.536	1.193
0.303	0.457	1.581
0.341	0.368	1.908
0.379	0.257	2.155
R_{crit}	0.417	2.312
X		
	q_A	q_R
0.000	0.000	1.104
3.100	0.731	0.731
6.200	1.462	0.358
X_c	9.173	2.163

X_c	4.1 kg/m ³	
SAFE		
SST min Area:	358 m ²	
	0.385 1.294	
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.058	0.927	0.000
0.116	0.856	0.001
0.174	0.787	0.029
0.232	0.719	0.153
0.290	0.650	0.381
0.347	0.581	0.655
0.405	0.509	0.921
0.463	0.432	1.147
0.521	0.346	1.322
0.579	0.240	1.444
R_{crit}	0.637	1.513
X		
	q_A	q_R
0.000	0.000	1.460
4.100	0.967	0.967
8.200	1.933	0.473
X_c	12.132	2.860

X_c	4.6 kg/m ³	
SAFE		
SST min Area:	534 m ²	
	0.475	0.987
SHC I		
R	α	q_A (m/hr)
	1.000	#DIV/0!
0.070	0.922	0.000
0.141	0.847	0.001
0.211	0.775	0.037
0.282	0.705	0.167
0.352	0.635	0.377
0.423	0.565	0.610
0.493	0.494	0.821
0.564	0.418	0.992
0.634	0.334	1.118
0.704	0.231	1.201
R_{crit}	0.775	1.244
X		
	q_A	q_R
0.000	0.000	1.638 kgSS/(m ² ·h)
4.600	1.085	1.085 kgSS/(m ² ·h)
9.200	2.169	0.531 kgSS/(m ² ·h)
X_c	13.611	3.209 0.000 kgSS/(m ² ·h)



SHC II	
R	q_{Amax} (m/hr)
0	1.843
2.5	1.843

APPLIED FLUX (SLR) 0.84 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	2.195
2.5	2.195

APPLIED FLUX (SLR) 0.73 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	1.502
2.5	1.502

APPLIED FLUX (SLR) 0.97 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	1.242
2.5	1.242

APPLIED FLUX (SLR) 1.08 kgTSS/(m²·h)

SHC I

$$q_A = \frac{F_g (1 + \alpha)}{R (1 - \alpha)} \exp \left[\frac{-n(1+R)X_p(1+\alpha)}{2R} \right]$$

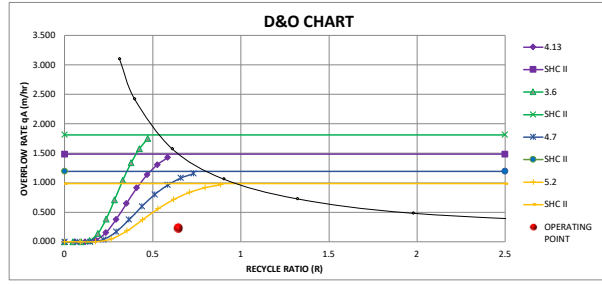
where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_p}}$

SHC II

$$q_{AmaxSHC II} = F_g e^{-nX_p}$$

SST's - MLE Process @ 30 Days SRT

DSVI	120 ml/g	(Range 50-200ml/g, >150ml/g = bulking sludge)
SSVI	80.4 ml/g	
V_0/n	18.76 kgTSS/(m ² ·h)	
V_0	7.121 m/h	
n	0.380 m ³ /kgTSS	
f_n	1.8432	
ADWF	463 m ³ /h	11.1 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	853 m ³ /h	20.5 Ml/d
$Q_{applied}$	463 m ³ /h	11.1 Ml/d
Flux Rating	0.8	0% added to area for non-idealities
SST Area	1963 m ²	1963 m ²
SST diameter	25	
No. of SST's	4.0	
OPERATING POINT		
q_A	0.236 m/h	
q_R	0.152 m/h	
R	0.644 [Q_R/Q_A]	



X_c	4.13	kg/m ³
SAFE		
SST min Area:	312 m ²	
	0.000	1.496
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.059	0.927	0.000
0.117	0.856	0.001
0.176	0.787	0.029
0.234	0.718	0.154
0.293	0.650	0.380
0.351	0.580	0.652
0.410	0.508	0.915
0.468	0.431	1.138
0.527	0.345	1.310
0.585	0.239	1.429
R_{crit}	0.644	0.000 1.496

X	q_A	q_R
0.000	0.000	1.600 kgSS/(m ² ·h)
4.138	0.973	0.973 kgSS/(m ² ·h)
8.255	1.946	0.346 kgSS/(m ² ·h)
X_c	10.536	2.484 0.000 kgSS/(m ² ·h)

X_c		3.6	kg/m ³
SAFE			
SST min Area:		255	m ²
		#NUM!	#NUM!
SHC I			
R	α	q_A (m/hr)	
0	1.000	#DIV/0!	
0.047	0.932	0.000	
0.094	0.865	0.000	
0.142	0.798	0.022	
0.189	0.732	0.141	
0.236	0.664	0.387	
0.283	0.595	0.709	
0.330	0.523	1.041	
0.377	0.445	1.338	
0.425	0.357	1.577	
0.472	0.249	1.752	
R_{crit}	0.519	0.000	1.857

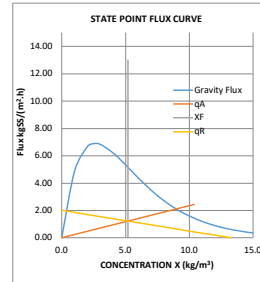
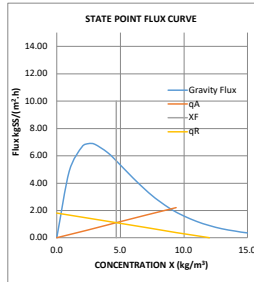
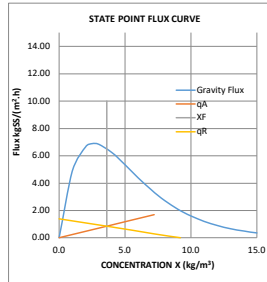
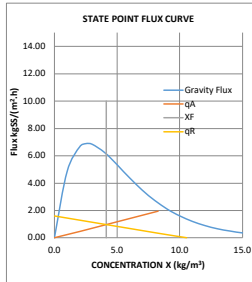
X	q_A	q_R
0.000	0.000	1.396 kgSS/(m ² ·h)
3.600	0.849	0.849 kgSS/(m ² ·h)
7.200	1.698	0.302 kgSS/(m ² ·h)
X_c	9.190	2.167 0.000 kgSS/(m ² ·h)

X_e	4.7	kg/m ³
	SAFE	
SST min Area:	436	m ²
	0.349	1.06
SHC I		
R	α	q_a (m/hr)
0	1.000	#DIV/0!
0.073	0.920	0.000
0.146	0.845	0.000
0.220	0.772	0.039
0.293	0.702	0.170
0.366	0.632	0.377
0.439	0.562	0.600
0.512	0.490	0.803
0.586	0.415	0.964
0.659	0.331	1.082
0.732	0.229	1.158
R_{crit}	0.805	0.000 1.197

X	q_A	q_R
0.000	0.000	1.822 kgSS/(m ² ·h)
4.700	1.108	1.108 kgSS/(m ² ·h)
9.400	2.216	0.394 kgSS/(m ² ·h)
X_c	11.998	2.829 0.000 kgSS/(m ² ·h)

X_c	5.2	kg/m ³
	SAFE	
SST min Area:	613	m ²
	0.454	0.755
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.089	0.914	0.000
0.177	0.834	0.003
0.266	0.758	0.050
0.354	0.685	0.186
0.443	0.615	0.375
0.532	0.545	0.562
0.620	0.474	0.719
0.709	0.400	0.838
0.797	0.318	0.919
0.886	0.220	0.969
R_{crit}	0.974	0.000
		0.989

X	q_A	q_R
0.000	0.000	2.016 kgSS/(m ² ·h)
5.200	1.226	1.226 kgSS/(m ² ·h)
10.400	2.452	0.436 kgSS/(m ² ·h)
X_c	13.274	3.130 0.000 kgSS/(m ² ·h)



SHC II	
R	q_{Amax} (m/hr)
0	1.486
2.5	1.486

APPLIED FLUX (SLR) 0.97 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	1.816
2.5	1.816

APPLIED FLUX (SLR) 0.85 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	1.196
2.5	1.196

APPLIED FLUX (SLR) 1.11 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	0.989
2.5	0.989

APPLIED FLUX (SLR) 1.23 kgTSS/(m²·h)

SHC I

$$q_A = \frac{V_0}{R} \frac{(1+\alpha)}{(1-\alpha)} \exp \left[\frac{-n(1+R)X_p(1+\alpha)}{2R} \right]$$

where

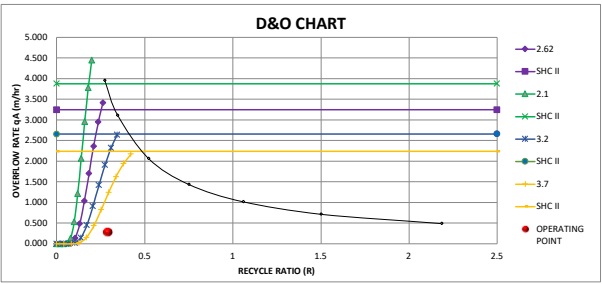
$$\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_p}}$$

SHC II

$$q_{AmaxSHC II} = V_0 e^{-nX_p}$$

SST's - UCT Process @ 10 Days SRT

DSVI	100	ml/g	(Range 50-200ml/g, >150ml/g = bulking sludge)			
SSVI	67	ml/g				
V_0/n	23.24	kgTSS/(m ² ·h)				
V_0	7.974	m ³ /h				
n	0.343	m ³ /kgTSS				
f_n	1.2288					
				<u>Recycle Ratio R</u>	<u>Q_R m³/hr</u>	
ADWF	579	m ³ /h	13.9	ML/d	0.289	167.4
PWWF		m ³ /h		ML/d		
PWWF	711	m ³ /h	17.1	ML/d	0.235	
$Q_{applied}$	579	m ³ /h	13.9	ML/d	0.289	167.4
Flux Rating	0.8		25% added to area for non-idealities			
SST Area	2016	m ²	2519 m ²			
SST diameter	32.7					
No. of SST's	3					
OPERATING POINT						
q_A	0.287	m/h				
q_R	0.083	m/h				
R	0.289	$[Q_R/Q_A]$				



X_c	2.62	kg/m ³
SAFE		
SST min Area:	178	m ²
	0.000	3.731
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.026	0.941	0.000
0.053	0.882	0.000
0.079	0.821	0.014
0.105	0.759	0.138
0.131	0.694	0.484
0.158	0.627	1.039
0.184	0.554	1.701
0.210	0.475	2.363
0.237	0.383	2.950
0.263	0.268	3.417
R_{crit}	0.289	0.000

X	q_A	q_R
0.000	0.000	0.968
2.616	0.751	0.751
5.232	1.502	0.534
X_c	11.660	3.348

X_c	2.1	kg/m ³
SAFE		
SST min Area:	149	m ²
	#NUM!	#NUM!
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.020	0.944	0.000
0.040	0.887	0.000
0.060	0.828	0.012
0.080	0.768	0.139
0.100	0.704	0.532
0.120	0.637	1.213
0.140	0.565	2.070
0.160	0.485	2.963
0.180	0.393	3.779
0.200	0.275	4.449
R_{crit}	0.220	0.000

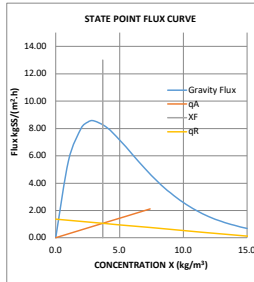
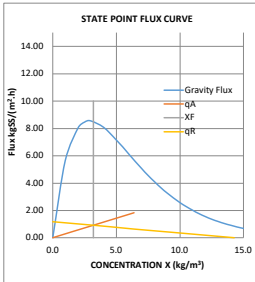
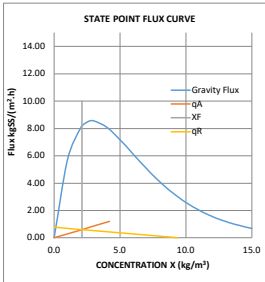
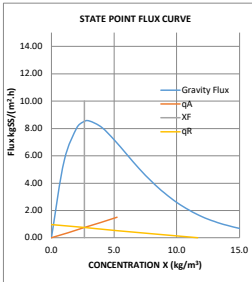
X	q_A	q_R
0.000	0.000	0.777
2.100	0.603	0.603
4.200	1.206	0.429
X_c	9.361	2.688

X_c	3.2	kg/m ³
SAFE		
SST min Area:	277	m ²
	0.427	2.092
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.034	0.937	0.000
0.069	0.875	0.000
0.103	0.812	0.018
0.138	0.748	0.144
0.172	0.682	0.454
0.206	0.614	0.910
0.241	0.541	1.421
0.275	0.462	1.910
0.309	0.373	2.326
0.344	0.260	2.646
R_{crit}	0.378	0.000

X	q_A	q_R
0.000	0.000	1.185
3.200	0.919	0.919
6.400	1.838	0.653
X_c	14.264	4.095

X_c	3.7	kg/m ³
SAFE		
SST min Area:	489	m ²
	0.547	3.194
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.042	0.934	0.000
0.085	0.869	0.000
0.127	0.803	0.022
0.169	0.738	0.152
0.211	0.671	0.439
0.254	0.602	0.830
0.296	0.530	1.247
0.338	0.451	1.629
0.380	0.363	1.943
0.423	0.253	2.177
R_{crit}	0.465	0.000

X	q_A	q_R
0.000	0.000	1.370
3.700	1.062	1.062
7.400	2.125	0.755
X_c	16.492	4.735



SHC II	
R	q_{Amax} (m/hr)
0	3.250
2.5	3.250

APPLIED FLUX (SLR) 0.75 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	3.880
2.5	3.880

APPLIED FLUX (SLR) 0.60 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	2.660
2.5	2.660

APPLIED FLUX (SLR) 0.92 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	2.241
2.5	2.241

APPLIED FLUX (SLR) 1.06 kgTSS/(m²·h)

SHC I

$$q_A = \frac{F_g (1 + \alpha)}{R (1 - \alpha)} \exp \left[\frac{-n(1 + R)X_p(1 + \alpha)}{2R} \right]$$

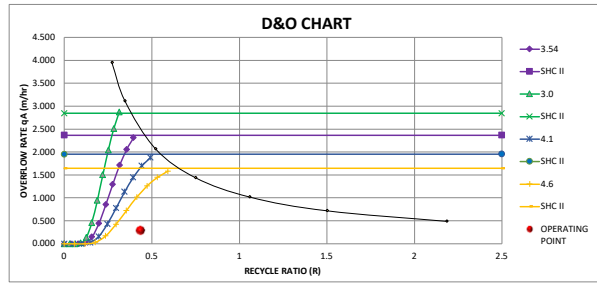
where

$$\alpha = \sqrt{1 - \frac{4R}{n(1 + R)X_p}}$$

SHC II

$$q_{AmaxSHC II} = F_g e^{-nX_p}$$

DSVI	100 ml/g	(Range 50-200ml/g, >150ml/g = bulking sludge)
SSVI	67 ml/g	
V_0/n	23.24 kgTSS/(m ² ·h)	
V_0	7.974 m ³ /h	
n	0.343 m ³ /kgTSS	
f_n	1.2288	
ADWF	579 m ³ /h	13.9 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	711 m ³ /h	17.1 Ml/d
$Q_{applied}$	579 m ³ /h	13.9 Ml/d
Flux Rating	0.8	25% added to area for non-idealities
SST Area	2016 m ²	2519 m ²
SST diameter	32.7	
No. of SST's	3	
OPERATING POINT		
q_A	0.287 m ³ /h	
q_R	0.125 m ³ /h	
R	0.435 [Q_R/Q_A]	



X_c	3.54 kg/m ³	SAFE
SST min Area:	244 m ²	
	0.000 2.478	
SHC I		
R	α	q_A (m ³ /hr)
0	1.000	#DIV/0!
0.040	0.935	0.000
0.079	0.871	0.000
0.119	0.806	0.021
0.158	0.741	0.149
0.198	0.675	0.443
0.238	0.606	0.854
0.277	0.534	1.299
0.317	0.455	1.712
0.356	0.366	2.056
0.396	0.255	2.315
R_{crit}	0.435	0.000 2.478

X	q_A	q_R
0.000	0.000	1.458 kgSS/(m ² ·h)
3.537	1.016	1.016 kgSS/(m ² ·h)
7.074	2.031	0.573 kgSS/(m ² ·h)
X_c	11.660	3.348 0.000 kgSS/(m ² ·h)

X_c	3.0 kg/m ³	SAFE
SST min Area:	203 m ²	
	#NUM! #NUM!	
SHC I		
R	α	q_A (m ³ /hr)
0	1.000	#DIV/0!
0.031	0.939	0.000
0.063	0.877	0.000
0.094	0.815	0.017
0.126	0.752	0.142
0.157	0.686	0.462
0.189	0.618	0.948
0.220	0.546	1.506
0.252	0.467	2.046
0.283	0.376	2.513
0.315	0.263	2.877
R_{crit}	0.346	0.000 3.115

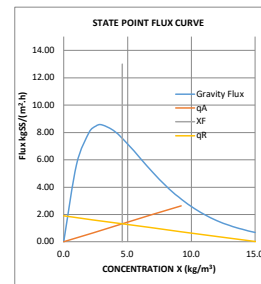
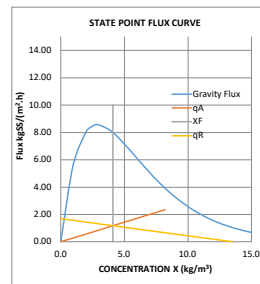
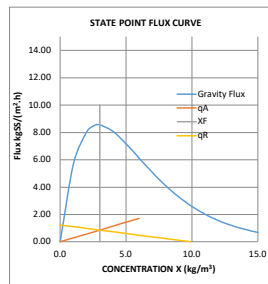
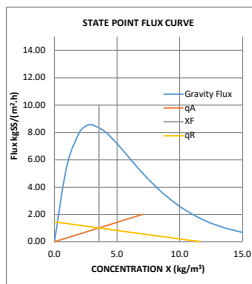
X	q_A	q_R
0.000	0.000	1.236 kgSS/(m ² ·h)
3.000	0.861	0.861 kgSS/(m ² ·h)
6.000	1.723	0.486 kgSS/(m ² ·h)
X_c	9.890	2.840 0.000 kgSS/(m ² ·h)

X_c	4.1 kg/m ³	SAFE
SST min Area:	348 m ²	
	0.371 1.663	
SHC I		
R	α	q_A (m ³ /hr)
0	1.000	#DIV/0!
0.049	0.931	0.000
0.099	0.863	0.001
0.148	0.796	0.026
0.197	0.729	0.161
0.247	0.662	0.431
0.296	0.592	0.780
0.345	0.520	1.135
0.394	0.442	1.449
0.444	0.355	1.700
0.493	0.247	1.882
R_{crit}	0.542	0.000 1.990

X	q_A	q_R
0.000	0.000	1.690 kgSS/(m ² ·h)
4.100	1.177	1.177 kgSS/(m ² ·h)
8.200	2.354	0.665 kgSS/(m ² ·h)
X_c	13.516	3.881 0.000 kgSS/(m ² ·h)

X_c	4.6 kg/m ³	SAFE
SST min Area:	522 m ²	
	0.481 1.110	
SHC I		
R	α	q_A (m ³ /hr)
0	1.000	#DIV/0!
0.059	0.926	0.000
0.118	0.855	0.001
0.178	0.786	0.033
0.237	0.717	0.173
0.296	0.649	0.426
0.355	0.579	0.727
0.415	0.507	1.017
0.474	0.430	1.263
0.533	0.344	1.452
0.592	0.239	1.583
R_{crit}	0.652	0.000 1.656

X	q_A	q_R
0.000	0.000	1.896 kgSS/(m ² ·h)
4.600	1.321	1.321 kgSS/(m ² ·h)
9.200	2.641	0.746 kgSS/(m ² ·h)
X_c	15.164	4.354 0.000 kgSS/(m ² ·h)



SHC II	
R	q_{Amax} (m ³ /hr)
0	2.370
2.5	2.370

APPLIED FLUX (SLR) 1.02 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m ³ /hr)
0	2.849
2.5	2.849

APPLIED FLUX (SLR) 0.86 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m ³ /hr)
0	1.954
2.5	1.954

APPLIED FLUX (SLR) 1.18 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m ³ /hr)
0	1.646
2.5	1.646

APPLIED FLUX (SLR) 1.32 kgTSS/(m²·h)

SHC I

$$q_A = \frac{V_0}{R} \frac{(1+\alpha)}{(1-\alpha)} \exp \left[\frac{-n(1+R)X_p(1+\alpha)}{2R} \right]$$

where

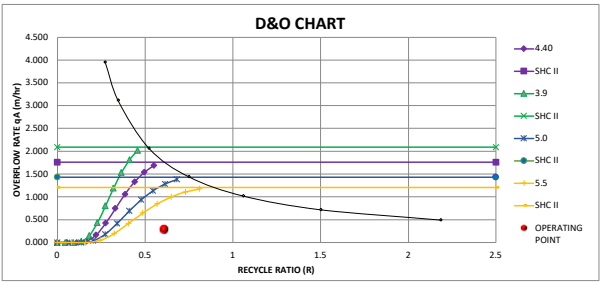
$$\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_p}}$$

SHC II

$$q_{AmaxSHC II} = V_0 e^{-nX_p}$$

SST's - UCT Process @ 20 Days SRT

DSVI	100	ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)	
SSVI	67	ml/g		
V_0/n	23.24	kgTSS/(m ² ·h)		
V_0	7.974	m ³ /h		
n	0.343	m ³ /kgTSS		
fn	1.2288			
ADWF	579	m ³ /h	13.9	ML/d
PDPWF		m ³ /h		ML/d
PWWF	711	m ³ /h	17.1	ML/d
$Q_{applied}$	579	m ³ /h	13.9	ML/d
			0.607	351.0
Flux Rating	0.8		25% added to area for non-idealities	
SST Area	2016	m ²	2519 m ²	
SST diameter	32.7			
No. of SST's	3			
OPERATING POINT				
q_A	0.287	m/h		
q_R	0.174	m/h		
R	0.607	$[Q_A/Q_R]$		



X_c	4.40	kg/m ³
SAFE		
SST min Area:	329	m ²
	0.000	1.779
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.055	0.928	0.000
0.110	0.858	0.001
0.165	0.790	0.030
0.221	0.722	0.168
0.276	0.654	0.427
0.331	0.584	0.747
0.386	0.512	1.061
0.441	0.435	1.332
0.496	0.349	1.544
0.551	0.242	1.693
R_{crit}	0.607	0.000

X	q_A	q_R
0.000	0.000	2.031
4.402	1.264	1.264
8.805	2.528	0.497
X_c	11.660	3.348

X_c	3.9	kg/m ³
SAFE		
SST min Area:	277	m ²
	#NUM!	#NUM!
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.046	0.932	0.000
0.091	0.866	0.000
0.137	0.800	0.024
0.183	0.734	0.156
0.228	0.666	0.435
0.274	0.597	0.804
0.320	0.525	1.188
0.365	0.447	1.535
0.411	0.359	1.815
0.457	0.250	2.022
R_{crit}	0.503	0.000

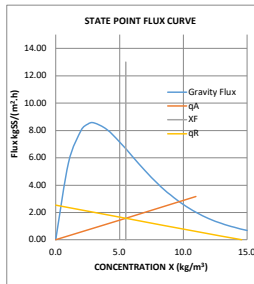
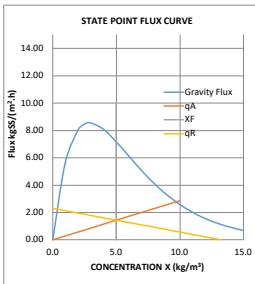
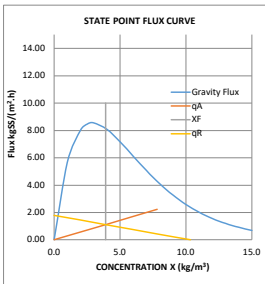
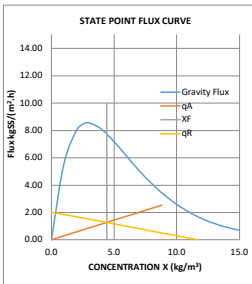
X	q_A	q_R
0.000	0.000	1.799
3.900	1.120	1.120
7.800	2.240	0.441
X_c	10.330	2.966

X_c	5.0	kg/m ³
SAFE		
SST min Area:	455	m ²
	0.340	1.272
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.068	0.923	0.000
0.136	0.848	0.001
0.205	0.777	0.040
0.273	0.707	0.185
0.341	0.638	0.423
0.409	0.568	0.690
0.478	0.496	0.936
0.546	0.420	1.137
0.614	0.336	1.286
0.682	0.232	1.385
R_{crit}	0.751	0.000

X	q_A	q_R
0.000	0.000	2.306
5.000	1.436	1.436
10.000	2.871	0.565
X_c	13.244	3.802

X_c	5.5	kg/m ³
SAFE		
SST min Area:	625	m ²
	0.447	0.922
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.081	0.917	0.000
0.162	0.839	0.002
0.243	0.765	0.050
0.325	0.693	0.200
0.406	0.623	0.421
0.487	0.553	0.649
0.568	0.482	0.847
0.649	0.407	1.000
0.730	0.324	1.109
0.812	0.224	1.177
R_{crit}	0.893	0.000

X	q_A	q_R
0.000	0.000	2.537
5.500	1.579	1.579
11.000	3.158	0.621
X_c	14.568	4.183



SHC II	
R	q_{Amax} (m/hr)
0	1.761
2.5	1.761

APPLIED FLUX (SLR) 1.26 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	2.092
2.5	2.092

APPLIED FLUX (SLR) 1.12 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	1.435
2.5	1.435

APPLIED FLUX (SLR) 1.44 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	1.209
2.5	1.209

APPLIED FLUX (SLR) 1.58 kgTSS/(m²·h)

SHC I

$$q_A = \frac{F_g (1 + \alpha)}{R (1 - \alpha)} \exp \left[\frac{-n(1+R)X_p(1+\alpha)}{2R} \right]$$

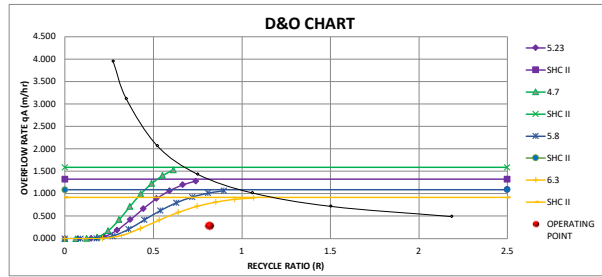
where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_p}}$

SHC II

$$q_{AmaxSHC II} = F_g e^{-nX_p}$$

SST's - UCT Process @ 25 Days SRT

DSVI	100 ml/g	(Range 50-200ml/g, >150ml/g = bulking sludge)
SSVI	67 ml/g	
V_0/n	23.24 kgTSS/(m ² ·h)	
V_0	7.974 m ³ /h	
n	0.343 m ³ /kgTSS	
f_n	1.2288	
ADWF	579 m ³ /h	13.9 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	711 m ³ /h	17.1 Ml/d
$Q_{applied}$	579 m ³ /h	13.9 Ml/d
Flux Rating	0.8	25% added to area for non-idealities
SST Area	2016 m ²	2519 m ²
SST diameter	32.7	
No. of SST's	3	
OPERATING POINT		
q_A	0.287 m/h	
q_R	0.234 m/h	
R	0.815 [Q_A/Q_R]	



X_e	5.23 kg/m ³
SAFE	
SST min Area:	437 m ²
	0.000 1.325
SHC I	
R	α q_A (m/hr)
0	1.000 #DIV/0!
0.074	0.920 0.000
0.148	0.844 0.002
0.222	0.771 0.044
0.296	0.701 0.192
0.370	0.631 0.422
0.444	0.561 0.670
0.518	0.489 0.893
0.592	0.414 1.070
0.667	0.330 1.199
0.741	0.229 1.283
R_{crit}	0.815 0.000 1.325

X	q_A	q_R
0.000	0.000	2.727 kgSS/(m ² ·h)
5.235	1.503	1.503 kgSS/(m ² ·h)
10.469	3.006	0.279 kgSS/(m ² ·h)
X_e	11.660	3.348 0.000 kgSS/(m ² ·h)

X_e	4.7 kg/m ³
SAFE	
SST min Area:	364 m ²
	#NUM! #NUM!
SHC I	
R	α q_A (m/hr)
0	1.000 #DIV/0!
0.061	0.925 0.000
0.123	0.854 0.001
0.184	0.784 0.034
0.246	0.715 0.176
0.307	0.646 0.425
0.368	0.576 0.717
0.430	0.504 0.996
0.491	0.428 1.230
0.552	0.342 1.408
0.614	0.237 1.531
R_{crit}	0.675 0.000 1.598

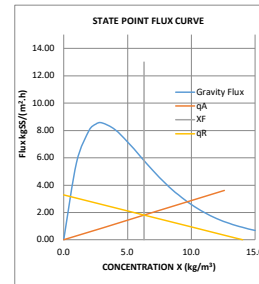
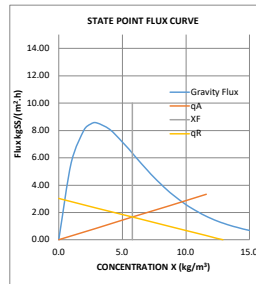
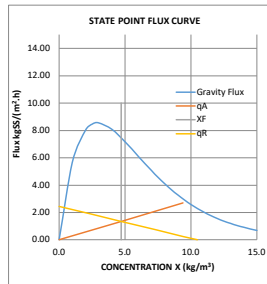
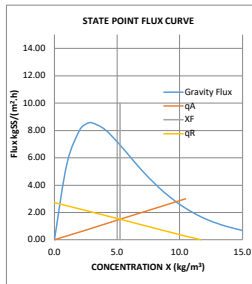
X	q_A	q_R
0.000	0.000	2.449 kgSS/(m ² ·h)
4.700	1.349	1.349 kgSS/(m ² ·h)
9.400	2.699	0.250 kgSS/(m ² ·h)
X_e	10.470	3.006 0.000 kgSS/(m ² ·h)

X_e	5.8 kg/m ³
SAFE	
SST min Area:	568 m ²
	0.315 1.019
SHC I	
R	α q_A (m/hr)
0	1.000 #DIV/0!
0.090	0.913 0.000
0.180	0.833 0.003
0.270	0.757 0.057
0.360	0.684 0.210
0.450	0.613 0.419
0.540	0.543 0.626
0.630	0.472 0.798
0.720	0.398 0.927
0.810	0.317 1.016
0.900	0.219 1.069
R_{crit}	0.990 0.000 1.090

X	q_A	q_R
0.000	0.000	3.022 kgSS/(m ² ·h)
5.800	1.665	1.665 kgSS/(m ² ·h)
11.600	3.331	0.309 kgSS/(m ² ·h)
X_e	12.920	3.710 0.000 kgSS/(m ² ·h)

X_e	6.3 kg/m ³
SAFE	
SST min Area:	737 m ²
	0.417 0.792
SHC I	
R	α q_A (m/hr)
0	1.000 #DIV/0!
0.107	0.906 0.000
0.214	0.821 0.005
0.321	0.742 0.072
0.427	0.668 0.228
0.534	0.596 0.416
0.641	0.526 0.588
0.748	0.456 0.722
0.855	0.383 0.817
0.962	0.304 0.877
1.068	0.210 0.909
R_{crit}	1.175 0.000 0.918

X	q_A	q_R
0.000	0.000	3.282 kgSS/(m ² ·h)
6.300	1.809	1.809 kgSS/(m ² ·h)
12.600	3.618	0.335 kgSS/(m ² ·h)
X_e	14.034	4.029 0.000 kgSS/(m ² ·h)



SHC II	
R	q_{Amax} (m/hr)
0	1.324
2.5	1.324

APPLIED FLUX (SLR) 1.50 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	1.590
2.5	1.590

APPLIED FLUX (SLR) 1.35 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	1.090
2.5	1.090

APPLIED FLUX (SLR) 1.67 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	0.918
2.5	0.918

APPLIED FLUX (SLR) 1.81 kgTSS/(m²·h)

SHC I

$$q_A = \frac{F_g (1 + \alpha)}{R (1 - \alpha)} \exp \left[\frac{-n(1+R)X_p(1+\alpha)}{2R} \right]$$

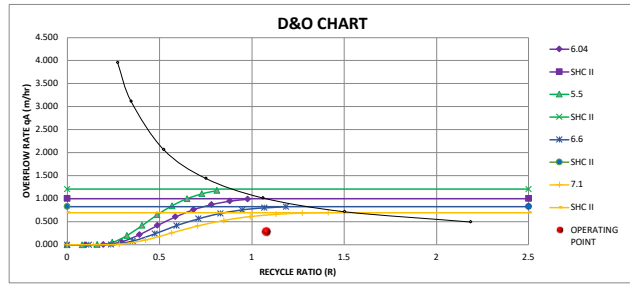
where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_p}}$

SHC II

$$q_{AmaxSHC II} = F_g e^{-nX_p}$$

SST's - UCT Process @ 30 Days SRT

DSVI	100 ml/g	(Range 50-200ml/g, >150ml/g = bulking sludge)
SSVI	67 ml/g	
V_0/n	23.24 kgTSS/(m ² ·h)	
V_0	7.974 m/h	
n	0.343 m ³ /kgTSS	
f_n	2	
ADWF	579 m ³ /h	13.9 Ml/d
PWWF	m ³ /h	Ml/d
PWWF	1157 m ³ /h	27.8 Ml/d
$Q_{applied}$	579 m ³ /h	13.9 Ml/d
Flux Rating	0.8	25% added to area for non-idealities
SST Area	2016 m ²	2519 m ²
SST diameter	32.7	
No. of SST's	3	
OPERATING POINT		
q_A	0.287 m/h	
q_R	0.309 m/h	
R	1.075 [Q_R/Q_A]	



X_c	6.04	kg/m ³
SAFE		
SST min Area:	577 m ²	1.03
0.000		
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.098	0.910	0.000
0.196	0.827	0.004
0.293	0.750	0.064
0.391	0.676	0.219
0.489	0.605	0.418
0.587	0.535	0.607
0.684	0.465	0.760
0.782	0.391	0.872
0.880	0.311	0.946
0.978	0.214	0.989
R_{crit}	1.075	0.000
		1.003

X	q_A	q_R
0.000	0.000	3.600 kgSS/(m ² ·h)
6.042	1.735	1.735 kgSS/(m ² ·h)
12.084	3.470	-0.131 kgSS/(m ² ·h)
X_c	11.660	3.348

X_c	5.5 kg/m ³	
SST min Area:	SAFE	479 m ²
	#PLUM	#BUDGET
SHC I		
R	α	q_A (m/hr)
	0.000	#DIV/0!
	0.081	0.917
	0.162	0.839
	0.243	0.765
	0.325	0.693
	0.406	0.623
	0.487	0.553
	0.568	0.482
	0.649	0.407
	0.730	0.324
	0.812	0.224
R_{crit}	0.893	0.000

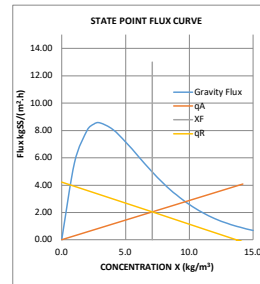
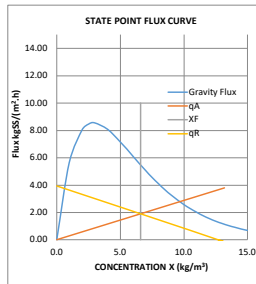
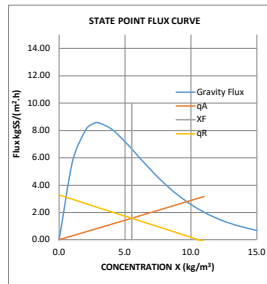
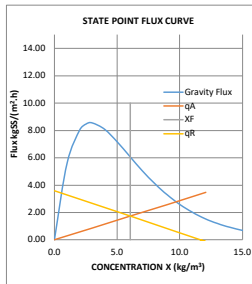
X	q_A	q_R
0.000	0.000	3.277 kgSS/(m ² ·h)
5.500	1.579	1.579 kgSS/(m ² ·h)
11.000	3.158	-0.119 kgSS/(m ² ·h)
X_c	10.614	3.048

X_f	6.6	kg/m ³
	SAFE	
SST min Area:	719	m ²
	0.294	0.80
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.119	0.902	0.000
0.237	0.813	0.000
0.356	0.732	0.082
0.474	0.657	0.238
0.593	0.585	0.414
0.711	0.515	0.565
0.830	0.446	0.679
0.949	0.374	0.756
1.067	0.297	0.802
1.186	0.204	0.825
R_{crit}	1.304	0.000

X	q_A	q_R
0.000	0.000	3.933 kgSS/(m ² ·h)
6.600	1.895	1.895 kgSS/(m ² ·h)
13.200	3.790	-0.143 kgSS/(m ² ·h)
X_c	12.737	3.657

X_c	7.1	kg/m ³
SAFE		
SST min Area:	898	m ²
	0.386	0.644
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.142	0.892	0.000
0.283	0.799	0.012
0.425	0.714	0.102
0.566	0.637	0.256
0.708	0.565	0.408
0.849	0.496	0.528
0.991	0.427	0.610
1.132	0.358	0.661
1.274	0.283	0.689
1.415	0.194	0.698
R_{crit}	1.557	0.000
	0.000	0.693

X	q_A	q_R
0.000	0.000	4.231 kgSS/(m ² ·h)
7.100	2.039	2.039 kgSS/(m ² ·h)
14.200	4.077	-0.154 kgSS/(m ² ·h)
X_c	13.702	3.934



SHC II	
R	q_{Amax} (m/hr)
0	1.003
2.5	1.003

APPUED FLUX (SLR) 1.73 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	1.209
2.5	1.209

APPUED FLUX (SLR) 1.58 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	0.829
2.5	0.829

APPUED FLUX (SLR) 1.89 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	0.698
2.5	0.698

APPUED FLUX (SLR) 2.04 kgTSS/(m²·h)

SHC I

$$q_A = \frac{V_0}{R} \frac{(1 + \alpha)}{(1 - \alpha)} \exp \left[\frac{-n(1 + R)X_p(1 + \alpha)}{2R} \right]$$

where

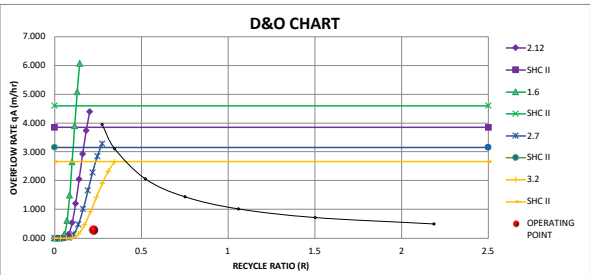
$$\alpha = \sqrt{1 - \frac{4R}{n(1 + R)X_p}}$$

SHC II

$$q_{AmaxSHC II} = V_0 e^{-nX_p}$$

**Annexure B3 – SST Capacity Check for Influent
Flow of 30 ML/d**

DSVI	100	ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)	
SSVI	67	ml/g		
V ₀ /n	23.24	kgTSS/(m ² ·h)		
V ₀	7.974	m ³ /h		
n	0.343	m ³ /kgTSS		
fn	1.8432			
ADWF	556	m ³ /h	13.3	MI/d
PDWF		m ³ /h		MI/d
PWWF	1024	m ³ /h	24.6	MI/d
Q _{applied}	556	m ³ /h	13.3	MI/d
			Recycle Ratio R	Q _R m ³ /hr
			0.222	123.6
Flux Rating	0.8		0% added to area for non-idealities	
SST Area	1963	m ²	1963 m ²	
SST diameter	25			
No. of SST's	4.0			
OPERATING POINT				
Q _A	0.283	m/h		
Q _R	0.063	m/h		
R	0.222	[Q _R /Q _A]		



X _p	2.12	kg/m ³
SAFE		
SST min Area: 144 m ²		
SHC I		
R	α	q _A (m/hr)
0	1.000	#DIV/0!
0.020	0.944	0.000
0.040	0.887	0.000
0.061	0.828	0.012
0.081	0.767	0.130
0.101	0.704	0.530
0.121	0.637	1.204
0.142	0.564	2.051
0.162	0.485	2.932
0.182	0.392	3.737
0.202	0.275	4.395
R _{crit}	0.222	0.000

X	q _A	q _R
0.000	0.000	0.734
2.122	0.600	0.600
4.243	1.201	0.467
X _A	11.660	3.299

X _p	1.6	kg/m ³
SAFE		
SST min Area: 121 m ²		
SHC I		
R	α	q _A (m/hr)
0	1.000	#DIV/0!
0.014	0.947	0.000
0.029	0.892	0.000
0.043	0.835	0.011
0.058	0.776	0.147
0.072	0.713	0.617
0.087	0.647	1.490
0.101	0.575	2.648
0.116	0.494	3.901
0.130	0.401	5.083
0.145	0.282	6.077
R _{crit}	0.159	0.000

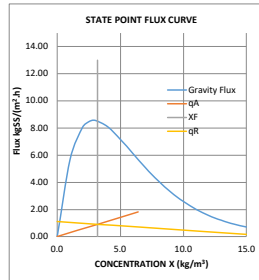
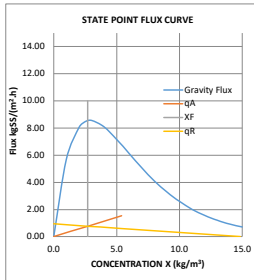
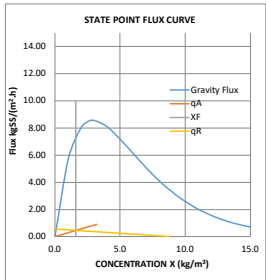
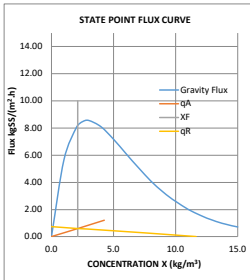
X	q _A	q _R
0.000	0.000	0.553
1.600	0.453	0.453
3.200	0.905	0.352
X _A	8.793	2.488

X _p	2.7	kg/m ³
SAFE		
SST min Area: 236 m ²		
SHC I		
R	α	q _A (m/hr)
0	1.000	#DIV/0!
0.027	0.941	0.000
0.055	0.881	0.000
0.082	0.820	0.015
0.110	0.757	0.139
0.137	0.693	0.479
0.164	0.625	1.017
0.192	0.552	1.654
0.219	0.473	2.287
0.247	0.382	2.844
0.274	0.267	3.286
R _{crit}	0.301	0.000

X	q _A	q _R
0.000	0.000	0.934
2.700	0.764	0.764
5.400	1.528	0.594
X _A	14.838	4.198

X _p	3.2	kg/m ³
SAFE		
SST min Area: 484 m ²		
SHC I		
R	α	q _A (m/hr)
0	1.000	#DIV/0!
0.034	0.937	0.000
0.069	0.875	0.000
0.103	0.812	0.018
0.138	0.748	0.144
0.172	0.682	0.454
0.206	0.614	0.910
0.241	0.541	1.421
0.275	0.462	1.910
0.309	0.373	2.326
0.344	0.260	2.646
R _{crit}	0.378	0.000

X	q _A	q _R
0.000	0.000	1.107
3.200	0.905	0.905
6.400	1.811	0.704
X _A	17.586	4.976



SHC II	
R	q _{amax} (m/hr)
0	3.851
2.5	3.851

APPLIED FLUX (SLR) 0.60 kgTSS/(m²·h)

SHC II	
R	q _{amax} (m/hr)
0	4.606
2.5	4.606

APPLIED FLUX (SLR) 0.45 kgTSS/(m²·h)

SHC II	
R	q _{amax} (m/hr)
0	3.158
2.5	3.158

APPLIED FLUX (SLR) 0.76 kgTSS/(m²·h)

SHC II	
R	q _{amax} (m/hr)
0	2.660
2.5	2.660

APPLIED FLUX (SLR) 0.91 kgTSS/(m²·h)

SHC I

$$q_A = \frac{V_p}{R} \left(\frac{1+\alpha}{1-\alpha} \right) \exp \left[\frac{n(1-R)X_p(1+\alpha)}{2R} \right]$$

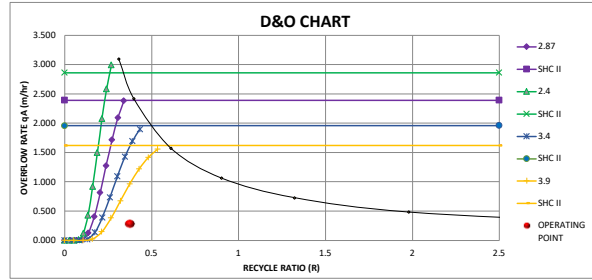
where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_p}}$

SHC II

$$q_{AmaxSHC II} = V_p e^{-\alpha X_p}$$

SST's - MLE Process @ 15 Days SRT

DSVI	120 ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)
SSVI	80.4 ml/g	
V_0/n	18.76 kgTSS/(m ² ·h)	
V_0	7.121 m ³ /h	
n	0.380 m ³ /kgTSS	
f_n	1.8432	
ADWF	556 m ³ /h	13.3 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	1024 m ³ /h	24.6 Ml/d
$Q_{applied}$	556 m ³ /h	13.3 Ml/d
Flux Rating	0.8	0% added to area for non-idealities
SST Area	1963 m ²	1963 m ²
SST diameter	25	
No. of SST's	4.0	
OPERATING POINT		
q_A	0.283 m/h	
q_R	0.106 m/h	
R	0.375 (Q_R/Q_A)	



X_f	2.87	kg/m ³
	SAFE	
SST min Area:	232	m ²
	0.000	2.573
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.034	0.938	0.000
0.068	0.875	0.000
0.102	0.812	0.016
0.136	0.748	0.128
0.170	0.683	0.406
0.204	0.614	0.816
0.238	0.542	1.277
0.272	0.463	1.718
0.307	0.373	2.095
0.341	0.260	2.385
0.375	0.000	2.573

X	q_A	q_R
0.000	0.000	1.117 kgSS/(m ² ·h)
2.871	0.812	0.812 kgSS/(m ² ·h)
5.743	1.625	0.508 kgSS/(m ² ·h)
X_A	10.536	2.981

X_F	2.4	kg/m ³
SAFE		
SST min Area:	194	m ²
	#NUM!	#NUM!
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.027	0.941	0.000
0.054	0.881	0.000
0.080	0.820	0.013
0.107	0.758	0.124
0.134	0.694	0.430
0.161	0.626	0.919
0.188	0.553	1.499
0.215	0.474	2.078
0.241	0.383	2.589
0.268	0.268	2.995
R_{crit}	0.295	0.000

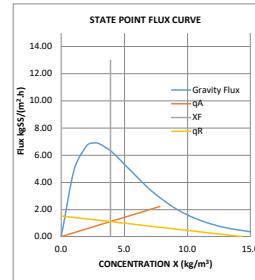
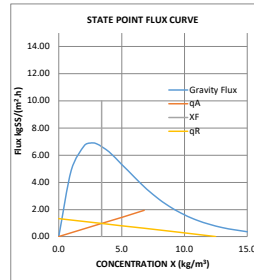
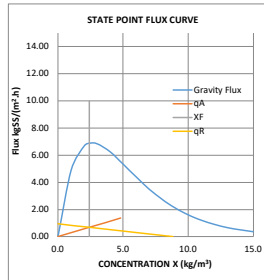
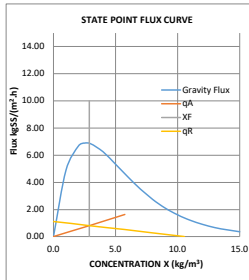
X	q_A	q_R
0.000	0.000	0.933 kgSS/(m ² ·h)
2.400	0.679	0.679 kgSS/(m ² ·h)
4.800	1.358	0.425 kgSS/(m ² ·h)
X_A	8.806	2.492

X_F	3.4 kg/m ³
SAFE	
SST min Area:	345 m ²
	0.394 1.61
SHC I	
R	α q_A (m/hr)
#DIV/0!	
0	1.000
0.043	0.933
0.087	0.868
0.130	0.802
0.173	0.736
0.217	0.670
0.260	0.601
0.303	0.528
0.346	0.450
0.390	0.362
0.433	0.252
0.476	0.000

X	q_A	q_R
0.000	0.000	1.322 kgSS/(m ² ·h)
3.400	0.962	0.962 kgSS/(m ² ·h)
6.800	1.924	0.602 kgSS/(m ² ·h)
X_A	12.476	3.530

X_F	3.9	kg/m ³
SAFE		
SST min Area:	573	m ²
	0.514	0.969
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.053	0.929	0.000
0.107	0.860	0.001
0.160	0.792	0.026
0.214	0.724	0.148
0.267	0.656	0.383
0.321	0.587	0.675
0.374	0.514	0.966
0.427	0.437	1.218
0.481	0.350	1.417
0.534	0.243	1.558
R_{crit}	0.588	0.000
	1.000	1.640

X	q_A	q_R
0.000	0.000	1.517 kgSS/(m ² ·h)
3.900	1.103	1.103 kgSS/(m ² ·h)
7.800	2.207	0.690 kgSS/(m ² ·h)
X_A	14.310	4.049



SHC II	
R	q_{Amax} (m/hr)
0	2.394
2.5	2.394

APPLIED FLUX (SLR) 0.81 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	2.863
2.5	2.863

APPLIED FLUX (SLR) 0.68 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	1.959
2.5	1.959

APPLIED FLUX (SLR) 0.96 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	1.620
2.5	1.620

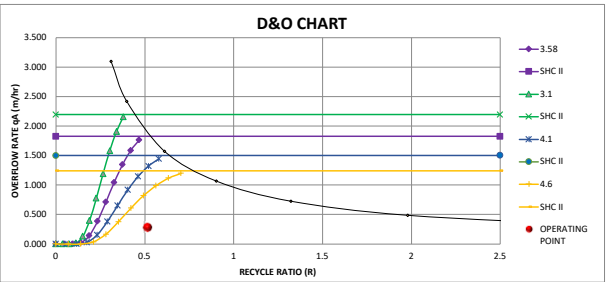
APPLIED FLUX (SLR) 1.10 kgTSS/(m²·h)

$$q_A = \frac{V_g}{R} \left(\frac{1+\alpha}{1-\alpha} \right) \exp \left[\frac{n(1-R)X_F(1+\alpha)}{2R} \right]$$

where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_F}}$

$$q_{AmaxSHC II} = V_g e^{-\alpha X_F}$$

DSVI	120 ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)					
SSVI	80.4 ml/g						
V_0/n	18.76 kgTSS/(m ² ·h)						
V_0	7.121 m/h						
n	0.380 m ³ /kgTSS						
f_n	1.8432						
ADWF	556 m ³ /h	13.3 Ml/d	<table><tr><th>Recycle Ratio R</th><th>Q_R m³/hr</th></tr><tr><td>0.515</td><td>286.1</td></tr></table>	Recycle Ratio R	Q_R m ³ /hr	0.515	286.1
Recycle Ratio R	Q_R m ³ /hr						
0.515	286.1						
PDWF	m ³ /h	Ml/d					
PWWF	1024 m ³ /h	24.6 Ml/d	0.279				
$Q_{applied}$	556 m ³ /h	13.3 Ml/d	0.515 286.1				
Flux Rating	0.8	0% added to area for non-idealities					
SST Area	1963 m ²	1963 m ²					
SST diameter	25						
No. of SST's	4.0						
OPERATING POINT							
Q_A	0.283 m/h						
Q_R	0.146 m/h						
R	0.515 (Q_A/Q_R)						



X_F	3.58 kg/m ³
SAFE	
SST min Area: 304 m ²	
SHC I	
R	q_A (m/hr)
0	1.000 #DIV/0!
0.047	0.932 0.000
0.094	0.865 0.000
0.140	0.799 0.022
0.187	0.732 0.141
0.234	0.665 0.387
0.281	0.596 0.711
0.328	0.523 1.046
0.375	0.445 1.345
0.421	0.358 1.587
0.468	0.249 1.764
R_{crit}	0.515 0.000 1.871

X	q_A	q_R
0.000	0.000	1.536 kgSS/(m ² ·h)
3.582	1.013	1.013 kgSS/(m ² ·h)
7.164	2.027	0.491 kgSS/(m ² ·h)
X_R	10.536	2.981 0.000 kgSS/(m ² ·h)

X_F	3.1 kg/m ³
SAFE	
SST min Area: 252 m ²	
SHC I	
R	q_A (m/hr)
0	1.000 #DIV/0!
0.038	0.936 0.000
0.076	0.872 0.000
0.114	0.808 0.018
0.152	0.743 0.132
0.189	0.677 0.398
0.227	0.609 0.777
0.265	0.536 1.193
0.303	0.457 1.581
0.341	0.368 1.908
0.379	0.257 2.155
R_{crit}	0.417 0.000 2.312

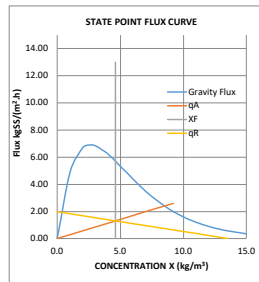
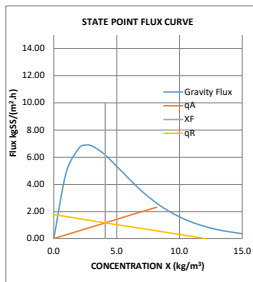
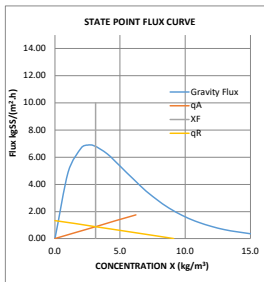
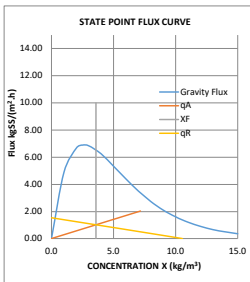
X	q_A	q_R
0.000	0.000	1.329 kgSS/(m ² ·h)
3.100	0.877	0.877 kgSS/(m ² ·h)
6.200	1.754	0.425 kgSS/(m ² ·h)
X_R	9.119	2.580 0.000 kgSS/(m ² ·h)

X_F	4.1 kg/m ³
SAFE	
SST min Area: 425 m ²	
SHC I	
R	q_A (m/hr)
0	1.000 #DIV/0!
0.058	0.927 0.000
0.116	0.856 0.001
0.174	0.787 0.029
0.232	0.719 0.153
0.290	0.650 0.381
0.347	0.581 0.655
0.405	0.509 0.921
0.463	0.432 1.147
0.521	0.346 1.322
0.579	0.240 1.444
R_{crit}	0.637 0.000 1.513

X	q_A	q_R
0.000	0.000	1.758 kgSS/(m ² ·h)
4.100	1.160	1.160 kgSS/(m ² ·h)
8.200	2.320	0.563 kgSS/(m ² ·h)
X_R	12.060	3.412 0.000 kgSS/(m ² ·h)

X_F	4.6 kg/m ³
SAFE	
SST min Area: 632 m ²	
SHC I	
R	q_A (m/hr)
0	1.000 #DIV/0!
0.070	0.922 0.000
0.141	0.847 0.001
0.211	0.775 0.037
0.282	0.705 0.167
0.352	0.635 0.377
0.423	0.565 0.610
0.493	0.494 0.821
0.564	0.418 0.992
0.634	0.334 1.118
0.704	0.231 1.201
R_{crit}	0.775 0.000 1.244

X	q_A	q_R
0.000	0.000	1.972 kgSS/(m ² ·h)
4.600	1.302	1.302 kgSS/(m ² ·h)
9.200	2.603	0.631 kgSS/(m ² ·h)
X_R	13.511	3.828 0.000 kgSS/(m ² ·h)



SHC II	
R	q_{Amax} (m/hr)
0	1.828
2.5	1.828

APPLIED FLUX (SLR) 1.01 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	2.195
2.5	2.195

APPLIED FLUX (SLR) 0.88 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	1.502
2.5	1.502

APPLIED FLUX (SLR) 1.16 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	1.242
2.5	1.242

APPLIED FLUX (SLR) 1.30 kgTSS/(m²·h)

SHC I

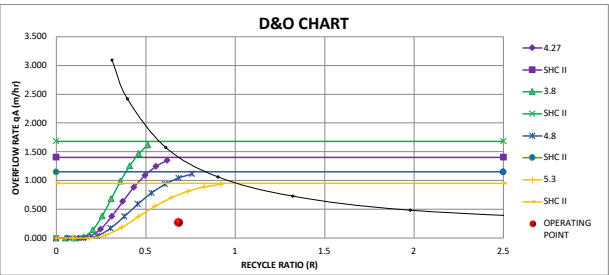
$$q_A = \frac{V_0}{R} \left(\frac{1+\alpha}{1-\alpha} \right) \exp \left[\frac{n(1-R)X_F(1+\alpha)}{2R} \right]$$

where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_F}}$

SHC II

$$q_{AmaxSHC II} = V_0 e^{-\alpha X_F}$$

DSVI	120 ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)
SSVI	80.4 ml/g	
V_0/n	18.76 kgTSS/(m ² ·h)	
V_0	7.121 m/h	
n	0.380 m ³ /kgTSS	
f_n	1.8432	
ADWF	556 m ³ /h	13.3 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	1024 m ³ /h	24.6 Ml/d
$Q_{applied}$	556 m ³ /h	13.3 Ml/d
Flux Rating	0.8	0% added to area for non-idealities
SST Area	1963 m ²	1963 m ²
SST diameter	25	
No. of SST's	4.0	
OPERATING POINT		
q_A	0.283 m/h	
q_R	0.193 m/h	
R	0.682 [Q_R/Q_A]	



X_F	4.27 kg/m ³
X_F	SAFE
SST min Area:	395 m ²
SHC I	
R	α
0	1.000
0.062	0.925
0.124	0.853
0.186	0.783
0.248	0.714
0.310	0.645
0.372	0.576
0.434	0.504
0.496	0.427
0.558	0.342
0.620	0.237
R_{crit}	0.682

X	q_A	q_R
0.000	0.000	2.034
4.273	1.209	1.209
8.546	2.418	0.384
X_A	10.536	2.981

X_F	3.8 kg/m ³
X_F	SAFE
SST min Area:	330 m ²
SHC I	
R	α
0	1.000
0.051	0.930
0.103	0.861
0.154	0.794
0.205	0.727
0.256	0.659
0.308	0.590
0.359	0.517
0.410	0.440
0.462	0.353
0.513	0.245
R_{crit}	0.564

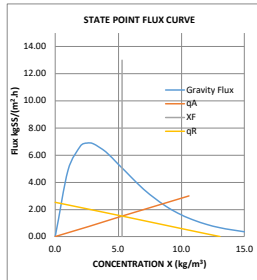
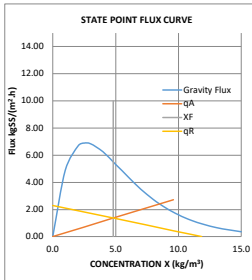
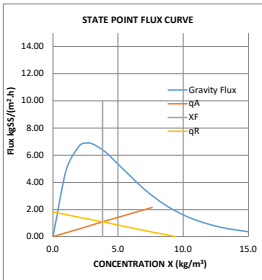
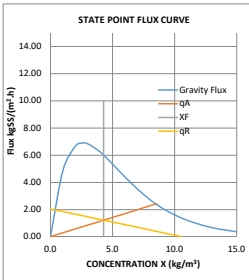
X	q_A	q_R
0.000	0.000	1.809
3.800	1.075	1.075
7.600	2.150	0.342
X_A	9.370	2.651

X_F	4.8 kg/m ³
X_F	SAFE
SST min Area:	532 m ²
SHC I	
R	α
0	1.000
0.076	0.919
0.152	0.843
0.228	0.770
0.304	0.699
0.380	0.629
0.456	0.559
0.532	0.487
0.609	0.412
0.685	0.329
0.761	0.227
R_{crit}	0.837

X	q_A	q_R
0.000	0.000	2.285
4.800	1.358	1.358
9.600	2.716	0.432
X_A	11.836	3.349

X_F	5.3 kg/m ³
X_F	SAFE
SST min Area:	737 m ²
SHC I	
R	α
0	1.000
0.092	0.912
0.184	0.831
0.276	0.755
0.368	0.682
0.460	0.611
0.552	0.541
0.644	0.470
0.736	0.396
0.828	0.315
0.920	0.218
R_{crit}	1.012

X	q_A	q_R
0.000	0.000	2.523
5.300	1.500	1.500
10.600	2.999	0.477
X_A	13.069	3.698



SHC II	
R	q_{Amax}
0	1.406
2.5	1.406

APPLIED FLUX (SLR) 1.21 kgTSS/(m²·h)

SHC II	
R	q_{Amax}
0	1.683
2.5	1.683

APPLIED FLUX (SLR) 1.08 kgTSS/(m²·h)

SHC II	
R	q_{Amax}
0	1.151
2.5	1.151

APPLIED FLUX (SLR) 1.36 kgTSS/(m²·h)

SHC II	
R	q_{Amax}
0	0.952
2.5	0.952

APPLIED FLUX (SLR) 1.50 kgTSS/(m²·h)

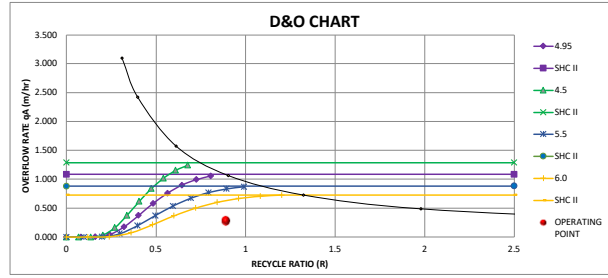
$$q_A = \frac{V_F}{R} \left(\frac{1+\alpha}{1-\alpha} \right) \exp \left[\frac{n(1-R)X_F(1+\alpha)}{2R} \right]$$

where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_F}}$

$$q_{AmaxSHC II} = V_F e^{-\alpha X_F}$$

SST's - MLE Process @ 30 Days SRT

DSVI	120 ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)
SSVI	80.4 ml/g	
V_0/n	18.76 kgTSS/(m ² ·h)	
V_0	7.121 m ³ /h	
n	0.380 m ³ /kgTSS	
f_n	1.8432	
ADWF	556 m ³ /h	13.3 Ml/d
PDPF	m ³ /h	Ml/d
PWWF	1024 m ³ /h	24.6 Ml/d
$Q_{applied}$	556 m ³ /h	13.3 Ml/d
Flux Rating	0.8	0% added to area for non-idealities
SST Area	1963 m ²	1963 m ²
SST diameter	25	
No. of SST's	4.0	
OPERATING POINT		
q_A	0.283 m/h	
q_R	0.251 m/h	
R	0.887 [Q_R/Q_A]	



X_f	4.95	kg/m ³
	SAFE	
SST min Area:	511	m ²
	0.000	1.086
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.081	0.917	0.000
0.161	0.839	0.002
0.242	0.765	0.044
0.323	0.694	0.178
0.403	0.623	0.376
0.484	0.553	0.581
0.565	0.482	0.759
0.645	0.407	0.898
0.726	0.325	0.996
0.806	0.224	1.058
0.887	0.000	1.086

X	q_A	q_R
0.000	0.000	2.645 kgSS/(m ² ·h)
4.953	1.401	1.401 kgSS/(m ² ·h)
9.906	2.803	0.158 kgSS/(m ² ·h)
X_A	10.536	2.981 0.000

X_F	4.5	kg/m ³
SAFE		
SST min Area:	431 m ²	
	#NUM!	#NUM!
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.068	0.923	0.000
0.136	0.849	0.001
0.203	0.777	0.035
0.271	0.708	0.164
0.339	0.638	0.378
0.407	0.568	0.618
0.474	0.497	0.840
0.542	0.421	1.021
0.610	0.336	1.155
0.678	0.233	1.246
R_{crit}	0.745	0.000
		1.293

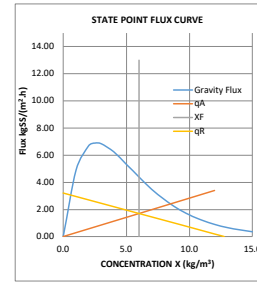
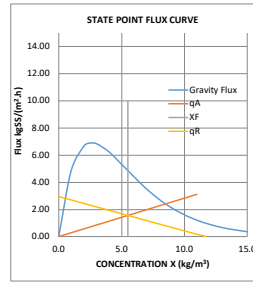
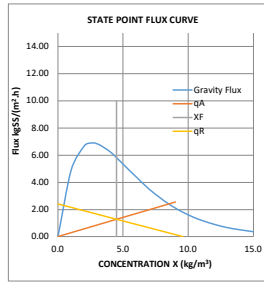
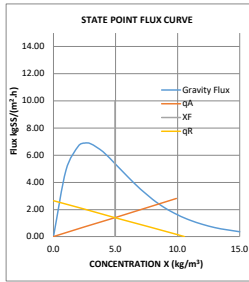
X	q_A	q_R
0.000	0.000	2.403 kgSS/(m ² ·h)
4.500	1.273	1.273 kgSS/(m ² ·h)
9.000	2.546	0.144 kgSS/(m ² ·h)
X_A	9.573	2.708 0.000

X_F	5.5	kg/m ³
SAFE		
SST min Area:	669	m ²
	0.315	0.837
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.099	0.909	0.000
0.199	0.826	0.004
0.298	0.749	0.058
0.397	0.675	0.197
0.496	0.604	0.373
0.596	0.534	0.539
0.695	0.463	0.673
0.794	0.390	0.770
0.893	0.310	0.834
0.993	0.214	0.870
R_{crit}	1.092	0.000
		0.883

X	q_A	q_R
0.000	0.000	2.937 kgSS/(m ² ·h)
5.500	1.556	1.556 kgSS/(m ² ·h)
11.000	3.112	0.176 kgSS/(m ² ·h)
X_A	11.700	3.310 0.000

X_u	6.0	kg/m ³
SST min Area:	SAFE	882 m ²
	0.418	0.630
SHC I		
R	α	q_u (m/hr)
	0	1.000 #DIV/0!
	0.120	0.901 0.000
	0.240	0.812 0.007
	0.361	0.731 0.075
	0.481	0.656 0.214
	0.601	0.584 0.369
	0.721	0.514 0.502
	0.842	0.444 0.601
	0.962	0.373 0.668
	1.082	0.296 0.708
	1.202	0.203 0.727
R_{crit}	1.323	0.000 0.729

X	q_A	q_R
0.000	0.000	3.204 kgSS/(m ² ·h)
6.000	1.698	1.698 kgSS/(m ² ·h)
12.000	3.395	0.192 kgSS/(m ² ·h)
X_A	12.769	3.611 0.000



SHC II		
R	q_{Amax}	(m/hr)
0	1.086	
2.5	1.086	

APPLIED FLUX (SLR) 1.40 kgTSS/(m²·h)

SHC II		
R	q_{Amax}	(m/hr)
0	1.290	
2.5	1.290	

APPLIED FLUX (SLR) 1.27 kgTSS/(m²·h)

SHC II		
R	q_{Amax}	(m/hr)
0	0.883	
2.5	0.883	

APPLIED FLUX (SLR) 1.56 kgTSS/(m²·h)

SHC II		
R	q_{Amax}	(m/hr)
0	0.730	
2.5	0.730	

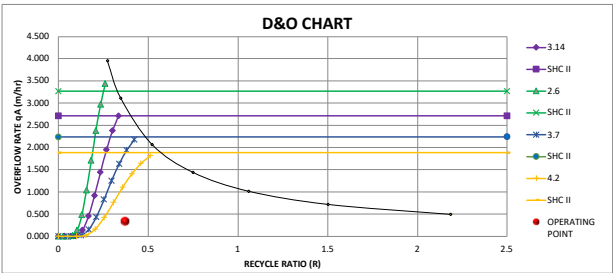
APPLIED FLUX (SLR) 1.70 kgTSS/(m²·h)

$$q_A = \frac{V_F (1 + \alpha)}{R (1 - \alpha)} \exp \left[\frac{n(1-R)X_F(1 + \alpha)}{2R} \right]$$

where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_F}}$

$$q_{AmaxSHC II} = V_F e^{-\alpha X_F}$$

DSVI	100 ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)
SSVI	67 ml/g	
V_0/n	23.24 kgTSS/(m ² ·h)	
V_0	7.974 m/h	
n	0.343 m ³ /kgTSS	
f_n	1.2288	
ADWF	694 m ³ /h	16.7 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	853 m ³ /h	20.5 Ml/d
$Q_{a,applied}$	694 m ³ /h	16.7 Ml/d
Flux Rating	0.8	25% added to area for non-idealities
SST Area	2016 m ²	2519 m ²
SST diameter	32.7	
No. of SST's	3	
OPERATING POINT		
q_A	0.345 m/h	
q_R	0.127 m/h	
R	0.368 (Q_R/Q_A)	



X_F	3.14 kg/m ³
X_F	SAFE
SST min Area:	256 m ²
R	0.368
q_A	0.345
q_R	0.127
R	0.368

X_F	2.6 kg/m ³
X_F	SAFE
SST min Area:	212 m ²
R	0.287
q_A	0.345
q_R	0.127
R	0.368

X_F	3.7 kg/m ³
X_F	SAFE
SST min Area:	373 m ²
R	0.465
q_A	0.345
q_R	0.127
R	0.368

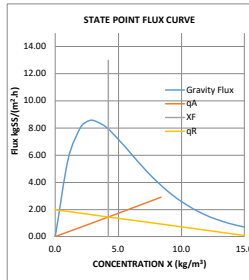
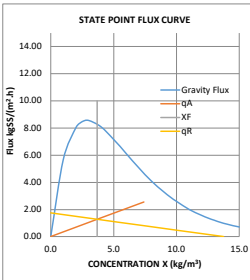
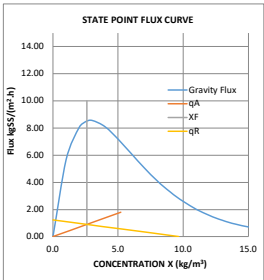
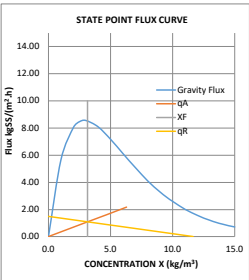
X_F	4.2 kg/m ³
X_F	SAFE
SST min Area:	592 m ²
R	0.563
q_A	0.345
q_R	0.127
R	0.368

X	q_A	q_R
0.000	0.000	1.480
3.139	1.082	1.082
6.278	2.163	0.683
X_F	11.660	4.017

X	q_A	q_R
0.000	0.000	1.226
2.600	0.896	0.896
5.200	1.792	0.566
X_F	9.658	3.327

X	q_A	q_R
0.000	0.000	1.744
3.700	1.275	1.275
7.400	2.550	0.805
X_F	13.744	4.735

X	q_A	q_R
0.000	0.000	1.980
4.200	1.447	1.447
8.400	2.894	0.914
X_F	15.601	5.375



X_F	$q_{A,max}$
0	2.716
2.5	2.716

X_F	$q_{A,max}$
0	3.268
2.5	3.268

X_F	$q_{A,max}$
0	2.241
2.5	2.241

X_F	$q_{A,max}$
0	1.888
2.5	1.888

$$q_A = \frac{V_0}{R} \left(\frac{1+\alpha}{1-\alpha} \right) \exp \left[\frac{n(1-R)X_F(1+\alpha)}{2R} \right]$$

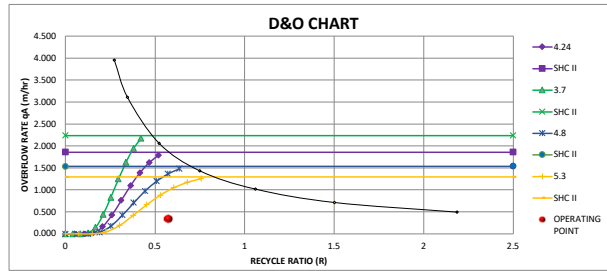
where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_F}}$

$$q_{A,maxSHC II} = V_0 e^{-nX_F}$$

SST's - UCT Process @ 15 Days SRT

DSVI	100 ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)
SSVI	67 ml/g	
V_0/n	23.24 kgTSS/(m ² ·h)	
V_0	7.974 m ³ /h	
n	0.343 m ³ /kgTSS	
f_n	1.2288	
ADWF	694 m ³ /h	16.7 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	853 m ³ /h	20.5 Ml/d
$Q_{applied}$	694 m ³ /h	16.7 Ml/d
Flux Rating	0.8	25% added to area for non-idealities
SST Area	2016 m ²	2519 m ²
SST diameter	32.7	
No. of SST's	3	

Q_A	0.345 m/h
Q_R	0.197 m/h
R	0.572 [Q _R /Q _A]



X_F	4.24 kg/m ³
SST min Area:	SAFE 374 m ²
R	0.572
Q_A	0.345
Q_R	0.197
R	0.572

X	Q_A	Q_R
0.000	0.000	2.299
4.245	1.462	1.462
8.489	2.925	0.625
X_A	11.660	4.017

X_F	3.7 kg/m ³
SST min Area:	SAFE 310 m ²
R	0.572
Q_A	0.345
Q_R	0.197
R	0.572

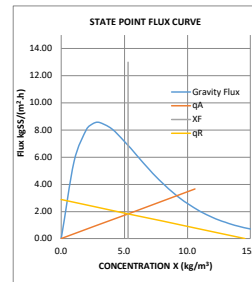
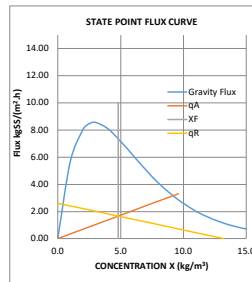
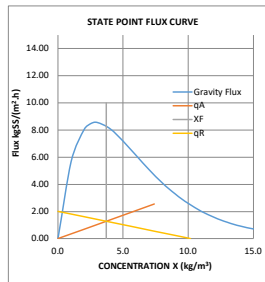
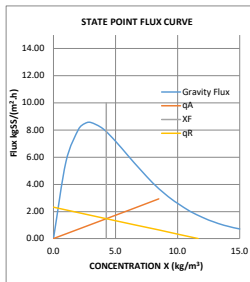
X	Q_A	Q_R
0.000	0.000	2.004
3.700	1.275	1.275
7.400	2.550	0.545
X_A	10.164	3.502

X_F	4.8 kg/m ³
SST min Area:	SAFE 509 m ²
R	0.572
Q_A	0.345
Q_R	0.197
R	0.572

X	Q_A	Q_R
0.000	0.000	2.600
4.800	1.654	1.654
9.600	3.308	0.707
X_A	13.186	4.543

X_F	5.3 kg/m ³
SST min Area:	SAFE 707 m ²
R	0.572
Q_A	0.345
Q_R	0.197
R	0.572

X	Q_A	Q_R
0.000	0.000	2.871
5.300	1.826	1.826
10.600	3.652	0.781
X_A	14.560	5.016



R	Q_{Amax}
0	1.859
2.5	1.859

APPLIED FLUX (SLR) 1.46 kgTSS/(m²·h)

R	Q_{Amax}
0	2.241
2.5	2.241

APPLIED FLUX (SLR) 1.27 kgTSS/(m²·h)

R	Q_{Amax}
0	1.537
2.5	1.537

APPLIED FLUX (SLR) 1.65 kgTSS/(m²·h)

R	Q_{Amax}
0	1.294
2.5	1.294

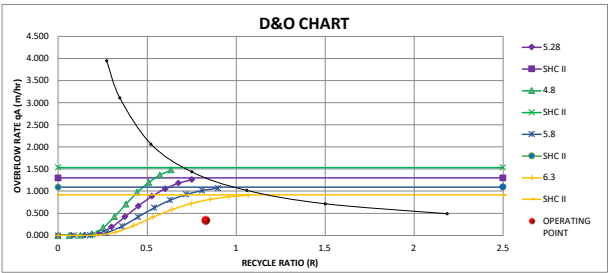
APPLIED FLUX (SLR) 1.83 kgTSS/(m²·h)

$$Q_A = \frac{V_0}{R} \left(\frac{1 + \alpha}{1 - \alpha} \right) \exp \left[\frac{n(1-R)X_F(1+\alpha)}{2R} \right]$$

where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_F}}$

$$Q_{AmaxSHC II} = V_0 e^{-nX_F}$$

DSVI	100 ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)
SSVI	67 ml/g	
V_0/n	23.24 kgTSS/(m ² ·h)	
V_0	7.974 m ³ /h	
n	0.343 m ³ /kgTSS	
f_n	1.2288	
ADWF	694 m ³ /h	16.7 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	853 m ³ /h	20.5 Ml/d
$Q_{applied}$	694 m ³ /h	16.7 Ml/d
Flux Rating	0.8	25% added to area for non-idealities
SST Area	2016 m ²	2519 m ²
SST diameter	32.7	
No. of SST's	3	
OPERATING POINT		
q_A	0.345 m/h	
q_R	0.285 m/h	
R	0.828 (Q_R/Q_A)	



X_F	5.28 kg/m ³
X_F	SAFE
SST min Area:	533 m ²
R	0.828
q_A	0.345 m/h
q_R	0.285 m/h
R	0.828 (Q_R/Q_A)

X_F	4.8 kg/m ³
X_F	SAFE
SST min Area:	452 m ²
R	0.700
q_A	0.345 m/h
q_R	0.285 m/h
R	0.828 (Q_R/Q_A)

X_F	5.8 kg/m ³
X_F	SAFE
SST min Area:	675 m ²
R	0.990
q_A	0.345 m/h
q_R	0.285 m/h
R	0.828 (Q_R/Q_A)

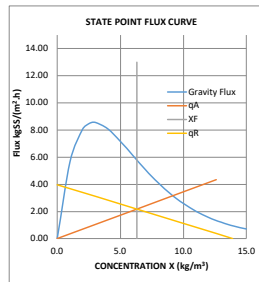
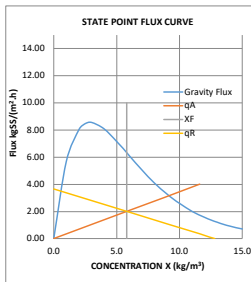
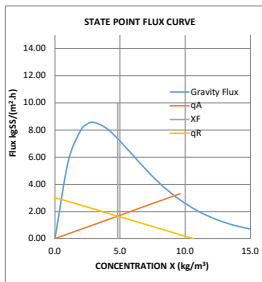
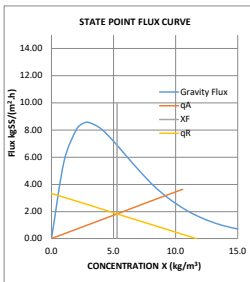
X_F	6.3 kg/m ³
X_F	SAFE
SST min Area:	872 m ²
R	1.175
q_A	0.345 m/h
q_R	0.285 m/h
R	0.828 (Q_R/Q_A)

X	q_A	q_R
0.000	0.000	3.328 kgSS/(m ² ·h)
5.283	1.820	1.820 kgSS/(m ² ·h)
10.565	3.640	0.312 kgSS/(m ² ·h)
X_R	11.660	4.017

X	q_A	q_R
0.000	0.000	3.024 kgSS/(m ² ·h)
4.800	1.654	1.654 kgSS/(m ² ·h)
9.600	3.308	0.284 kgSS/(m ² ·h)
X_R	10.595	3.650

X	q_A	q_R
0.000	0.000	3.654 kgSS/(m ² ·h)
5.800	1.998	1.998 kgSS/(m ² ·h)
11.600	3.997	0.343 kgSS/(m ² ·h)
X_R	12.802	4.411

X	q_A	q_R
0.000	0.000	3.969 kgSS/(m ² ·h)
6.300	2.171	2.171 kgSS/(m ² ·h)
12.600	4.341	0.373 kgSS/(m ² ·h)
X_R	13.906	4.791



R	q_{Amax} (m/hr)
0	1.302
2.5	1.302

APPLIED FLUX (SLR) 1.82 kgTSS/(m²·h)

R	q_{Amax} (m/hr)
0	1.537
2.5	1.537

APPLIED FLUX (SLR) 1.65 kgTSS/(m²·h)

R	q_{Amax} (m/hr)
0	1.090
2.5	1.090

APPLIED FLUX (SLR) 2.00 kgTSS/(m²·h)

R	q_{Amax} (m/hr)
0	0.918
2.5	0.918

APPLIED FLUX (SLR) 2.17 kgTSS/(m²·h)

SHC I

$$q_A = \frac{V_p}{R} \left(\frac{1+\alpha}{1-\alpha} \right) \exp \left[\frac{n(1-R)X_F(1+\alpha)}{2R} \right]$$

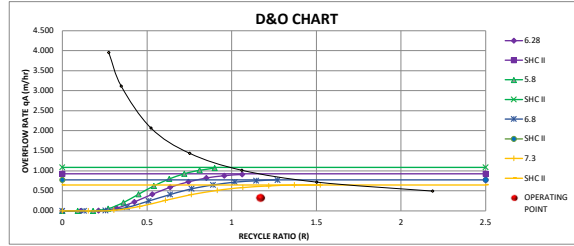
where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_F}}$

SHC II

$$q_{AmaxSHC II} = V_p e^{-nX_F}$$

SST's - UCT Process @ 25 Days SRT

DSVI	100 ml/g	(Range 50-200ml/g, >150ml/g = bulking sludge)
SSVI	67 ml/g	
V_d/n	23.24 kgTSS/(m ² .h)	
V_d	7.974 m/h	
n	0.343 m ³ /kgTSS	
f_n	1.2288	
ADWF	694 m ³ /h	16.7 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	853 m ³ /h	20.5 Ml/d
Q_{supply}	694 m ³ /h	16.7 Ml/d
Flux Rating	0.8	25% added to area for non-idealities
SST Area	2016 m ²	2519 m ²
SST diameter	32.7	
No. of SST's	3	
OPERATING POINT		
R	0.345 m/h	
R_{th}	0.402 m/h	
R	1.168 (Q_d/Q_r)	



X_r	6.28 kg/m ³
X_r	SAFE
SST min Area:	751 m ²
R	0.000
Q_d	0.000
Q_r	0.924

X_r	5.6 kg/m ³
X_r	SAFE
SST min Area:	637 m ²
R	0.000
Q_d	0.000
Q_r	1.090

X_r	6.6 kg/m ³
X_r	SAFE
SST min Area:	914 m ²
R	0.000
Q_d	0.000
Q_r	0.774

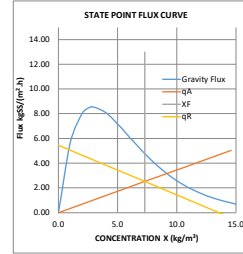
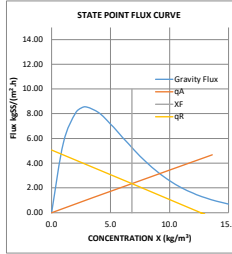
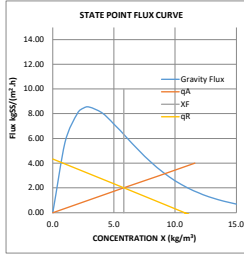
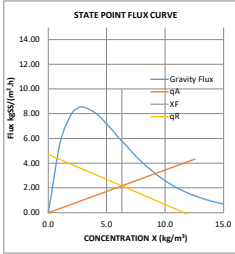
X_r	7.3 kg/m ³
X_r	SAFE
SST min Area:	1130 m ²
R	0.000
Q_d	0.000
Q_r	0.645

X	Q_d	Q_r
0.000	0.000	4.692 kgSS/(m ² .h)
6.282	2.164	2.164 kgSS/(m ² .h)
12.563	4.328	0.363 kgSS/(m ² .h)
X_r	11.660	4.017 kgSS/(m ² .h)

X	Q_d	Q_r
0.000	0.000	4.332 kgSS/(m ² .h)
5.800	1.998	1.998 kgSS/(m ² .h)
11.600	3.997	0.333 kgSS/(m ² .h)
X_r	10.767	3.710 kgSS/(m ² .h)

X	Q_d	Q_r
0.000	0.000	5.079 kgSS/(m ² .h)
6.800	2.343	2.343 kgSS/(m ² .h)
13.600	4.686	0.393 kgSS/(m ² .h)
X_r	12.623	4.349 kgSS/(m ² .h)

X	Q_d	Q_r
0.000	0.000	5.452 kgSS/(m ² .h)
7.300	2.515	2.515 kgSS/(m ² .h)
14.600	5.030	0.422 kgSS/(m ² .h)
X_r	13.551	4.669 kgSS/(m ² .h)



R	Q_{max} (m/h)
0	0.924
2.5	0.924

APPLIED FLUX (SLR) 2.16 kgTSS/(m².h)

R	Q_{max} (m/h)
0	1.090
2.5	1.090

APPLIED FLUX (SLR) 2.00 kgTSS/(m².h)

R	Q_{max} (m/h)
0	0.774
2.5	0.774

APPLIED FLUX (SLR) 2.34 kgTSS/(m².h)

R	Q_{max} (m/h)
0	0.652
2.5	0.652

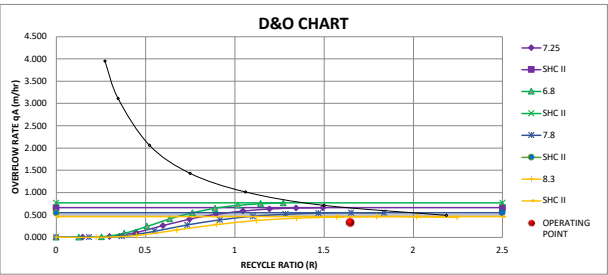
APPLIED FLUX (SLR) 2.52 kgTSS/(m².h)

$$q_A = \frac{V_d}{R} \frac{(1+\alpha)}{(1-\alpha)} \exp \left[\frac{-n(1-R)X_r(1+\alpha)}{2R} \right]$$

where $\alpha = \sqrt{1 - \frac{4R}{n(1-R)X_r}}$

$$q_{LmaxSHC II} = V_d e^{-nX_r}$$

DSVI	100	ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)	
SSVI	67	ml/g		
V_0/n	23.24	kgTSS/(m ² ·h)		
V_0	7.974	m ³ /h		
n	0.343	m ³ /kgTSS		
f_n	2			
			<u>Recycle Ratio R</u>	<u>Q_R m³/hr</u>
ADWF	694	m ³ /h	16.7	MI/d
PDWF		m ³ /h		1.644 1141.8
PWWF	1389	m ³ /h	33.3	MI/d
			0.822	
$Q_{a,applied}$	694	m ³ /h	16.7	MI/d
			1.644	1141.8
Flux Rating	0.8		25% added to area for non-idealities	
SST Area	2016	m ²	2519 m ²	
SST diameter	32.7			
No. of SST's	3			
OPERATING POINT				
q_A	0.345	m/h		
q_R	0.566	m/h		
R	1.644	$[Q_R/Q_A]$		



X_F	7.25	kg/m ³
SAFE		
SST min Area:	1048	m ²
R	0.650	
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.149	0.889	0.000
0.299	0.794	0.014
0.448	0.709	0.109
0.598	0.631	0.261
0.747	0.559	0.405
0.897	0.490	0.516
1.046	0.422	0.590
1.196	0.352	0.635
1.345	0.278	0.657
1.495	0.191	0.663
R_{crit}	1.644	0.000

X	q_A	q_R
0.000	0.000	6.605
7.250	2.498	2.498
14.501	4.996	-1.609
X_A	11.660	4.017

X_F	6.8	kg/m ³
SAFE		
SST min Area:	898	m ²
R	0.650	
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.127	0.898	0.000
0.254	0.808	0.009
0.382	0.726	0.090
0.509	0.649	0.245
0.636	0.577	0.412
0.763	0.508	0.550
0.890	0.439	0.651
1.018	0.368	0.717
1.145	0.291	0.755
1.272	0.200	0.772
R_{crit}	1.399	0.000

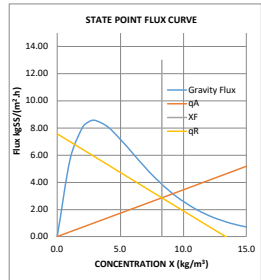
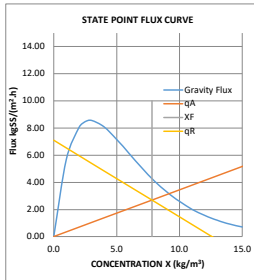
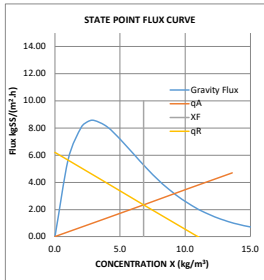
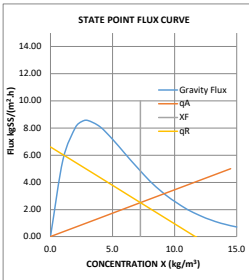
X	q_A	q_R
0.000	0.000	6.195
6.800	2.343	2.343
13.600	4.686	-1.509
X_A	10.936	3.768

X_F	7.8	kg/m ³
SAFE		
SST min Area:	1265	m ²
R	0.534	
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.184	0.876	0.000
0.367	0.774	0.025
0.551	0.685	0.136
0.735	0.606	0.277
0.918	0.533	0.393
1.102	0.465	0.471
1.286	0.399	0.518
1.469	0.332	0.542
1.653	0.262	0.549
1.837	0.179	0.545
R_{crit}	2.021	0.000

X	q_A	q_R
0.000	0.000	7.106
7.800	2.687	2.687
15.600	5.375	-1.731
X_A	12.544	4.322

X_F	8.3	kg/m ³
SAFE		
SST min Area:	1517	m ²
R	0.437	
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.225	0.862	0.000
0.449	0.751	0.040
0.674	0.659	0.163
0.898	0.579	0.288
1.123	0.507	0.376
1.347	0.440	0.428
1.572	0.376	0.454
1.796	0.312	0.462
2.021	0.245	0.460
2.245	0.167	0.451
R_{crit}	2.470	0.000

X	q_A	q_R
0.000	0.000	7.561
8.300	2.860	2.860
16.600	5.719	-1.842
X_A	13.348	4.599



SHC II	
R	$q_{A,max}$ (m/hr)
0	0.663
2.5	0.663

APPLIED FLUX (SLR) 2.50 kgTSS/(m²·h)

$$q_A = \frac{V_0}{R} \left(\frac{1+\alpha}{1-\alpha} \right) \exp \left[\frac{n(1-R)X_F(1+\alpha)}{2R} \right]$$

where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_F}}$

SHC II	
R	$q_{A,max}$ (m/hr)
0	0.774
2.5	0.774

APPLIED FLUX (SLR) 2.34 kgTSS/(m²·h)

$$q_{A,maxSHC II} = V_0 e^{-\alpha X_F}$$

SHC II	
R	$q_{A,max}$ (m/hr)
0	0.549
2.5	0.549

APPLIED FLUX (SLR) 2.69 kgTSS/(m²·h)

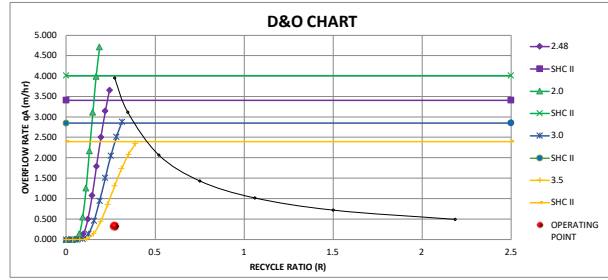
SHC II	
R	$q_{A,max}$ (m/hr)
0	0.462
2.5	0.462

APPLIED FLUX (SLR) 2.86 kgTSS/(m²·h)

**Annexure B4 – SST Capacity Check for Influent
Flow of 35 ML/d**

SST's - MLE Process @ 10 Days SRT

DSVI	100 ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)
SSVI	67 ml/g	
V_0/n	23.24 kgTSS/(m ² ·h)	
V_0	7.974 m ³ /h	
n	0.343 m ³ /kgTSS	
f_n	1.8432	
ADWF	648 m ³ /h	15.6 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	1195 m ³ /h	28.7 Ml/d
$Q_{applied}$	648 m ³ /h	15.6 Ml/d
Flux Rating	0.8	0% added to area for non-idealities
SST Area	1963 m ²	1963 m ²
SST diameter	25	
No. of SST's	4.0	
OPERATING POINT		
q_A	0.330 m/h	
q_R	0.089 m/h	
R	0.269 [Q_A/Q_R]	



X_F	2.48 kg/m ³
SST min Area:	SAFE 190 m ²
R	0.269
SHC I	
R	α
0	1.000
0.024	0.942
0.049	0.883
0.073	0.823
0.098	0.761
0.122	0.697
0.147	0.630
0.171	0.557
0.196	0.478
0.220	0.386
0.245	0.270
R_{crit}	0.269

X	q_A	q_R
0.000	0.000	1.037
2.475	0.817	0.817
4.951	1.634	0.597
X_A	11.660	3.849

X_F	2.0 kg/m ³
SST min Area:	SAFE 161 m ²
R	0.207
SHC I	
R	α
0	1.000
0.019	0.945
0.038	0.888
0.056	0.830
0.075	0.769
0.094	0.706
0.113	0.639
0.132	0.567
0.151	0.487
0.169	0.394
0.188	0.277
R_{crit}	0.207

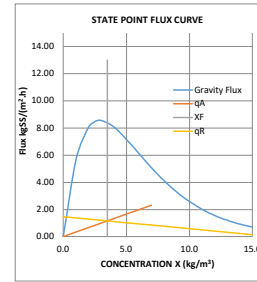
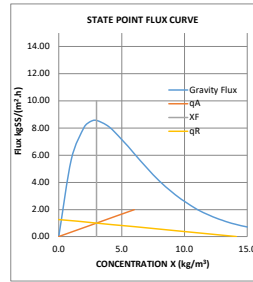
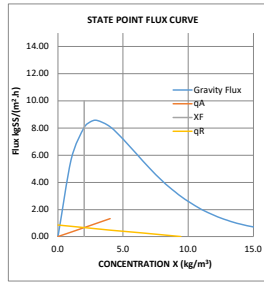
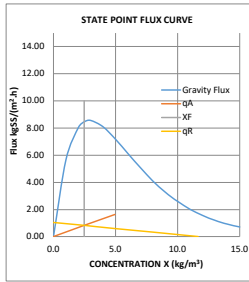
X	q_A	q_R
0.000	0.000	0.838
2.000	0.660	0.660
4.000	1.320	0.482
X_A	9.421	3.110

X_F	3.0 kg/m ³
SST min Area:	SAFE 280 m ²
R	0.346
SHC I	
R	α
0	1.000
0.031	0.939
0.063	0.877
0.094	0.815
0.126	0.752
0.157	0.686
0.189	0.618
0.220	0.546
0.252	0.467
0.283	0.376
0.315	0.263
R_{crit}	0.346

X	q_A	q_R
0.000	0.000	1.257
3.000	0.990	0.990
6.000	1.981	0.723
X_A	14.132	4.665

X_F	3.5 kg/m ³
SST min Area:	SAFE 509 m ²
R	0.429
SHC I	
R	α
0	1.000
0.039	0.935
0.078	0.871
0.117	0.807
0.156	0.742
0.195	0.676
0.234	0.607
0.273	0.534
0.312	0.456
0.351	0.367
0.390	0.256
R_{crit}	0.429

X	q_A	q_R
0.000	0.000	1.467
3.500	1.155	1.155
7.000	2.311	0.844
X_A	16.487	5.442



SHC II	
R	q_{max} (m/hr)
0	3.411
2.5	3.411

APPLIED FLUX (SLR) 0.82 kgTSS/(m²·h)

SHC II	
R	q_{max} (m/hr)
0	4.015
2.5	4.015

APPLIED FLUX (SLR) 0.66 kgTSS/(m²·h)

SHC II	
R	q_{max} (m/hr)
0	2.849
2.5	2.849

APPLIED FLUX (SLR) 0.99 kgTSS/(m²·h)

SHC II	
R	q_{max} (m/hr)
0	2.400
2.5	2.400

APPLIED FLUX (SLR) 1.16 kgTSS/(m²·h)

SHC I

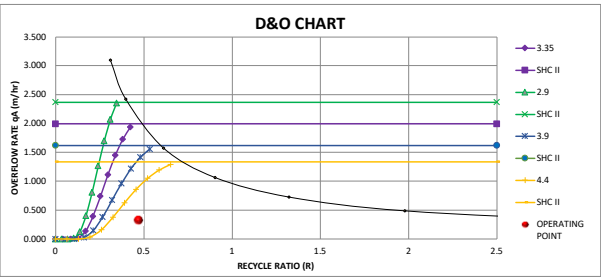
$$q_A = \frac{V_0}{R} \left(\frac{1+\alpha}{1-\alpha} \right) \exp \left[\frac{n(1-R)X_F(1+\alpha)}{2R} \right]$$

where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_F}}$

SHC II

$$q_{maxSHC II} = V_0 e^{-nX_F}$$

DSVI	120 ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)
SSVI	80.4 ml/g	
V_0/n	18.76 kgTSS/(m ² ·h)	
V_0	7.121 m ³ /h	
n	0.380 m ³ /kgTSS	
f_n	1.8432	
ADWF	648 m ³ /h	15.6 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	1195 m ³ /h	28.7 Ml/d
$Q_{applied}$	648 m ³ /h	15.6 Ml/d
Flux Rating	0.8	0% added to area for non-idealities
SST Area	1963 m ²	1963 m ²
SST diameter	25	
No. of SST's	4.0	
OPERATING POINT		
q_A	0.330 m/h	
q_R	0.154 m/h	
R	0.466 [Q _A /Q _R]	



X_f	3.35	kg/m ³
	SAFE	
SST min Area:	325	m ²
	#NUM!	#NUM!
SHC I		
R	α	q_A (m/hr)
	0	1.000
	0.042	0.934
	0.085	0.868
	0.127	0.803
	0.170	0.738
	0.212	0.671
	0.254	0.602
	0.297	0.530
	0.339	0.451
	0.381	0.363
	0.424	0.253
R_{crit}	0.466	0.000

X	q_A	q_R
0.000	0.000	1.621 kgSS/(m ² ·h)
3.350	1.106	1.106 kgSS/(m ² ·h)
6.700	2.212	0.590 kgSS/(m ² ·h)
X_A	10.536	3.478

X_f	2.9 kg/m ³
	SAFE
SST min Area:	274 m ²
	#NUM!
	#NUM!
SHC I	
R	α q_A (m/hr)
0	1.000 #DIV/0!
0.035	0.937 0.000
0.069	0.875 0.000
0.104	0.812 0.016
0.138	0.748 0.129
0.173	0.682 0.405
0.207	0.614 0.811
0.242	0.541 1.266
0.276	0.462 1.700
0.311	0.372 2.070
0.345	0.260 2.354
R_{crit}	0.380 0.000 2.538

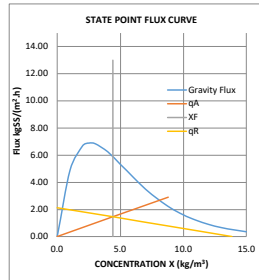
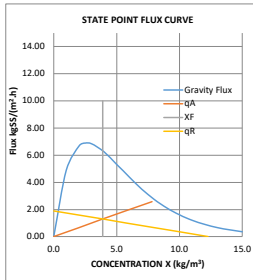
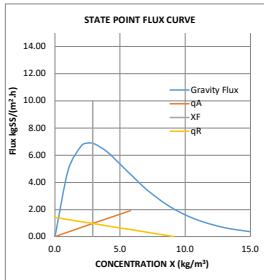
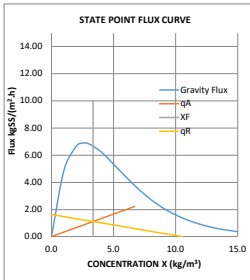
X	q_A	q_R
0.000	0.000	1.404 kgSS/(m ² ·h)
2.900	0.957	0.957 kgSS/(m ² ·h)
5.800	1.915	0.511 kgSS/(m ² ·h)
X_A	9.121	3.011

X_f	3.9	kg/m ³
	SAFE	
SST min Area:	474	m ²
	0.376	1.968
SHC I		
R	α	q_a (m/hr)
	0	1.000
	0.053	0.929
	0.107	0.860
	0.160	0.792
	0.214	0.724
	0.267	0.656
	0.321	0.587
	0.374	0.514
	0.427	0.437
	0.481	0.350
	0.534	0.243
R_{crit}	0.588	0.000

X	q_A	q_R
0.000	0.000	1.888 kgSS/(m ² ·h)
3.900	1.287	1.287 kgSS/(m ² ·h)
7.800	2.575	0.687 kgSS/(m ² ·h)
X_A	12.266	4.049

X_f	4.4 kg/m ³	
	SAFE	
SST min Area:	728 m ²	
	0.488	0.891
SHC I		
R	α	q_a (m/hr)
	0	1.000
	0.065	0.924
	0.130	0.851
	0.196	0.780
	0.261	0.710
	0.326	0.641
	0.391	0.572
	0.456	0.500
	0.521	0.423
	0.587	0.339
	0.652	0.235
R_{crit}	0.717	0.000

X	q_A	q_R
0.000	0.000	2.130 kgSS/(m ² ·h)
4.400	1.452	1.452 kgSS/(m ² ·h)
8.800	2.905	0.775 kgSS/(m ² ·h)
X_A	13.839	4.568



SHC II	
R	q_{Amax} (m/hr)
0	1.996
2.5	1.996

APPLIED FLUX (SLR) 1.11 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	2.368
2.5	2.368

APPLIED FLUX (SLR) 0.96 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	1.620
2.5	1.620

APPLIED FLUX (SLR) 1.29 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	1.340
2.5	1.340

APPLIED FLUX (SLR) 1.45 kgTSS/(m²·h)

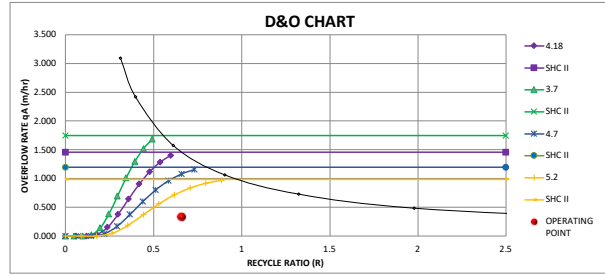
$$q_A = \frac{V_F}{R} \left(\frac{1+\alpha}{1-\alpha} \right) \exp \left[\frac{n(1-R)X_F(1+\alpha)}{2R} \right]$$

where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_F}}$

$$q_{AmaxSHC II} = V_F e^{-\alpha X_F}$$

SST's - MLE Process @ 20 Days SRT

DSVI	120 ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)
SSVI	80.4 ml/g	
V_0/n	18.76 kgTSS/(m ² ·h)	
V_0	7.121 m/h	
n	0.380 m ³ /kgTSS	
f_n	1.8432	
ADWF	648 m ³ /h	15.6 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	1195 m ³ /h	28.7 Ml/d
$Q_{applied}$	648 m ³ /h	15.6 Ml/d
Flux Rating	0.8	0% added to area for non-idealities
SST Area	1963 m ²	1963 m ²
SST diameter	25	
No. of SST's	4.0	
OPERATING POINT		
q_A	0.330 m/h	
q_R	0.217 m/h	
R	0.657 [Q_R/Q_A]	



X_f	4.18	kg/m ³
	SAFE	
SST min Area:	445	m ²
	0.000	1.466
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.060	0.926	0.000
0.120	0.855	0.001
0.179	0.785	0.030
0.239	0.717	0.155
0.299	0.648	0.380
0.359	0.578	0.647
0.418	0.506	0.904
0.478	0.430	1.121
0.538	0.344	1.287
0.598	0.239	1.402
R_{crit}	0.657	0.000 1.466

X	q_A	q_R
0.000	0.000	2.286 kgSS/(m ² ·h)
4.179	1.379	1.379 kgSS/(m ² ·h)
8.358	2.759	0.473 kgSS/(m ² ·h)
X_A	10.536	3.478 0.000 kgSS/(m ² ·h)

X_F	3.7	kg/m ³
SAFE		
SST min Area:	371	m ²
	#NUM!	#DIV!
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.049	0.931	0.000
0.098	0.863	0.000
0.148	0.796	0.023
0.197	0.729	0.143
0.246	0.662	0.385
0.295	0.592	0.697
0.344	0.520	1.015
0.394	0.442	1.296
0.443	0.355	1.521
0.492	0.247	1.684
R_{crit}	0.541	0.000
		1.781

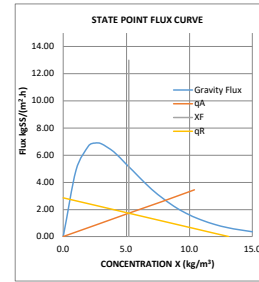
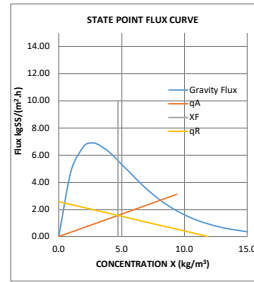
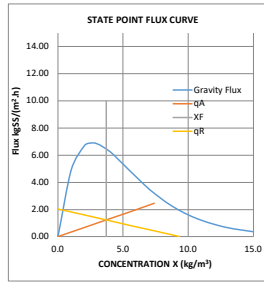
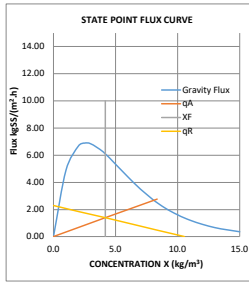
X	q_A	q_R
0.000	0.000	2.024 kgSS/(m ² ·h)
3.700	1.221	1.221 kgSS/(m ² ·h)
7.400	2.443	0.419 kgSS/(m ² ·h)
X_A	9.329	3.079 0.000 kgSS/(m ² ·h)

X_F	4.7	kg/m ³
SAFE		
SST min Area:	600	m ²
	0.333	1.082
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.073	0.920	0.000
0.146	0.845	0.001
0.220	0.772	0.039
0.293	0.702	0.170
0.366	0.632	0.377
0.439	0.562	0.601
0.512	0.490	0.803
0.586	0.415	0.964
0.659	0.331	1.082
0.732	0.229	1.158
0.805	0.000	1.197

X	q_A	q_R
0.000	0.000	2.571 kgSS/(m ² ·h)
4.700	1.551	1.551 kgSS/(m ² ·h)
9.400	3.103	0.532 kgSS/(m ² ·h)
X_A	11.850	3.912 0.000 kgSS/(m ² ·h)

X_F		5.2	kg/m ³
SAFE			
SST min Area:		838	m ²
		0.443	0.774
SHC I			
R	α	q_A (m/hr)	
0	1.000	#DIV/0!	
0.089	0.914	0.000	
0.177	0.834	0.003	
0.266	0.758	0.050	
0.354	0.685	0.186	
0.443	0.615	0.375	
0.532	0.545	0.562	
0.620	0.474	0.719	
0.709	0.400	0.838	
0.797	0.318	0.919	
0.886	0.220	0.969	
R_{crit}	0.974	0.989	

X	q_A	q_R
0.000	0.000	2.845 kgSS/(m ² ·h)
5.200	1.717	1.717 kgSS/(m ² ·h)
10.400	3.433	0.588 kgSS/(m ² ·h)
X_A	13.111	4.328 0.000 kgSS/(m ² ·h)



SHC II		
R	q_{Amax}	(m/hr)
0	1.457	
2.5	1.457	

APPLIED FLUX (SLR) 1.38 kgTSS/(m²·h)

SHC II		
R	q_{Amax}	(m/hr)
0	1.748	
2.5	1.748	

APPLIED FLUX (SLR) 1.22 kgTSS/(m²·h)

SHC II		
R	q_{Amax}	(m/hr)
0	1.196	
2.5	1.196	

APPLIED FLUX (SLR) 1.55 kgTSS/(m²·h)

SHC II		
R	q_{Amax}	(m/hr)
0	0.989	
2.5	0.989	

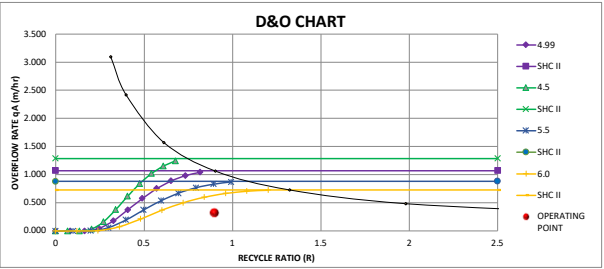
APPLIED FLUX (SLR) 1.72 kgTSS/(m²·h)

$$q_A = \frac{V_0}{R} \left(\frac{1+\alpha}{1-\alpha} \right) \exp \left[\frac{n(1-R)X_F(1+\alpha)}{2R} \right]$$

where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_F}}$

$$q_{AmaxSHC II} = V_0 e^{-nX_F}$$

DSVI	120	ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)	
SSVI	80.4	ml/g		
V_0/n	18.76	kgTSS/(m ² ·h)		
V_0	7.121	m ³ /h		
n	0.380	m ³ /kgTSS		
f_n	1.8432			
ADWF	648	m ³ /h	15.6	MI/d
PDWF		m ³ /h		MI/d
PWWF	1195	m ³ /h	28.7	MI/d
$Q_{applied}$	648	m ³ /h	15.6	MI/d
			0.898	582.1
Flux Rating	0.8		0% added to area for non-idealities	
SST Area	1963	m ²	1963 m ²	
SST diameter	25			
No. of SST's	4.0			
OPERATING POINT				
q_A	0.330	m/h		
q_R	0.296	m/h		
R	0.898	$[Q_R/Q_A]$		



X_F	4.99	kg/m ³
SAFE		
SST min Area:	604	m ²
R	0.898	1.073
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.082	0.917	0.000
0.163	0.839	0.002
0.245	0.764	0.045
0.327	0.693	0.179
0.408	0.622	0.376
0.490	0.552	0.578
0.571	0.481	0.754
0.653	0.406	0.890
0.735	0.324	0.986
0.816	0.224	1.046
R_{crit}	0.898	0.000

X	q_A	q_R
0.000	0.000	3.123
4.985	1.646	1.646
9.970	3.291	0.168
X_A	10.536	3.478

X_F	4.5	kg/m ³
SAFE		
SST min Area:	502	m ²
R	0.898	1.073
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.068	0.923	0.000
0.136	0.849	0.001
0.203	0.777	0.035
0.271	0.708	0.164
0.339	0.638	0.378
0.407	0.568	0.618
0.474	0.497	0.840
0.542	0.421	1.021
0.610	0.336	1.155
0.678	0.233	1.246
R_{crit}	0.745	0.000

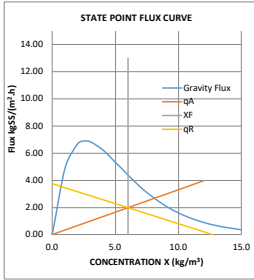
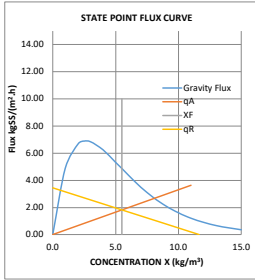
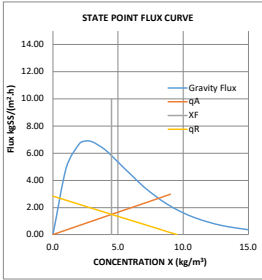
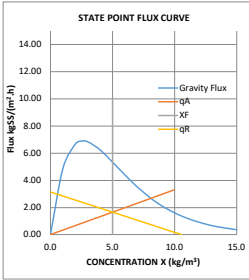
X	q_A	q_R
0.000	0.000	2.819
4.500	1.485	1.485
9.000	2.971	0.151
X_A	9.511	3.140

X_F	5.5	kg/m ³
SAFE		
SST min Area:	775	m ²
R	0.898	0.833
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.099	0.909	0.000
0.199	0.826	0.004
0.298	0.749	0.058
0.397	0.675	0.197
0.496	0.604	0.373
0.596	0.534	0.539
0.695	0.463	0.673
0.794	0.390	0.770
0.893	0.310	0.834
0.993	0.214	0.870
R_{crit}	1.092	0.000

X	q_A	q_R
0.000	0.000	3.446
5.500	1.816	1.816
11.000	3.631	0.185
X_A	11.624	3.837

X_F	6.0	kg/m ³
SAFE		
SST min Area:	1019	m ²
R	0.898	0.833
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.120	0.901	0.000
0.240	0.812	0.007
0.361	0.731	0.075
0.481	0.656	0.214
0.601	0.584	0.369
0.721	0.514	0.502
0.842	0.444	0.601
0.962	0.373	0.668
1.082	0.296	0.708
1.202	0.203	0.727
R_{crit}	1.323	0.000

X	q_A	q_R
0.000	0.000	3.759
6.000	1.981	1.981
12.000	3.961	0.202
X_A	12.681	4.186



SHC II		
R	q_{Amax}	(m/hr)
0	1.073	
2.5	1.073	

APPLIED FLUX (SLR) 1.65 kgTSS/(m²·h)

SHC II		
R	q_{Amax}	(m/hr)
0	1.290	
2.5	1.290	

APPLIED FLUX (SLR) 1.49 kgTSS/(m²·h)

SHC II		
R	q_{Amax}	(m/hr)
0	0.883	
2.5	0.883	

APPLIED FLUX (SLR) 1.82 kgTSS/(m²·h)

SHC II		
R	q_{Amax}	(m/hr)
0	0.730	
2.5	0.730	

APPLIED FLUX (SLR) 1.98 kgTSS/(m²·h)

SHC I

$$q_A = \frac{V_0}{R} \left(\frac{1 + \alpha}{1 - \alpha} \right) \exp \left[\frac{n(1-R)X_F(1+\alpha)}{2R} \right]$$

where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_F}}$

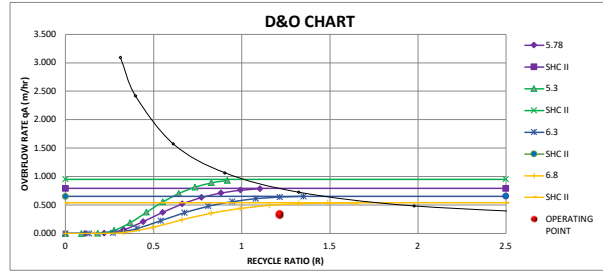
SHC II

$$q_{AmaxSHC II} = V_0 e^{-nX_F}$$

DSVI	120 ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)
SSVI	80.4 ml/g	
V_0/n	18.76 kgTSS/(m ² ·h)	
V_0	7.121 m ³ /h	
n	0.380 m ³ /kgTSS	
f_n	1.8432	
ADWF	648 m ³ /h	15.6 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	1195 m ³ /h	28.7 Ml/d
$Q_{applied}$	648 m ³ /h	15.6 Ml/d
		1.215 787.2

Flux Rating	0.8	0% added to area for non-idealities
SST Area	1963 m ²	1963 m ²
SST diameter	25	
No. of SST's	4.0	

Q_A	0.330 m/h
Q_R	0.401 m/h
R	1.215 (Q_R/Q_A)



X_F	5.78 kg/m ³
SST min Area:	SAFE 816 m ²

SST min Area:	816 m ²
#NUM!	#NUM!

X	Q_A	Q_R
0.000	0.000	4.224 kgSS/(m ² ·h)
5.779	1.908	1.908 kgSS/(m ² ·h)
11.557	3.815	-0.409 kgSS/(m ² ·h)
X_A	10.536	3.478 0.000

X_F	5.3 kg/m ³
SST min Area:	SAFE 681 m ²

SST min Area:	681 m ²
#NUM!	#NUM!

X	Q_A	Q_R
0.000	0.000	3.874 kgSS/(m ² ·h)
5.300	1.750	1.750 kgSS/(m ² ·h)
10.600	3.499	-0.375 kgSS/(m ² ·h)
X_A	9.664	3.190 0.000

X_F	6.3 kg/m ³
SST min Area:	SAFE 1013 m ²

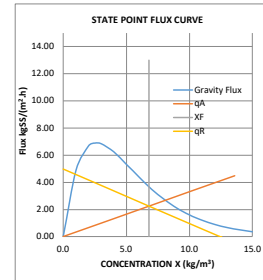
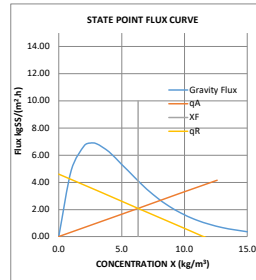
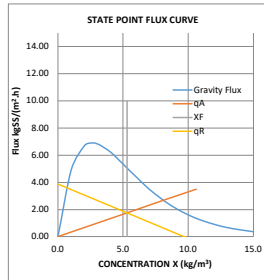
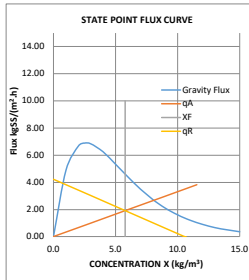
SST min Area:	1013 m ²
	0.288
	0.640

X	Q_A	Q_R
0.000	0.000	4.605 kgSS/(m ² ·h)
6.300	2.080	2.080 kgSS/(m ² ·h)
12.600	4.159	-0.446 kgSS/(m ² ·h)
X_A	11.487	3.792 0.000

X_F	6.8 kg/m ³
SST min Area:	SAFE 1278 m ²

SST min Area:	1278 m ²	
	0.388	0.507

X	Q_A	Q_R
0.000	0.000	4.971 kgSS/(m ² ·h)
6.800	2.245	2.245 kgSS/(m ² ·h)
13.600	4.489	-0.482 kgSS/(m ² ·h)
X_A	12.399	4.093 0.000



SHC II	
R	Q_{Amax} (m/hr)
0	0.794
2.5	0.794

APPLIED FLUX (SLR) 1.91 kgTSS/(m²·h)

SHC II	
R	Q_{Amax} (m/hr)
0	0.952
2.5	0.952

APPLIED FLUX (SLR) 1.75 kgTSS/(m²·h)

SHC II	
R	Q_{Amax} (m/hr)
0	0.651
2.5	0.651

APPLIED FLUX (SLR) 2.08 kgTSS/(m²·h)

SHC II	
R	Q_{Amax} (m/hr)
0	0.539
2.5	0.539

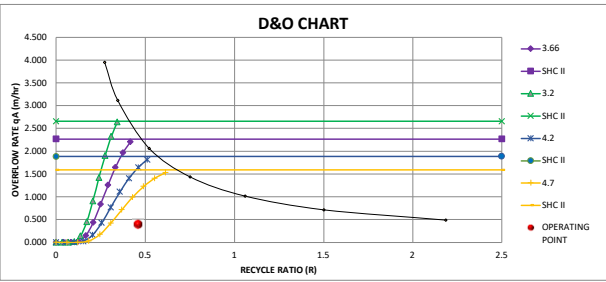
APPLIED FLUX (SLR) 2.24 kgTSS/(m²·h)

$$Q_A = \frac{V_0}{R} \left(\frac{1+\alpha}{1-\alpha} \right) \exp \left[\frac{n(1-R)X_F(1+\alpha)}{2R} \right]$$

where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_F}}$

$$Q_{AmaxSHC II} = V_0 e^{-nX_F}$$

DSVI	100 ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)
SSVI	67 ml/g	
V_0/n	23.24 kgTSS/(m ² ·h)	
V_0	7.974 m ³ /h	
n	0.343 m ³ /kgTSS	
f_n	1.2288	
ADWF	810 m ³ /h	19.4 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	996 m ³ /h	23.9 Ml/d
$Q_{applied}$	810 m ³ /h	19.4 Ml/d
Flux Rating	0.8	25% added to area for non-idealities
SST Area	2016 m ²	2519 m ²
SST diameter	32.7	
No. of SST's	3	
OPERATING POINT		
q_A	0.402 m/h	
q_R	0.184 m/h	
R	0.458 (Q_A/Q_R)	



X_F	3.66 kg/m ³
X_F	SAFE
SST min Area:	357 m ²
R	0.458
q_A	0.402
q_R	0.184
R	0.458

X_F	3.2 kg/m ³
X_F	SAFE
SST min Area:	305 m ²
R	0.458
q_A	0.402
q_R	0.184
R	0.458

X_F	4.3 kg/m ³
X_F	SAFE
SST min Area:	496 m ²
R	0.458
q_A	0.402
q_R	0.184
R	0.458

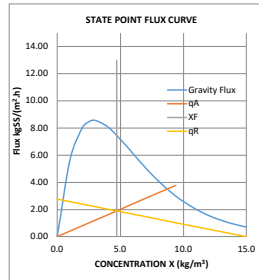
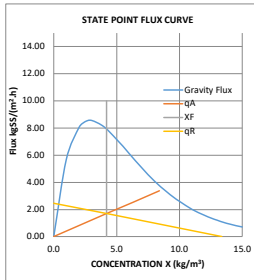
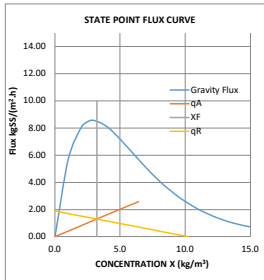
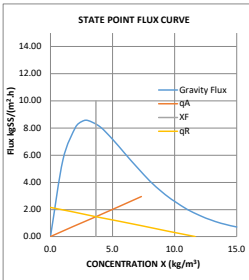
X_F	4.7 kg/m ³
X_F	SAFE
SST min Area:	730 m ²
R	0.458
q_A	0.402
q_R	0.184
R	0.458

X	q_A	q_R
0.000	0.000	2.146
3.662	1.472	1.472
7.325	2.944	0.736
X_A	11.660	4.687

X	q_A	q_R
0.000	0.000	1.875
3.200	1.286	1.286
6.400	2.573	0.643
X_A	10.188	4.095

X	q_A	q_R
0.000	0.000	2.461
4.200	1.688	1.688
8.400	3.377	0.844
X_A	13.372	5.375

X	q_A	q_R
0.000	0.000	2.754
4.700	1.889	1.889
9.400	3.778	0.945
X_A	14.964	6.015



X_F	q_{max}
3.66	2.270
2.5	2.270

APPLIED FLUX (SLR) 1.47 kgTSS/(m²·h)

X_F	q_{max}
3.2	2.660
2.5	2.660

APPLIED FLUX (SLR) 1.29 kgTSS/(m²·h)

X_F	q_{max}
4.3	1.888
2.5	1.888

APPLIED FLUX (SLR) 1.69 kgTSS/(m²·h)

X_F	q_{max}
4.7	1.590
2.5	1.590

APPLIED FLUX (SLR) 1.89 kgTSS/(m²·h)

SHC I

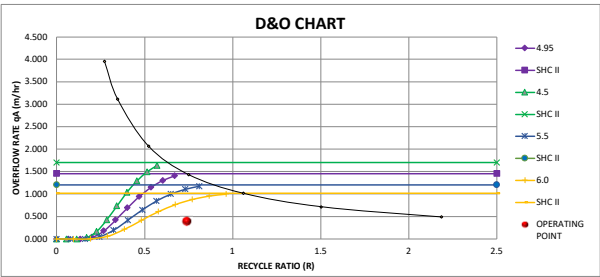
$$q_A = \frac{V_0}{R} \left(\frac{1 + \alpha}{1 - \alpha} \right) \exp \left[\frac{n(1-R)X_F(1+\alpha)}{2R} \right]$$

where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_F}}$

SHC II

$$q_{AmaxSHC II} = V_0 e^{-\alpha X_F}$$

DSVI	100 ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)
SSVI	67 ml/g	
V_0/n	23.24 kgTSS/(m ² ·h)	
V_0	7.974 m ³ /h	
n	0.343 m ³ /kgTSS	
f_n	1.2288	
ADWF	810 m ³ /h	19.4 MI/d
PDWF	m ³ /h	MI/d
PWWF	996 m ³ /h	23.9 MI/d
Q_{applied}	810 m ³ /h	19.4 MI/d
Flux Rating	0.8	25% added to area for non-idealities
SST Area	2016 m ²	2519 m ²
SST diameter	32.7	
No. of SST's	3	
OPERATING POINT		
q_A	0.402 m/h	
q_R	0.297 m/h	
R	0.738 (Q_A/Q_R)	



X_F	4.95	kg/m ³
	SAFE	
SST min Area:	555	m ²
	0.000	1.462
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.067	0.923	0.000
0.134	0.849	0.001
0.201	0.778	0.039
0.268	0.708	0.183
0.336	0.639	0.423
0.403	0.569	0.695
0.470	0.497	0.946
0.537	0.421	1.151
0.604	0.337	1.305
0.671	0.233	1.408
R_{crit}	0.738	0.000 1.462

X	q_A	q_R
0.000	0.000	3.460 kgSS/(m ² ·h)
4.952	1.991	1.991 kgSS/(m ² ·h)
9.904	3.981	0.521 kgSS/(m ² ·h)
X_A	11.660	4.687 0.000

X_F	4.5	kg/m ³
SAFE		
SST min Area:	476	m ²
	#NUM!	#NUM!
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.057	0.927	0.000
0.114	0.857	0.001
0.171	0.788	0.031
0.229	0.720	0.170
0.286	0.651	0.427
0.343	0.582	0.737
0.400	0.510	1.039
0.457	0.433	1.297
0.514	0.347	1.497
0.571	0.241	1.638
R_{crit}	0.628	0.000 1.717

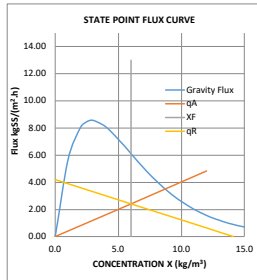
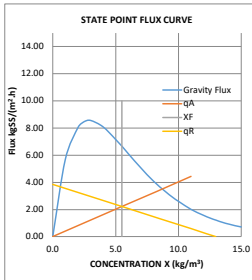
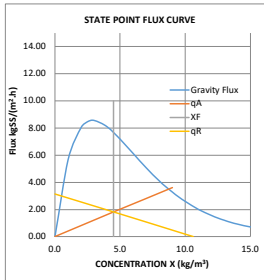
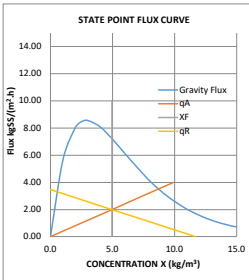
X	q_A	q_R
0.000	0.000	3.144 kgSS/(m ² ·h)
4.500	1.809	1.809 kgSS/(m ² ·h)
9.000	3.618	0.474 kgSS/(m ² ·h)
X_A	10.596	4.259 0.000

X_f	5.5 kg/m ³
SAFE	
SST min Area:	725 m ²
	0.316 1.117
SHC I	
R	α q_A (m/hr)
0	1.000 #DIV/0!
0.081	0.917 0.000
0.162	0.839 0.002
0.243	0.765 0.050
0.325	0.693 0.200
0.406	0.623 0.421
0.487	0.553 0.649
0.568	0.482 0.847
0.649	0.407 1.000
0.730	0.324 1.109
0.812	0.224 1.177
R_{crit}	0.893 0.000 1.209

X	q_A	q_R
0.000	0.000	3.843 kgSS/(m ² ·h)
5.500	2.211	2.211 kgSS/(m ² ·h)
11.000	4.422	0.579 kgSS/(m ² ·h)
X_A	12.951	5.206 0.000

X_F	6.0	kg/m ³
SST min Area:	SAFE	956 m ²
	0.648	0.847
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.096	0.911	0.000
0.193	0.828	0.004
0.289	0.751	0.063
0.385	0.678	0.217
0.482	0.607	0.418
0.578	0.537	0.610
0.675	0.466	0.767
0.771	0.392	0.881
0.867	0.312	0.958
0.964	0.215	1.002
R_{crit}	1.060	0.000 1.018

X	q_A	q_R
0.000	0.000	4.192 kgSS/(m ² ·h)
6.000	2.412	2.412 kgSS/(m ² ·h)
12.000	4.824	0.631 kgSS/(m ² ·h)
X_A	14.128	5.679 0.000



SHC II		
R	q_{max} (m/hr)	
0	1.458	
2.5	1.458	
APPLIED FLUX (SLR)	1.99 kgTSS/(m ² ·h)	

SHC I

$$q_A = \frac{V_F}{R} \left(\frac{1+\alpha}{1-\alpha} \right) \exp \left[\frac{n(1-R)X_F(1+\alpha)}{2R} \right]$$

where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_F}}$

SHC II		
R	q_{max} (m/hr)	
0	1.703	
2.5	1.703	
APPLIED FLUX (SLR)	1.81 kgTSS/(m ² ·h)	

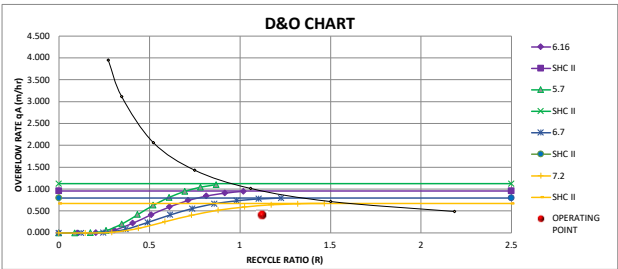
SHC II

$$q_{\text{maxSHC II}} = V_F e^{-\alpha X_F}$$

SHC II		
R	q_{max} (m/hr)	
0	1.209	
2.5	1.209	
APPLIED FLUX (SLR)	2.21 kgTSS/(m ² ·h)	

SHC II		
R	q_{max} (m/hr)	
0	1.018	
2.5	1.018	
APPLIED FLUX (SLR)	2.41 kgTSS/(m ² ·h)	

DSVI	100 ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)
SSVI	67 ml/g	
V_0/n	23.24 kgTSS/(m ² ·h)	
V_0	7.974 m ³ /h	
n	0.343 m ³ /kgTSS	
f_n	1.2288	
ADWF	810 m ³ /h	19.4 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	996 m ³ /h	23.9 Ml/d
$Q_{applied}$	810 m ³ /h	19.4 Ml/d
Flux Rating	0.8	25% added to area for non-idealities
SST Area	2016 m ²	2519 m ²
SST diameter	32.7	
No. of SST's	3	
OPERATING POINT		
q_A	0.402 m/h	
q_R	0.451 m/h	
R	1.121 [Q_R/Q_A]	

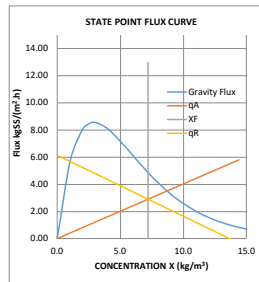
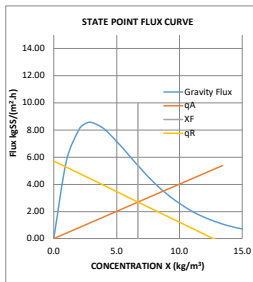
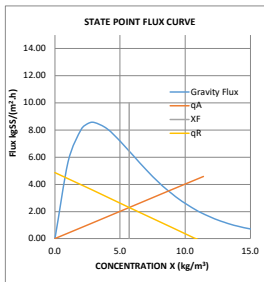
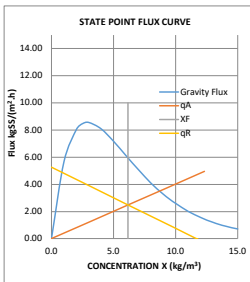


X_F	6.16	kg/m ³
SAFE		
SST min Area:	842	m ²
	0.006	0.963
SHC I		
	α	q_A (m/hr)
	0	1.000
		#DIV/0!
	0.102	0.908
	0.204	0.824
	0.306	0.746
	0.408	0.672
	0.510	0.601
	0.612	0.531
	0.713	0.461
	0.815	0.388
	0.917	0.308
	1.019	0.212
R_{crit}	1.121	0.000
X	q_A	q_R
	0.000	0.000
	6.163	2.477
	12.326	4.955
X_R	11.660	4.687

X_F	5.7 kg/m ³	
X_F	SAFE	
SST min Area:	718 m ²	
	$\#DIV/0!$	$\#DIV/0!$
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.087	0.915	0.000
0.174	0.835	0.003
0.261	0.759	0.055
0.348	0.687	0.207
0.435	0.617	0.420
0.522	0.547	0.633
0.609	0.475	0.814
0.696	0.401	0.951
0.782	0.319	1.046
0.869	0.221	1.104
R_{crit}	0.956	0.000
X		
	q_A	q_R
0.000	0.000	4.860
5.700	2.291	2.291
11.400	4.582	-0.278
X_R	10.784	4.335

X_F	6.7 kg/m ³	
X_F	SAFE	
SST min Area:	1026 m ²	
	0.959	0.799
SHC I		
R	α	q_A (m/hr)
	0	1.000 #DIV/0!
	0.123	0.900 0.000
	0.246	0.810 0.008
	0.368	0.729 0.086
	0.491	0.653 0.242
	0.614	0.581 0.413
	0.737	0.512 0.558
	0.860	0.442 0.665
	0.982	0.371 0.736
	1.105	0.294 0.778
	1.228	0.202 0.798
R_{crit}	1.351	0.000 0.799
X		
	q_A	q_R
	0.000	0.000 5.713
	6.700	2.693 2.693
	13.400	5.386 -0.326
X_R	12.676	5.095 0.000

X_F	7.2 kg/m ³	
X_F	SAFE	
SST min Area:	1286 m ²	
	0.376	0.634
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.147	0.890	0.000
0.293	0.795	0.014
0.440	0.711	0.107
0.587	0.633	0.259
0.734	0.561	0.406
0.880	0.492	0.520
1.027	0.424	0.597
1.174	0.354	0.644
1.321	0.280	0.667
1.467	0.192	0.675
R_{crit}	1.614	0.000
	0.000	0.669
X		
	q_A	q_R
0.000	0.000	6.139 kgSS/(m ² ·h)
7.200	2.894	2.894 kgSS/(m ² ·h)
14.400	5.788	-0.351 kgSS/(m ² ·h)
X_R	13.622	5.476 0.000 kgSS/(m ² ·h)



SHC II		
R	q_{Amax}	(m/hr)
0	0.963	
2.5	0.963	
APPLIED FLUX (SLR)	2.48	kgTSS/(m ² ·h)

SHC II		
R	q_{Amax}	(m/hr)
0	1.128	
2.5	1.128	
APPLIED FLUX (SLR)	2.29	kgTSS/(m ² ·h)

SHC II		
R	q_{Amax}	(m/hr)
0	0.801	
2.5	0.801	
APPLIED FLUX (SLR)	2.69	kgTSS/(m ² ·h)

SHC II		
R	q_{Amax}	(m/hr)
0	0.675	
2.5	0.675	
APPLIED FLUX (SLR)	2.89	kgTSS/(m ² ·h)

SHC I

$$q_A = \frac{V_F (1 + \alpha)}{R (1 - \alpha)} \exp \left[\frac{n(1-R)X_F(1 + \alpha)}{2R} \right]$$

where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_F}}$

SHC II

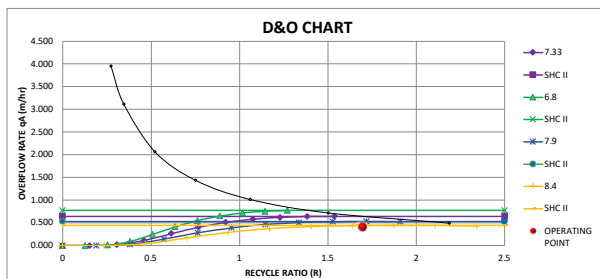
$$q_{AmaxSHC II} = V_F e^{-\alpha X_F}$$

SST's - UCT Process @ 25 Days SRT

DSVI	100	m/g	(Range 50-200m/g; >150m/g = bulking sludge)	
SSVI	67	m/g		
V ₀ /n	23.24	kgTSS/(m ³ .h)		
V ₀	7.974	m/h		
n	0.343	m ³ /kgTSS		
f	1.2288			
ADWF	810	m ³ /h	19.4	MI/d
PdWF	m ³ /h		1.692	1370.6
PdWF	m ³ /h		MI/d	
PWWF	996	m ³ /h	23.9	MI/d
			1.377	
Q _{applied}	810	m ³ /h	19.4	MI/d
			1.692	1370.6

Flux Rating		25% added to area for non-idealities
SST Area	2016 m ²	2519 m²

SST diameter	32.7
No. of SST's	3
OPERATING POINT	
Q_A	0.402 m/h
Q_R	0.680 m/h
R	1.692 [Q_R/Q_A]



X_f	7.33	kg/m ³

SST min Area: 1255 m²

SHC I		BNUM1	BNUM1
R	α	Q_0 (m/hr)	$dD/DI(0)$
0	1.000	0.000	
0.154	0.888	0.000	
0.308	0.791	0.015	
0.461	0.705	0.113	
0.615	0.628	0.263	
0.769	0.555	0.404	
0.923	0.486	0.510	
1.077	0.418	0.580	
1.230	0.350	0.621	
1.384	0.276	0.641	
1.538	0.189	0.645	
1.692	0.000	0.638	

X	q _A	q _R	
0.000	0.000	7.929	kgSS/(m ² ·h)
7.328	2.946	2.946	kgSS/(m ² ·h)
14.657	5.892	-2.038	kgSS/(m ² ·h)
11.660	4.687	0.000	kgSS/(m ² ·h)

X_f	6.8	kg/m ³

SST min Area: 1047 m²

SFC I		#NUM!	#NUM!
R	α	q_a (m/hr)	#DIV/0!
	0	1.000	
	0.127	0.898	0.000
	0.254	0.808	0.009
	0.382	0.726	0.090
	0.509	0.649	0.245
	0.636	0.577	0.412
	0.763	0.508	0.550
	0.890	0.439	0.653
	1.018	0.368	0.717
	1.145	0.291	0.759
	1.272	0.200	0.777
	1.399	0.000	0.777

X	q _A	q _R	
0.000	0.000	7.357	kgSS/(m ² ·h)
6.800	2.733	2.733	kgSS/(m ² ·h)
13.600	5.467	-1.891	kgSS/(m ² ·h)
10.820	4.349	0.000	kgSS/(m ² ·h)

X_F	7.9	kg/m ³

SST min Area: 1527 m²

SHC I		0.265	0.530
R	α	q_A (m/hr)	#DIV/0!
0	1.000	0.000	
0.191	0.874	0.000	
0.382	0.769	0.020	
0.573	0.680	0.141	
0.764	0.601	0.280	
0.955	0.528	0.390	
1.146	0.460	0.460	
1.337	0.394	0.505	
1.528	0.328	0.525	
1.719	0.259	0.533	
1.910	0.177	0.520	
2.101	0.000	0.510	

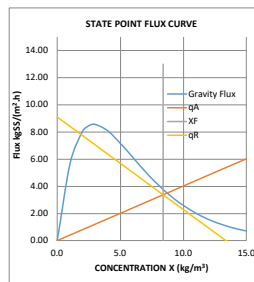
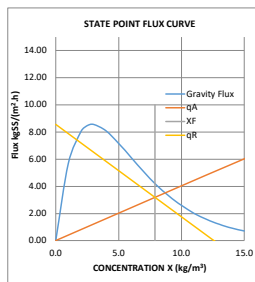
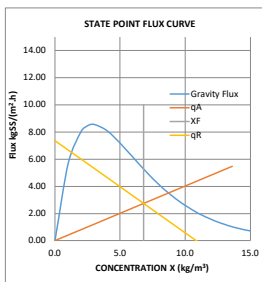
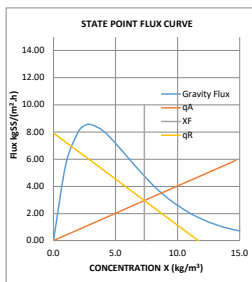
X	q _A	q _R	
0.000	0.000	8.548	kgSS/(m ² ·h)
7.900	3.176	3.176	kgSS/(m ² ·h)
15.800	6.351	-2.197	kgSS/(m ² ·h)
12.570	5.053	0.000	kgSS/(m ² ·h)

x_f	8.4	kg/m ³

SST min Area: 1828 m²

SHC I		
R	α	Q_0 (m/hr)
0	1.000	#DIV/0!
0.234	0.858	0.000
0.468	0.746	0.044
0.703	0.654	0.168
0.937	0.573	0.289
1.171	0.501	0.372
1.405	0.435	0.419
1.640	0.371	0.441
1.874	0.308	0.447
2.108	0.242	0.433
2.342	0.165	0.433
2.576	0.000	0.419

X	q _A	q _R	
0.000	0.000	9.089	kgSS/(m ² ·h)
8.400	3.377	3.377	kgSS/(m ² ·h)
16.800	6.753	-2.336	kgSS/(m ² ·h)
13.365	5.372	0.000	kgSS/(m ² ·h)



R	$q_{A,max}$ (m/hr)
0	0.645
2.5	0.645

APPLIED FLUX (SLR) 2.95 kgTSS/(m².h)

R	q _{Amax} (m/hr)
0	0.774
2.5	0.774

APPLIED FLUX (SLR) 2.73 kgTSS/(m².h)

R	q _{Amax} (m/hr)
0	0.531
2.5	0.531

APPLIED FLUX (SLR) 3.18 kgTSS/(m².h)

R	q_{Amax} (m/hr)
0	0.447
2.5	0.447

APPLIED FLUX (SLR) 3.38 kgTSS/(m².h)

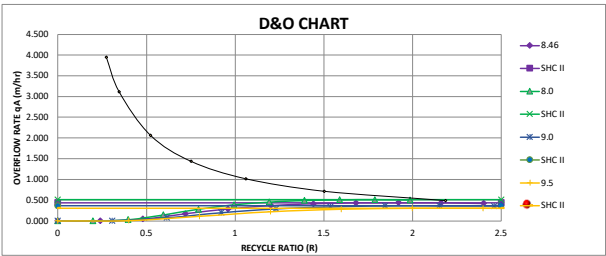
$$q_A = \frac{V_0}{R} \frac{(1+\alpha)}{(1-\alpha)} \exp\left[\frac{-n(1-R)X_F(1+\alpha)}{2R}\right]$$

where

$$\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_F}}$$

$$q_{AmaxSHC II} = V_0 e^{-nX_f}$$

DSVI	100 ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)
SSVI	67 ml/g	
V_0/n	23.24 kgTSS/(m ² ·h)	
V_0	7.974 m/h	
n	0.343 m ³ /kgTSS	
f_n	2	
ADWF	810 m ³ /h	19.4 MI/d
PDWF	m ³ /h	MI/d
PWWF	1620 m ³ /h	38.9 MI/d
$Q_{applied}$	810 m ³ /h	19.4 MI/d
Flux Rating	0.8	25% added to area for non-idealities
SST Area	2016 m ²	2519 m ²
SST diameter	32.7	
No. of SST's	3	
OPERATING POINT		
q_A	0.402 m/h	
q_R	1.062 m/h	
R	2.642 [Q_R/Q_A]	



X_F	8.46 kg/m ³
X_F	SAFE
SST min Area:	1850 m ²
R	0.000
SHC I	
R	q_A (m/hr)
0	1.000
0.240	0.856
0.480	0.743
0.721	0.650
0.961	0.570
1.201	0.498
1.441	0.432
1.681	0.368
1.922	0.306
2.162	0.240
2.402	0.163
R_{crit}	2.642

X	q_A	q_R
0.000	0.000	12.384
8.459	3.400	3.400
16.918	6.800	-5.584
X_A	11.660	4.687

X_F	8.0 kg/m ³
X_F	SAFE
SST min Area:	1580 m ²
R	0.000
SHC I	
R	q_A (m/hr)
0	1.000
0.199	0.871
0.397	0.765
0.596	0.675
0.795	0.595
0.993	0.523
1.192	0.455
1.391	0.390
1.589	0.325
1.788	0.255
1.987	0.174
R_{crit}	2.186

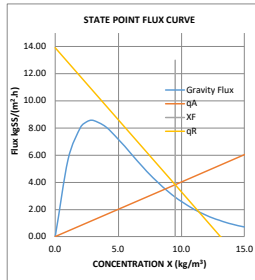
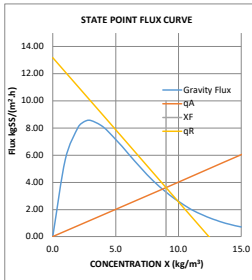
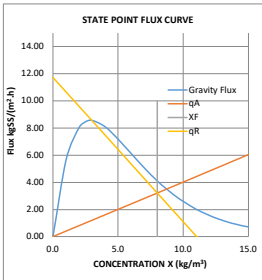
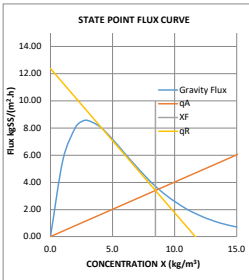
X	q_A	q_R
0.000	0.000	11.712
8.000	3.216	3.216
16.000	6.431	-5.281
X_A	11.028	4.433

X_F	9.0 kg/m ³
X_F	FAIL
SST min Area:	2303 m ²
R	0.000
SHC I	
R	q_A (m/hr)
0	1.000
0.308	0.834
0.615	0.712
0.923	0.615
1.230	0.534
1.538	0.464
1.845	0.400
2.153	0.340
2.460	0.281
2.768	0.220
3.075	0.149
R_{crit}	3.383

X	q_A	q_R
0.000	0.000	13.176
9.000	3.618	3.618
18.000	7.235	-5.941
X_A	12.406	4.987

X_F	9.5 kg/m ³
X_F	FAIL
SST min Area:	2682 m ²
R	0.000
SHC I	
R	q_A (m/hr)
0	1.000
0.400	0.806
0.800	0.674
1.199	0.575
1.599	0.495
1.999	0.426
2.399	0.366
2.798	0.309
3.198	0.255
3.598	0.199
3.998	0.135
R_{crit}	4.397

X	q_A	q_R
0.000	0.000	13.908
9.500	3.819	3.819
19.000	7.637	-6.271
X_A	13.096	5.264



SHC II	
R	q_{Amax} (m/hr)
0	0.438
2.5	0.438

APPLIED FLUX (SLR) 3.40 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	0.513
2.5	0.513

APPLIED FLUX (SLR) 3.22 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	0.364
2.5	0.364

APPLIED FLUX (SLR) 3.62 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	0.306
2.5	0.306

APPLIED FLUX (SLR) 3.82 kgTSS/(m²·h)

SHC I

$$q_A = \frac{V_g}{R} \left(\frac{1+\alpha}{1-\alpha} \right) \exp \left[\frac{n(1-R)X_F(1+\alpha)}{2R} \right]$$

where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_F}}$

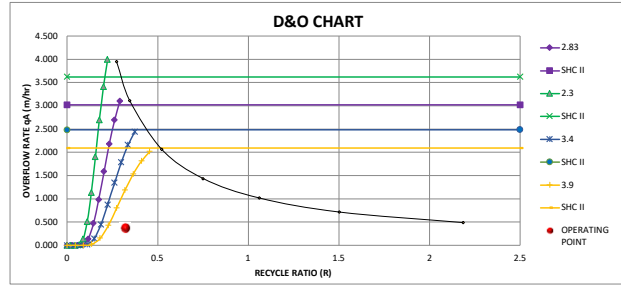
SHC II

$$q_{AmaxSHC II} = V_g e^{-nX_F}$$

**Annexure B5 – SST Capacity Check for Influent
Flow of 40 ML/d**

SST's - MLE Process @ 10 Days SRT

DSVI	100 ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)
SSVI	67 ml/g	
V_0/n	23.24 kgTSS/(m ² ·h)	
V_0	7.974 m ³ /h	
n	0.343 m ³ /kgTSS	
f_n	1.8432	
ADWF	741 m ³ /h	17.8 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	1365 m ³ /h	32.8 Ml/d
$Q_{applied}$	741 m ³ /h	17.8 Ml/d
Flux Rating	0.8	0% added to area for non-idealities
SST Area	1963 m ²	1963 m ²
SST diameter	25	
No. of SST's	4.0	
OPERATING POINT		
q_A	0.377 m/h	
q_R	0.121 m/h	
R	0.320 [Q_R/Q_A]	



X_f	2.83	kg/m ³
	SAFE	
SST min Area:	245	m ²
	0.000	3.369
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.029	0.940	0.000
0.058	0.879	0.000
0.087	0.818	0.016
0.116	0.755	0.140
0.146	0.690	0.471
0.175	0.622	0.986
0.204	0.550	1.587
0.233	0.470	2.177
0.262	0.380	2.693
0.291	0.265	3.099
0.320	0.000	3.369

X	q_A	q_R
0.000	0.000	1.409 kgSS/(m ² ·h)
2.829	1.067	1.067 kgSS/(m ² ·h)
5.658	2.134	0.725 kgSS/(m ² ·h)
X_A	11.660	4.399

X_F	2.3	kg/m ³
SAFE		
SST min Area:	204	m ²
	#NUM!	#DIV!
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.022	0.943	0.000
0.045	0.885	0.000
0.067	0.826	0.013
0.089	0.764	0.138
0.112	0.700	0.510
0.134	0.633	1.136
0.156	0.561	1.908
0.179	0.481	2.700
0.201	0.389	3.415
0.223	0.273	3.994
R_{crit}	0.246	0.000
		4.392

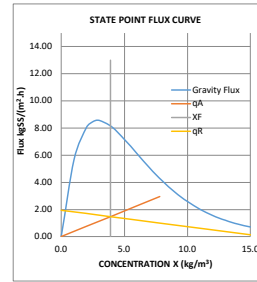
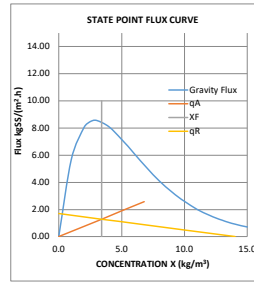
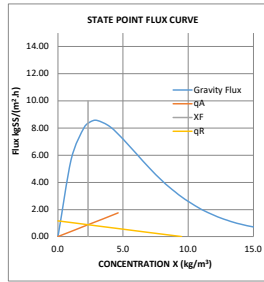
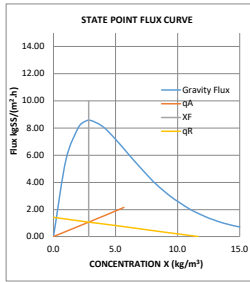
X	q_A	q_R
0.000	0.000	1.146 kgSS/(m ² ·h)
2.300	0.868	0.868 kgSS/(m ² ·h)
4.600	1.735	0.590 kgSS/(m ² ·h)
X_A	9.480	3.576

X_F	3.4	kg/m ³
	SAFE	
SST min Area:	369	m ²
	0.410	2.000
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.037	0.936	0.000
0.075	0.872	0.000
0.112	0.809	0.019
0.150	0.744	0.147
0.187	0.678	0.447
0.225	0.609	0.875
0.262	0.537	1.346
0.299	0.458	1.788
0.337	0.369	2.160
0.374	0.257	2.442
0.412	0.000	2.622

X	q_A	q_R
0.000	0.000	1.694 kgSS/(m ² ·h)
3.400	1.283	1.283 kgSS/(m ² ·h)
6.800	2.565	0.872 kgSS/(m ² ·h)
X_A	14.014	5.287

X_F	3.9	kg/m ³
SAFE		
SST min Area:	621	m ²
	0.524	1.193
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.046	0.932	0.000
0.091	0.866	0.000
0.137	0.800	0.024
0.183	0.734	0.156
0.228	0.666	0.435
0.274	0.597	0.804
0.320	0.525	1.188
0.365	0.447	1.535
0.411	0.359	1.815
0.457	0.250	2.022
R_{crit}	0.503	0.000
		2.147

X	q_A	q_R
0.000	0.000	1.943 kgSS/(m ² ·h)
3.900	1.471	1.471 kgSS/(m ² ·h)
7.800	2.943	1.000 kgSS/(m ² ·h)
X_A	16.075	6.064



SHC II	
R	q_{Amax} (m/hr)
0	3.021
2.5	3.021

APPLIED FLUX (SLR) 1.07 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	3.622
2.5	3.622

APPLIED FLUX (SLR) 0.87 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	2.484
2.5	2.484

APPLIED FLUX (SLR) 1.28 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	2.092
2.5	2.092

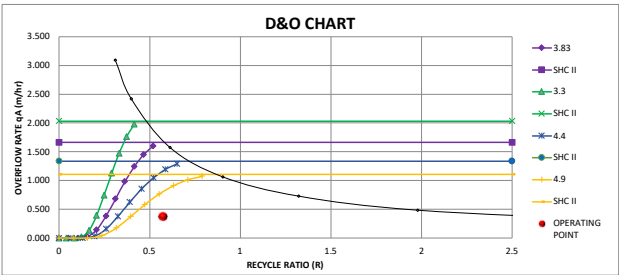
APPLIED FLUX (SLR) 1.47 kgTSS/(m²·h)

$$q_A = \frac{V_g}{R} \left(\frac{1+\alpha}{1-\alpha} \right) \exp \left[\frac{n(1-R)X_F(1+\alpha)}{2R} \right]$$

where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_F}}$

$$q_{AmaxSHC II} = V_g e^{-\alpha X_F}$$

DSVI	120 ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)
SSVI	80.4 ml/g	
V_0/n	18.76 kgTSS/(m ² ·h)	
V_0	7.121 m/h	
n	0.380 m ³ /kgTSS	
f_n	1.8432	
ADWF	741 m ³ /h	17.8 Ml/d
PDPF	m ³ /h	Ml/d
PWWF	1365 m ³ /h	32.8 Ml/d
$Q_{applied}$	741 m ³ /h	17.8 Ml/d
Flux Rating	0.8	0% added to area for non-idealities
SST Area	1963 m ²	1963 m ²
SST diameter	25	
No. of SST's	4.0	
OPERATING POINT		
q_A	0.377 m/h	
q_R	0.215 m/h	
R	0.571 [Q _A /Q _R]	



K_f	3.83	kg/m ³
	SAFE	
SST min Area:	445 m ²	
	0.000	1.689
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.052	0.930	0.000
0.104	0.861	0.001
0.156	0.793	0.025
0.208	0.726	0.146
0.259	0.658	0.384
0.311	0.589	0.683
0.363	0.516	0.983
0.415	0.439	1.245
0.467	0.352	1.453
0.519	0.245	1.601
R_{crit}	0.571	0.000 1.689

X	q_A	q_R
0.000	0.000	2.269 kgSS/(m ² ·h)
3.829	1.444	1.444 kgSS/(m ² ·h)
7.657	2.889	0.620 kgSS/(m ² ·h)
X_A	10.536	3.975 0.000 kgSS/(m ² ·h)

K_f	SAFE	3.3 kg/m ³
SST min Area:	364 m ²	
	0.571	1.689
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.041	0.934	0.000
0.083	0.869	0.000
0.124	0.804	0.019
0.166	0.739	0.135
0.207	0.672	0.393
0.249	0.603	0.748
0.290	0.531	1.127
0.332	0.453	1.476
0.373	0.364	1.764
0.415	0.254	1.979
R_{crit}	0.456	0.000 2.113

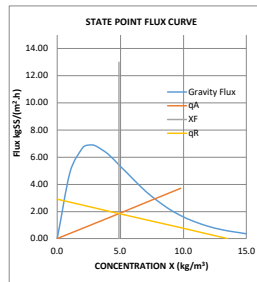
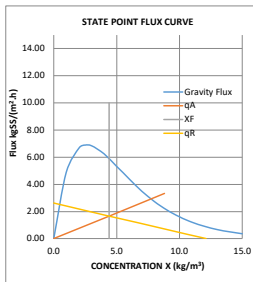
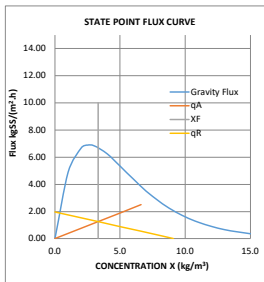
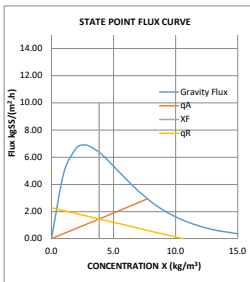
X	q_A	q_R
0.000	0.000	1.956 kgSS/(m ² ·h)
3.300	1.245	1.245 kgSS/(m ² ·h)
6.600	2.490	0.534 kgSS/(m ² ·h)
X_A	9.082	3.426 0.000 kgSS/(m ² ·h)

K_f	4.4 kg/m ³	
SAFE		
SST min Area:		636 m ²
		0.360 1.164
SHC I		
R	α	q_a (m/hr)
	0	1.000 #DIV/0!
	0.065	0.924 0.000
	0.130	0.851 0.001
	0.196	0.780 0.033
	0.261	0.710 0.161
	0.326	0.641 0.378
	0.391	0.572 0.627
	0.456	0.500 0.859
	0.521	0.423 1.051
	0.587	0.339 1.195
	0.652	0.235 1.292
R_{crit}	0.717	0.000 1.344

X	q_A	q_R
0.000	0.000	2.607 kgSS/(m ² ·h)
4.400	1.660	1.660 kgSS/(m ² ·h)
8.800	3.320	0.712 kgSS/(m ² ·h)
X_A	12.109	4.568 0.000 kgSS/(m ² ·h)

K_f	4.9 kg/m ³	
SAFE		
SST min Area:	922 m ²	
	0.468	0.804
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.079	0.918	0.000
0.158	0.841	0.002
0.237	0.767	0.043
0.316	0.695	0.177
0.395	0.625	0.376
0.474	0.555	0.585
0.553	0.484	0.768
0.632	0.409	0.911
0.711	0.326	1.013
0.790	0.225	1.078
R_{crit}	0.869	0.000 1.109

X	q_A	q_R
0.000	0.000	2.904 kgSS/(m ² ·h)
4.900	1.849	1.849 kgSS/(m ² ·h)
9.800	3.697	0.793 kgSS/(m ² ·h)
X_A	13.485	5.087 0.000 kgSS/(m ² ·h)



SHC II		
R	q_{Amax}	(m/hr)
0	1.665	
2.5	1.665	
APPLIED FLUX (SLR)	1.44 kgTSS/(m ² ·h)	

SHC II		
R	q_{Amax}	(m/hr)
0	2.035	
2.5	2.035	
APPLIED FLUX (SLR)	1.24 kgTSS/(m ² ·h)	

SHC II		
R	q_{Amax}	(m/hr)
0	1.340	
2.5	1.340	
APPLIED FLUX (SLR)	1.66 kgTSS/(m ² ·h)	

SHC II		
R	q_{Amax}	(m/hr)
0	1.108	
2.5	1.108	
APPLIED FLUX (SLR)	1.85 kgTSS/(m ² ·h)	

SHC I

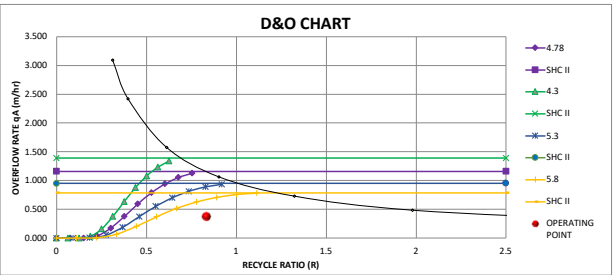
$$q_A = \frac{V_g (1 + \alpha)}{R (1 - \alpha)} \exp \left[\frac{n(1-R)X_p(1 + \alpha)}{2R} \right]$$

where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_p}}$

SHC II

$$q_{AmaxSHC II} = V_g e^{-\alpha X_p}$$

DSVI	120 ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)
SSVI	80.4 ml/g	
V_0/n	18.76 kgTSS/(m ² ·h)	
V_0	7.121 m/h	
n	0.380 m ³ /kgTSS	
f_n	1.8432	
ADWF	741 m ³ /h	17.8 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	1365 m ³ /h	32.8 Ml/d
$Q_{applied}$	741 m ³ /h	17.8 Ml/d
Flux Rating	0.8	0% added to area for non-idealities
SST Area	1963 m ²	1963 m ²
SST diameter	25	
No. of SST's	4.0	
OPERATING POINT		
q_A	0.377 m/h	
q_R	0.313 m/h	
R	0.829 [Q_R/Q_A]	



X_F	4.78 kg/m ³
SAFE	
SST min Area:	638 m ²
R	0.829
q_A	0.377
q_R	0.313
R	0.829

X_F	4.3 kg/m ³
SAFE	
SST min Area:	532 m ²
R	0.689
q_A	0.439
q_R	0.303
R	0.689

X_F	5.3 kg/m ³
SAFE	
SST min Area:	832 m ²
R	1.012
q_A	0.313
q_R	0.313
R	1.012

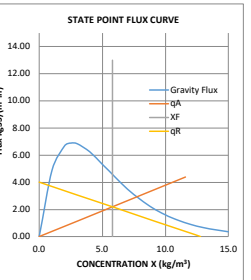
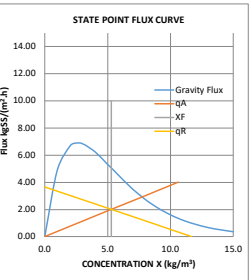
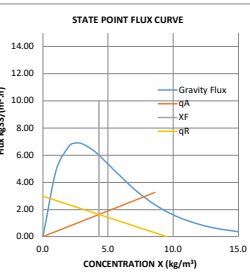
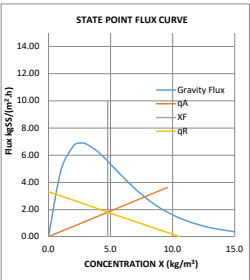
X_F	5.8 kg/m ³
SAFE	
SST min Area:	1108 m ²
R	1.225
q_A	0.257
q_R	0.313
R	1.225

X	q_A	q_R
0.000	0.000	3.296
4.776	1.802	1.802
9.552	3.604	0.308
X_A	10.536	3.975

X	q_A	q_R
0.000	0.000	2.967
4.300	1.622	1.622
8.600	3.244	0.277
X_A	9.486	3.579

X	q_A	q_R
0.000	0.000	3.657
5.300	1.999	1.999
10.600	3.999	0.342
X_A	11.692	4.411

X	q_A	q_R
0.000	0.000	4.002
5.800	2.188	2.188
11.600	4.376	0.374
X_A	12.796	4.827



SHC II	q_{Amax}
R	0
2.5	1.162

SHC II	q_{Amax}
R	0
2.5	1.392

SHC II	q_{Amax}
R	0
2.5	0.952

SHC II	q_{Amax}
R	0
2.5	0.788

APPLIED FLUX (SLR) 1.80 kgTSS/(m²·h)

APPLIED FLUX (SLR) 1.62 kgTSS/(m²·h)

APPLIED FLUX (SLR) 2.00 kgTSS/(m²·h)

APPLIED FLUX (SLR) 2.19 kgTSS/(m²·h)

SHC I

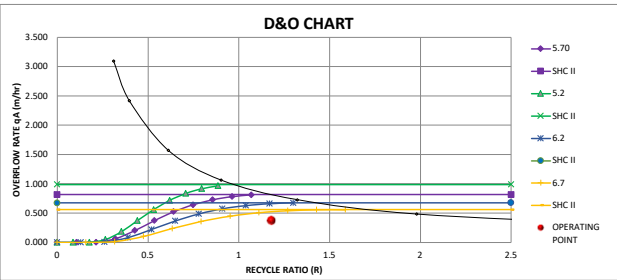
$$q_A = \frac{V_g}{R} \left(\frac{1+\alpha}{1-\alpha} \right) \exp \left[\frac{n(1-R)X_F(1+\alpha)}{2R} \right]$$

where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_F}}$

SHC II

$$q_{AmaxSHC II} = V_g e^{-\alpha X_F}$$

DSVI	120 ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)
SSVI	80.4 ml/g	
V_0/n	18.76 kgTSS/(m ² ·h)	
V_0	7.121 m ³ /h	
n	0.380 m ³ /kgTSS	
f_n	1.8432	
ADWF	741 m ³ /h	17.8 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	1365 m ³ /h	32.8 Ml/d
$Q_{applied}$	741 m ³ /h	17.8 Ml/d
Flux Rating	0.8	0% added to area for non-idealities
SST Area	1963 m ²	1963 m ²
SST diameter	25	
No. of SST's	4.0	
OPERATING POINT		
q_A	0.377 m/h	
q_R	0.444 m/h	
R	1.177 [Q_R/Q_A]	



X_f	5.70	kg/m ³
	SAFE	
SST min Area:	905	m ²
	0.000	0.819
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.107	0.906	0.000
0.214	0.821	0.005
0.321	0.742	0.064
0.428	0.668	0.204
0.535	0.596	0.372
0.642	0.526	0.525
0.749	0.456	0.644
0.856	0.383	0.728
0.963	0.304	0.782
1.070	0.210	0.811
R_{crit}	1.177	0.000

X	q_A	q_R
0.000	0.000	4.680 kgSS/(m ² ·h)
5.697	2.149	2.149 kgSS/(m ² ·h)
11.395	4.299	-0.381 kgSS/(m ² ·h)
X_A	10.536	3.975

X_f	5.2 kg/m ³	
SAFE		
SST min Area:	749 m ²	
	#NUM!	#NUM!
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.089	0.914	0.000
0.177	0.834	0.003
0.266	0.758	0.050
0.354	0.685	0.186
0.443	0.615	0.375
0.532	0.545	0.562
0.620	0.474	0.719
0.709	0.400	0.838
0.797	0.318	0.919
0.886	0.220	0.969
R_{crit}	0.974	0.000

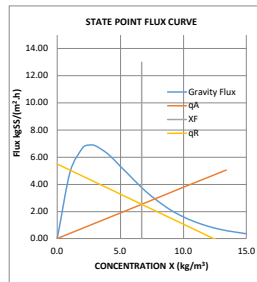
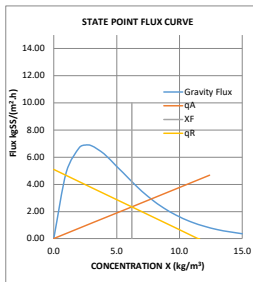
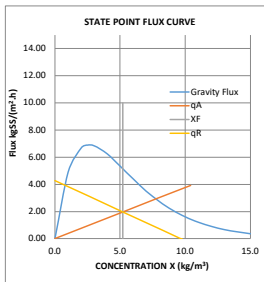
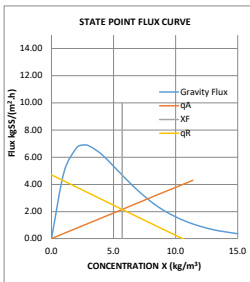
X	q_A	q_R
0.000	0.000	4.271 kgSS/(m ² ·h)
5.200	1.962	1.962 kgSS/(m ² ·h)
10.400	3.923	-0.348 kgSS/(m ² ·h)
X_A	9.617	3.628

X_f	6.2 kg/m ³	
SAFE		
SST min Area:	1117 m ²	
	0.285	0.663
SHC I		
R	α	q_a (m/hr)
	0	1.000 #DIV/0!
	0.130	0.897 0.000
	0.260	0.806 0.009
	0.390	0.723 0.082
	0.520	0.647 0.221
	0.650	0.575 0.367
	0.780	0.505 0.487
	0.910	0.436 0.574
	1.040	0.366 0.630
	1.170	0.289 0.662
	1.300	0.199 0.675
R_{crit}	1.430	0.000 0.674

X	q_A	q_R
0.000	0.000	5.093 kgSS/(m ² ·h)
6.200	2.339	2.339 kgSS/(m ² ·h)
12.400	4.678	-0.415 kgSS/(m ² ·h)
X_A	11.466	4.326

X_f	6.7 kg/m ³	
SST min Area:	SAFE 1413 m ²	
	0.387	0.524
SHC I		
R	α	q_a (m/hr)
	0	1.000 #DIV/0!
	0.159	0.886 0.000
	0.318	0.788 0.015
	0.476	0.702 0.104
	0.635	0.624 0.238
	0.794	0.551 0.359
	0.953	0.482 0.449
	1.111	0.415 0.508
	1.270	0.347 0.541
	1.429	0.274 0.557
	1.588	0.187 0.559
R_{crit}	1.746	0.000 0.552

X	q_A	q_R
0.000	0.000	5.504 kgSS/(m ² ·h)
6.700	2.528	2.528 kgSS/(m ² ·h)
13.400	5.055	-0.448 kgSS/(m ² ·h)
X_A	12.391	4.674



SHC II		
R	q_{Amax}	(m/hr)
0	0.819	
2.5	0.819	

APPLIED FLUX (SLR) 2.15 kgTSS/(m²·h)

SHC II		
R	q_{Amax}	(m/hr)
0	0.989	
2.5	0.989	

APPLIED FLUX (SLR) 1.96 kgTSS/(m²·h)

SHC II		
R	q_{Amax}	(m/hr)
0	0.677	
2.5	0.677	

APPLIED FLUX (SLR) 2.34 kgTSS/(m²·h)

SHC II		
R	q_{Amax}	(m/hr)
0	0.560	
2.5	0.560	

APPLIED FLUX (SLR) 2.53 kgTSS/(m²·h)

SHC I

$$q_A = \frac{V_0}{R} \left(\frac{1+\alpha}{1-\alpha} \right) \exp \left[\frac{n(1-R)X_F(1+\alpha)}{2R} \right]$$

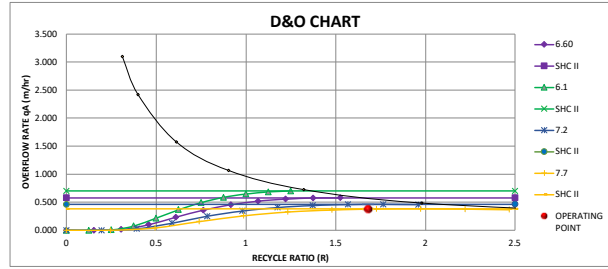
where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_F}}$

SHC II

$$q_{AmaxSHC II} = V_0 e^{-nX_F}$$

SST's - MLE Process @ 30 Days SRT

DSVI	120 ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)
SSVI	80.4 ml/g	
V_0/n	18.76 kgTSS/(m ² ·h)	
V_0	7.121 m/h	
n	0.380 m ³ /kgTSS	
f_n	1.8432	
ADWF	741 m ³ /h	17.8 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	1365 m ³ /h	32.8 Ml/d
$Q_{applied}$	741 m ³ /h	17.8 Ml/d
Flux Rating	0.8	0% added to area for non-idealities
SST Area	1963 m ²	1963 m ²
SST diameter	25	
No. of SST's	4.0	
OPERATING POINT		
q_A	0.377 m/h	
q_R	0.634 m/h	
R	1.679 (Q_R/Q_A)	



X_F	6.60 kg/m ³
X_F	SAFE
SST min Area:	1276 m ²
SHC I	
R	q_A (m/hr)
0	1.000
0.153	0.888
0.305	0.792
0.458	0.706
0.611	0.629
0.763	0.556
0.916	0.487
1.069	0.419
1.221	0.350
1.374	0.277
1.527	0.190
1.679	0.000

X	q_A	q_R
0.000	0.000	6.676 kgSS/(m ² ·h)
6.604	2.491	2.491 kgSS/(m ² ·h)
13.208	4.983	-1.693 kgSS/(m ² ·h)
X_R	10.536	3.975

X_F	6.1 kg/m ³
X_F	SAFE
SST min Area:	1054 m ²
SHC I	
R	q_A (m/hr)
0	1.000
0.125	0.899
0.250	0.809
0.375	0.727
0.500	0.651
0.625	0.579
0.750	0.510
0.875	0.440
1.000	0.369
1.125	0.293
1.250	0.201
1.375	0.000

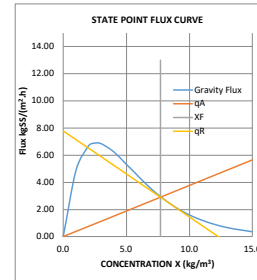
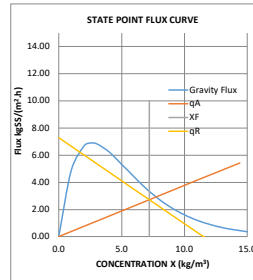
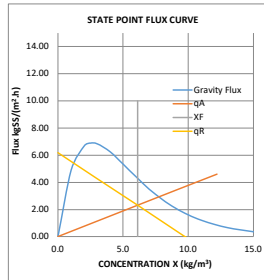
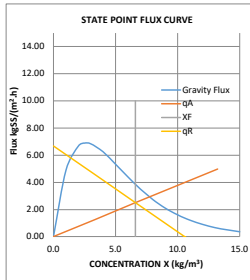
X	q_A	q_R
0.000	0.000	6.166 kgSS/(m ² ·h)
6.100	2.301	2.301 kgSS/(m ² ·h)
12.200	4.603	-1.564 kgSS/(m ² ·h)
X_R	9.732	3.671

X_F	7.2 kg/m ³
X_F	SAFE
SST min Area:	1601 m ²
SHC I	
R	q_A (m/hr)
0	1.000
0.196	0.872
0.392	0.767
0.589	0.677
0.785	0.597
0.981	0.525
1.177	0.457
1.373	0.391
1.569	0.326
1.766	0.256
1.962	0.175
2.158	0.000

X	q_A	q_R
0.000	0.000	7.278 kgSS/(m ² ·h)
7.200	2.716	2.716 kgSS/(m ² ·h)
14.400	5.432	-1.846 kgSS/(m ² ·h)
X_R	11.487	4.334

X_F	7.7 kg/m ³
X_F	SAFE
SST min Area:	1960 m ²
SHC I	
R	q_A (m/hr)
0	1.000
0.247	0.854
0.494	0.740
0.740	0.646
0.987	0.566
1.234	0.494
1.481	0.428
1.728	0.365
1.974	0.303
2.221	0.238
2.468	0.162
2.715	0.000

X	q_A	q_R
0.000	0.000	7.784 kgSS/(m ² ·h)
7.700	2.905	2.905 kgSS/(m ² ·h)
15.400	5.810	-1.974 kgSS/(m ² ·h)
X_R	12.285	4.635



SHC II	q_{Amax} (m/hr)
R	0
2.5	0.580

APPLIED FLUX (SLR) 2.49 kgTSS/(m²·h)

SHC II	q_{Amax} (m/hr)
R	0
2.5	0.703

APPLIED FLUX (SLR) 2.30 kgTSS/(m²·h)

SHC II	q_{Amax} (m/hr)
R	0
2.5	0.463

APPLIED FLUX (SLR) 2.72 kgTSS/(m²·h)

SHC II	q_{Amax} (m/hr)
R	0
2.5	0.383

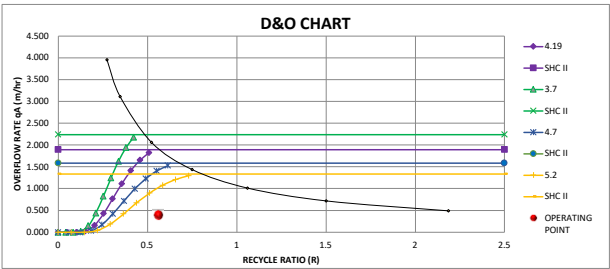
APPLIED FLUX (SLR) 2.90 kgTSS/(m²·h)

$$q_A = \frac{V_0}{R} \left(\frac{1+\alpha}{1-\alpha} \right) \exp \left[\frac{n(1-R)X_F(1+\alpha)}{2R} \right]$$

where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_F}}$

$$q_{AmaxSHC II} = V_0 e^{-\alpha X_F}$$

DSVI	100	ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)	
SSVI	67	ml/g		
V_0/n	23.24	kgTSS/(m ² ·h)		
V_0	7.974	m/h		
n	0.343	m ³ /kgTSS		
f_n	1.2288			
ADWF	810	m ³ /h	19.4	MI/d
PDWF		m ³ /h	23.9	MI/d
PWWF	996	m ³ /h	23.9	MI/d
			0.456	
$Q_{a,applied}$	810	m ³ /h	19.4	MI/d
			0.560	453.7
Flux Rating	0.8		25% added to area for non-idealities	
SST Area	2016	m ²	2519 m ²	
SST diameter	32.7			
No. of SST's	3			
OPERATING POINT				
q_A	0.402	m/h		
q_R	0.225	m/h		
R	0.560	$[Q_R/Q_A]$		



X_F	4.19	kg/m ³
SAFE		
SST min Area: 427 m ²		
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.051	0.930	0.000
0.102	0.862	0.001
0.153	0.794	0.027
0.204	0.727	0.163
0.255	0.659	0.430
0.305	0.590	0.770
0.356	0.518	1.113
0.407	0.440	1.414
0.458	0.353	1.654
0.509	0.245	1.826
R_{crit}	0.560	0.000

X	q_A	q_R
0.000	0.000	2.625
4.186	1.682	1.682
8.371	3.365	0.740
X_A	11.660	4.687

X_F	3.7	kg/m ³
SAFE		
SST min Area: 362 m ²		
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.042	0.934	0.000
0.085	0.869	0.000
0.127	0.803	0.022
0.169	0.738	0.152
0.211	0.671	0.439
0.254	0.602	0.830
0.296	0.530	1.247
0.338	0.451	1.629
0.380	0.363	1.943
0.423	0.253	2.177
R_{crit}	0.465	0.000

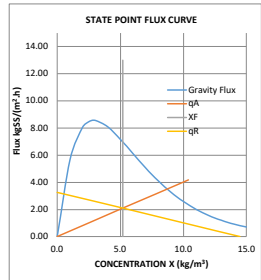
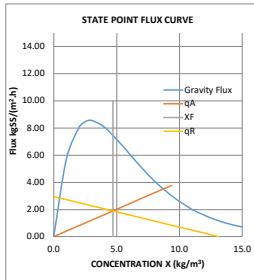
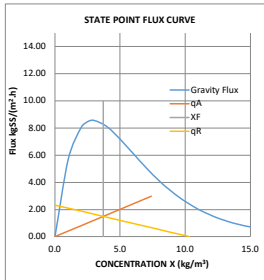
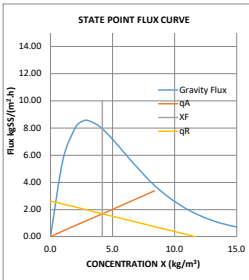
X	q_A	q_R
0.000	0.000	2.320
3.700	1.487	1.487
7.400	2.975	0.654
X_A	10.308	4.143

X_F	4.7	kg/m ³
SAFE		
SST min Area: 568 m ²		
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.061	0.925	0.000
0.123	0.854	0.001
0.184	0.784	0.034
0.246	0.715	0.176
0.307	0.646	0.425
0.368	0.576	0.717
0.430	0.504	0.996
0.491	0.428	1.230
0.552	0.342	1.408
0.614	0.237	1.531
R_{crit}	0.675	0.000

X	q_A	q_R
0.000	0.000	2.947
4.700	1.889	1.889
9.400	3.778	0.831
X_A	13.094	5.263

X_F	5.2	kg/m ³
SAFE		
SST min Area: 792 m ²		
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.073	0.920	0.000
0.146	0.845	0.002
0.220	0.772	0.043
0.293	0.702	0.191
0.366	0.632	0.422
0.439	0.562	0.673
0.512	0.490	0.899
0.585	0.415	1.080
0.659	0.331	1.212
0.732	0.229	1.298
R_{crit}	0.805	0.000

X	q_A	q_R
0.000	0.000	3.261
5.200	2.090	2.090
10.400	4.180	0.920
X_A	14.487	5.823



SHC II		
R	$q_{A,max}$	(m/hr)
0	1.897	
2.5	1.897	
APPLIED FLUX (SLR)		
1.68 kgTSS/(m ² ·h)		

SHC II		
R	$q_{A,max}$	(m/hr)
0	2.241	
2.5	2.241	
APPLIED FLUX (SLR)		
1.49 kgTSS/(m ² ·h)		

SHC II		
R	$q_{A,max}$	(m/hr)
0	1.590	
2.5	1.590	
APPLIED FLUX (SLR)		
1.89 kgTSS/(m ² ·h)		

SHC II		
R	$q_{A,max}$	(m/hr)
0	1.340	
2.5	1.340	
APPLIED FLUX (SLR)		
2.09 kgTSS/(m ² ·h)		

SHC I

$$q_A = \frac{V_0}{R} \left(\frac{1+\alpha}{1-\alpha} \right) \exp \left[\frac{n(1-R)X_F(1+\alpha)}{2R} \right]$$

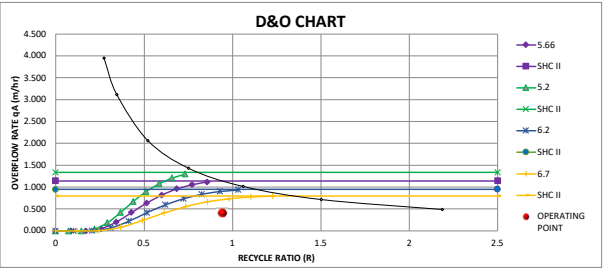
where

$$\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_F}}$$

SHC II

$$q_{A,maxSHC II} = V_0 e^{-nX_F}$$

DSVI	100	ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)	
SSVI	67	ml/g		
V_0/n	23.24	kgTSS/(m ² ·h)		
V_0	7.974	m ³ /h		
n	0.343	m ³ /kgTSS		
f_n	1.2288			
ADWF	810	m ³ /h	19.4	MI/d
PDWF		m ³ /h	MI/d	
PWWF	996	m ³ /h	23.9	MI/d
$Q_{applied}$	810	m ³ /h	19.4	MI/d
			Recycle Ratio R	Q_R m ³ /hr
			0.943	764.1
			0.767	
			0.943	764.1
Flux Rating	0.8		25% added to area for non-idealities	
SST Area	2016	m ²	2519 m ²	
SST diameter	32.7			
No. of SST's	3			
OPERATING POINT				
q_A	0.402	m/h		
q_R	0.379	m/h		
R	0.943	$[Q_A/Q_R]$		



X_F	5.66	kg/m ³
SAFE		
SST min Area:	708	m ²
R	0.943	1.144
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.086	0.915	0.000
0.171	0.836	0.003
0.257	0.761	0.054
0.343	0.688	0.206
0.429	0.618	0.420
0.514	0.548	0.636
0.600	0.477	0.821
0.686	0.402	0.961
0.772	0.320	1.058
0.857	0.221	1.118
R_{crit}	0.943	0.000

X	q_A	q_R
0.000	0.000	4.420
5.659	2.275	2.275
11.319	4.550	0.130
X_A	11.660	4.687

X_F	5.2	kg/m ³
SAFE		
SST min Area:	605	m ²
R	0.805	1.341
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.073	0.920	0.000
0.146	0.845	0.002
0.220	0.772	0.043
0.293	0.702	0.191
0.366	0.632	0.422
0.439	0.562	0.673
0.512	0.490	0.899
0.585	0.415	1.080
0.659	0.331	1.212
0.732	0.229	1.298
R_{crit}	0.805	0.000

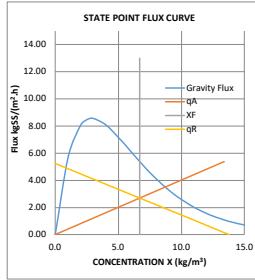
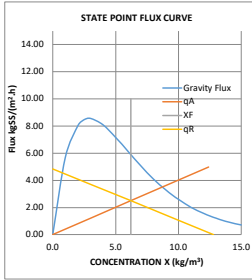
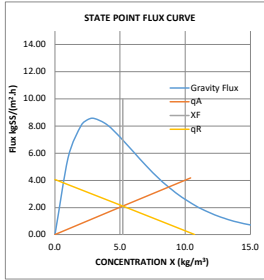
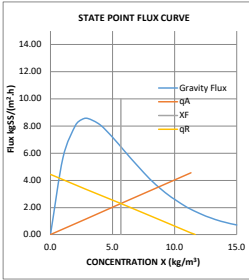
X	q_A	q_R
0.000	0.000	4.061
5.200	2.090	2.090
10.400	4.180	0.119
X_A	10.714	4.307

X_F	6.3	kg/m ³
SAFE		
SST min Area:	891	m ²
R	0.951	0.951
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.103	0.908	0.000
0.206	0.824	0.005
0.310	0.745	0.069
0.413	0.671	0.224
0.516	0.600	0.417
0.619	0.530	0.595
0.723	0.459	0.737
0.826	0.386	0.838
0.929	0.307	0.903
1.032	0.212	0.939
R_{crit}	1.135	0.000

X	q_A	q_R
0.000	0.000	4.842
6.200	2.492	2.492
12.400	4.984	0.142
X_A	12.774	5.135

X_F	6.7	kg/m ³
SAFE		
SST min Area:	1130	m ²
R	0.801	0.717
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.123	0.900	0.000
0.246	0.810	0.008
0.368	0.729	0.086
0.491	0.653	0.242
0.614	0.581	0.413
0.737	0.512	0.558
0.860	0.442	0.665
0.982	0.371	0.736
1.105	0.294	0.778
1.228	0.202	0.798
R_{crit}	1.351	0.000

X	q_A	q_R
0.000	0.000	5.233
6.700	2.693	2.693
13.400	5.386	0.153
X_A	13.804	5.549



SHC II		
R	q_{Amax}	(m/hr)
0	1.144	
2.5	1.144	
APPLIED FLUX (SLR)	2.27	kgTSS/(m ² ·h)

$$q_A = \frac{V_g}{R} \left(\frac{1+\alpha}{1-\alpha} \right) \exp \left[\frac{n(1-R)X_F(1+\alpha)}{2R} \right]$$

where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_F}}$

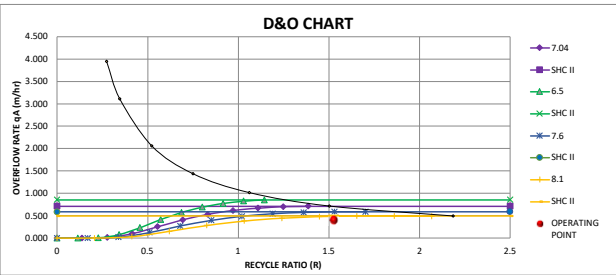
SHC II		
R	q_{Amax}	(m/hr)
0	1.340	
2.5	1.340	
APPLIED FLUX (SLR)	2.09	kgTSS/(m ² ·h)

$$q_{AmaxSHC II} = V_g e^{-\alpha X_F}$$

SHC II		
R	q_{Amax}	(m/hr)
0	0.951	
2.5	0.951	
APPLIED FLUX (SLR)	2.49	kgTSS/(m ² ·h)

SHC II		
R	q_{Amax}	(m/hr)
0	0.801	
2.5	0.801	
APPLIED FLUX (SLR)	2.69	kgTSS/(m ² ·h)

DSVI	100 ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)
SSVI	67 ml/g	
V_0/n	23.24 kgTSS/(m ² ·h)	
V_0	7.974 m ³ /h	
n	0.343 m ³ /kgTSS	
f_n	1.2288	
ADWF	810 m ³ /h	19.4 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	996 m ³ /h	23.9 Ml/d
$Q_{a,applied}$	810 m ³ /h	19.4 Ml/d
Recycle Ratio R	Q_R m ³ /hr	1.526 1236.1
Flux Rating	0.8	25% added to area for non-idealities
SST Area	2016 m ²	2519 m ²
SST diameter	32.7	
No. of SST's	3	
OPERATING POINT		
q_A	0.402 m/h	
q_R	0.613 m/h	
R	1.526 (Q_R/Q_A)	



X_f	7.04	kg/m ³
	SAFE	
SST min Area:	1138 m ²	
	0.000	0.707
SHC I		
R	α	q_A (m/hr)
	0	1.000
	0.139	0.894
	0.277	0.800
	0.416	0.717
	0.555	0.640
	0.693	0.568
	0.832	0.498
	0.971	0.430
	1.110	0.360
	1.248	0.284
	1.387	0.195
R_{crit}	1.526	0.000

X	q_A	q_R
0.000	0.000	7.151 kgSS/(m ² ·h)
7.044	2.831	2.831 kgSS/(m ² ·h)
14.087	5.663	-1.488 kgSS/(m ² ·h)
X_A	11.660	4.687 0.000 kgSS/(m ² ·h)

X_f	6.5 kg/m ³
	SAFE
SST min Area:	945 m ²
	#NUM!
	#NUM!
SHC I	
R	α
0	1.000
0.115	0.903
0.229	0.816
0.344	0.736
0.458	0.661
0.573	0.589
0.687	0.519
0.802	0.449
0.916	0.377
1.031	0.299
1.145	0.206
R_{crit}	1.260

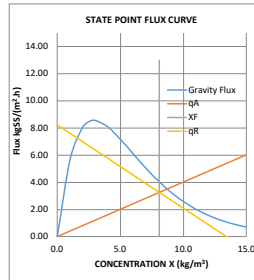
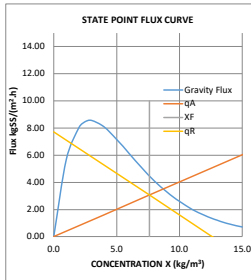
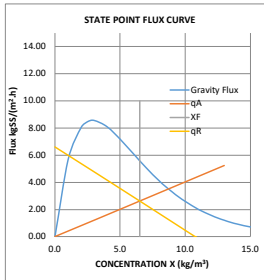
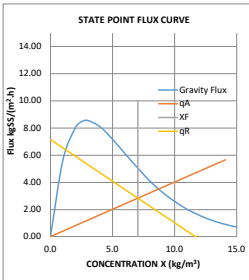
X	q_A	q_R
0.000	0.000	6.599 kgSS/(m ² ·h)
6.500	2.613	2.613 kgSS/(m ² ·h)
13.000	5.226	-1.373 kgSS/(m ² ·h)
X_A	10.760	4.325 0.000 kgSS/(m ² ·h)

X_f	7.6	kg/m ³
	SAFE	
SST min Area:	1381	m ²
	0.271	0.587
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.170	0.881	0.000
0.340	0.781	0.020
0.510	0.694	0.126
0.681	0.615	0.272
0.851	0.543	0.398
1.021	0.474	0.488
1.191	0.407	0.544
1.361	0.340	0.575
1.531	0.268	0.587
1.702	0.183	0.586
R_{crit}	1.872	0.000
		0.577

X	q_A	q_R
0.000	0.000	7.716 kgSS/(m ² ·h)
7.600	3.055	3.055 kgSS/(m ² ·h)
15.200	6.110	-1.606 kgSS/(m ² ·h)
X_A	12.581	5.057 0.000 kgSS/(m ² ·h)

X_F	8.1 kg/m ³	
SAFE		
SST min Area:	1665 m ²	
	0.000	0.007
SHC I		
R	α	q_A (m/hr)
	0	1.000
	0.207	0.868
	0.414	0.761
	0.620	0.670
	0.827	0.590
	1.034	0.518
	1.241	0.450
	1.448	0.385
	1.655	0.321
	1.861	0.252
	2.068	0.172
R_{crit}	2.275	0.000

X	q_A	q_R
0.000	0.000	8.223 kgSS/(m ² ·h)
8.100	3.256	3.256 kgSS/(m ² ·h)
16.200	6.512	-1.711 kgSS/(m ² ·h)
X_A	13.409	5.390 0.000 kgSS/(m ² ·h)



SHC II		
R	$q_{A,max}$	(m/hr)
0	0.712	
2.5	0.712	
APPLIED FLUX (SLR)	2.83 kgTSS/(m ² ·h)	

$$q_A = \frac{V_F}{R} \left(\frac{1+\alpha}{1-\alpha} \right) \exp \left[\frac{n(1-R)X_F(1+\alpha)}{2R} \right]$$

where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_F}}$

SHC II		
R	$q_{A,max}$	(m/hr)
0	0.858	
2.5	0.858	
APPLIED FLUX (SLR)	2.61 kgTSS/(m ² ·h)	

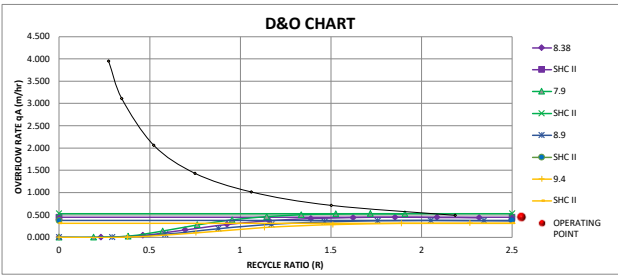
$$q_{A,maxSHC II} = V_F e^{-\alpha X_F}$$

SHC II		
R	$q_{A,max}$	(m/hr)
0	0.588	
2.5	0.588	
APPLIED FLUX (SLR)	3.05 kgTSS/(m ² ·h)	

SHC II		
R	$q_{A,max}$	(m/hr)
0	0.495	
2.5	0.495	
APPLIED FLUX (SLR)	3.26 kgTSS/(m ² ·h)	

SST's - UCT Process @ 25 Days SRT

DSVI	100 ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)
SSVI	67 ml/g	
V_0/n	23.24 kgTSS/(m ² ·h)	
V_0	7.974 m/h	
n	0.343 m ³ /kgTSS	
f_n	1.2288	
ADWF	926 m ³ /h	22.2 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	1138 m ³ /h	27.3 Ml/d
$Q_{applied}$	926 m ³ /h	22.2 Ml/d
Flux Rating	0.8	25% added to area for non-idealities
SST Area	2016 m ²	2519 m ²
SST diameter	32.7	
No. of SST's	3	
OPERATING POINT		
q_A	0.459 m/h	
q_R	1.171 m/h	
R	2.550 [Q _A /Q _R]	



X_F	8.38 kg/m ³	FAIL
SST min Area: 2054 m ²		
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.232	0.859	0.000
0.464	0.748	0.043
0.695	0.655	0.167
0.927	0.575	0.289
1.159	0.503	0.373
1.391	0.436	0.421
1.622	0.372	0.444
1.854	0.309	0.451
2.086	0.243	0.447
2.318	0.166	0.437
R_{crit}	2.550	0.000

X	q_A	q_R
0.000	0.000	13.657 kgSS/(m ² ·h)
8.375	3.848	3.848 kgSS/(m ² ·h)
16.751	7.695	-5.962 kgSS/(m ² ·h)
X_A	11.660	5.357

X_F	7.9 kg/m ³	SAFE
SST min Area: 1745 m ²		
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.191	0.874	0.000
0.382	0.769	0.027
0.573	0.680	0.141
0.764	0.601	0.280
0.955	0.528	0.390
1.146	0.460	0.463
1.337	0.394	0.505
1.528	0.328	0.525
1.719	0.259	0.531
1.910	0.177	0.526
R_{crit}	2.101	0.000

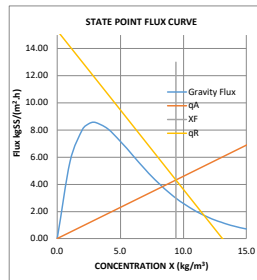
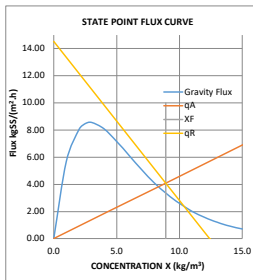
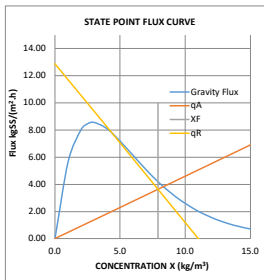
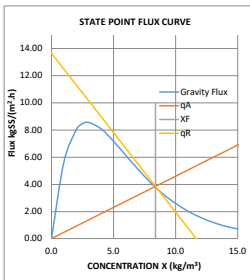
X	q_A	q_R
0.000	0.000	12.882 kgSS/(m ² ·h)
7.900	3.629	3.629 kgSS/(m ² ·h)
15.800	7.258	-5.624 kgSS/(m ² ·h)
X_A	10.999	5.053

X_F	8.0 kg/m ³	FAIL
SST min Area: 2531 m ²		
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.293	0.838	0.001
0.586	0.718	0.069
0.879	0.622	0.196
1.172	0.541	0.292
1.466	0.470	0.346
1.759	0.406	0.370
2.052	0.345	0.376
2.345	0.286	0.372
2.638	0.224	0.362
2.931	0.152	0.349
R_{crit}	3.224	0.000

X	q_A	q_R
0.000	0.000	14.512 kgSS/(m ² ·h)
8.900	4.089	4.089 kgSS/(m ² ·h)
17.800	8.177	-6.335 kgSS/(m ² ·h)
X_A	12.391	5.692

X_F	9.4 kg/m ³	FAIL
SST min Area: 2952 m ²		
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.378	0.812	0.005
0.756	0.683	0.103
1.134	0.584	0.219
1.512	0.503	0.285
1.890	0.434	0.312
2.268	0.373	0.317
2.646	0.316	0.312
3.024	0.260	0.301
3.402	0.203	0.288
3.781	0.138	0.274
R_{crit}	4.159	0.000

X	q_A	q_R
0.000	0.000	15.328 kgSS/(m ² ·h)
9.400	4.318	4.318 kgSS/(m ² ·h)
18.800	8.636	-6.691 kgSS/(m ² ·h)
X_A	13.087	6.012



SHC II		
R	q_{Amax}	(m/hr)
0	0.451	
2.5	0.451	

APPLIED FLUX (SLR) 3.85 kgTSS/(m²·h)

SHC II		
R	q_{Amax}	(m/hr)
0	0.531	
2.5	0.531	

APPLIED FLUX (SLR) 3.63 kgTSS/(m²·h)

SHC II		
R	q_{Amax}	(m/hr)
0	0.376	
2.5	0.376	

APPLIED FLUX (SLR) 4.09 kgTSS/(m²·h)

SHC II		
R	q_{Amax}	(m/hr)
0	0.317	
2.5	0.317	

APPLIED FLUX (SLR) 4.32 kgTSS/(m²·h)

SHC I

$$q_A = \frac{V_g (1 + \alpha)}{R (1 - \alpha)} \exp \left[\frac{n(1-R)X_F(1+\alpha)}{2R} \right]$$

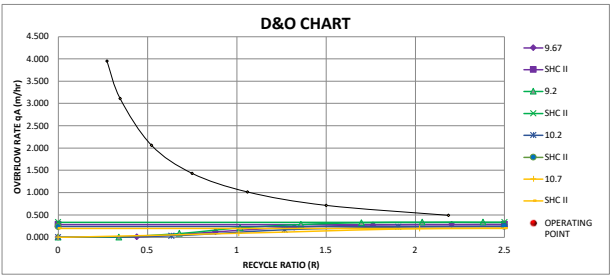
where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_F}}$

SHC II

$$q_{AmaxSHC II} = V_g e^{-\alpha X_F}$$

SST's - UCT Process @ 30 Days SRT

DSVI	100 ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)
SSVI	67 ml/g	
V_0/n	23.24 kgTSS/(m ² ·h)	
V_0	7.974 m/h	
n	0.343 m ³ /kgTSS	
f_n	2	
ADWF	926 m ³ /h	22.2 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	1852 m ³ /h	44.4 Ml/d
$Q_{applied}$	926 m ³ /h	22.2 Ml/d
Flux Rating	0.8	25% added to area for non-idealities
SST Area	2016 m ²	2519 m ²
SST diameter	32.7	
No. of SST's	3	
OPERATING POINT		
q_A	0.459 m/h	
q_R	2.228 m/h	
R	4.850 [Q_R/Q_A]	



X_f	9.67	kg/m ³
	FAIL	
SST min Area:	3200 m ²	
	0.000	0.222
SHC I		
R	α	q_A (m/hr)
	0	#DIV/0!
	0.441	0.009
	0.882	0.124
	1.323	0.228
	1.764	0.275
	2.205	0.289
	2.646	0.286
	3.087	0.276
	3.528	0.263
	3.968	0.250
	4.409	0.236
R_{crit}	4.850	0.222

X	q_A	q_R
0.000	0.000	25.982 kgSS/(m ² ·h)
9.667	4.441	4.441 kgSS/(m ² ·h)
19.335	8.882	-17.100 kgSS/(m ² ·h)
X_A	11.660	5.357

X_f	9.2	kg/m ³
SST min Area:	2726 m ²	
	FAIL	
	#NUM!	#NUM!
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.340	0.824	0.003
0.680	0.698	0.088
1.020	0.600	0.211
1.360	0.519	0.289
1.700	0.449	0.327
2.040	0.387	0.339
2.380	0.328	0.338
2.719	0.271	0.329
3.059	0.212	0.317
3.399	0.144	0.303
R_{crit}	3.739	0.000

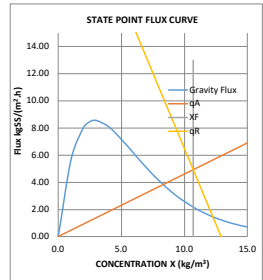
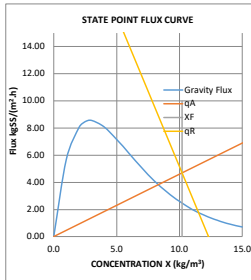
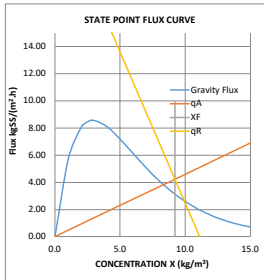
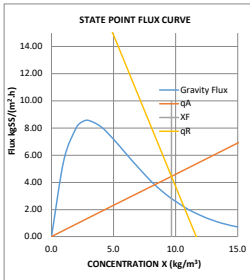
X	q_A	q_R
0.000	0.000	24.726 kgSS/(m ² ·h)
9.200	4.226	4.226 kgSS/(m ² ·h)
18.400	8.453	-16.273 kgSS/(m ² ·h)
X_A	11.097	5.098

X_f	10.2	kg/m ³
	FAIL	
SST min Area:	4726	m ²
	0.229	0.196
SHC I		
R	α	q_A (m/hr)
	0	1.000
	0.635	0.746
	1.270	0.600
	1.905	0.500
	2.540	0.424
	3.175	0.361
	3.810	0.307
	4.445	0.258
	5.080	0.212
	5.715	0.165
	6.349	0.111
R_{crit}	6.984	0.000

X	q_A	q_R
0.000	0.000	27.413 kgSS/(m ² ·h)
10.200	4.686	4.686 kgSS/(m ² ·h)
20.400	9.372	-18.042 kgSS/(m ² ·h)
X_A	12.303	5.652

X_F	10.7	kg/m ³
	FAIL	
SST min Area:	5391	m ²
	0.311	0.172
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
1.013	0.672	0.090
2.026	0.520	0.193
3.039	0.424	0.201
4.051	0.355	0.186
5.064	0.300	0.168
6.077	0.253	0.151
7.090	0.212	0.137
8.103	0.173	0.124
9.116	0.134	0.114
10.128	0.090	0.105
R_{crit}	11.141	0.000
	0.097	

X	q_A	q_R
0.000	0.000	28.757 kgSS/(m ² ·h)
10.700	4.915	4.915 kgSS/(m ² ·h)
21.400	9.831	-18.926 kgSS/(m ² ·h)
X_A	12.906	5.929



SHC II	
R	q_{Amax} (m/hr)
0	0.289
2.5	0.289

APPLIED FLUX (SLR) 4.44 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	0.340
2.5	0.340

APPLIED FLUX (SLR) 4.23 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	0.241
2.5	0.241

APPLIED FLUX (SLR) 4.69 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	0.203
2.5	0.203

APPLIED FLUX (SLR) 4.92 kgTSS/(m²·h)

SHC I

$$q_A = \frac{V_p}{R} \left(\frac{1+\alpha}{1-\alpha} \right) \exp \left[\frac{n(1-R)X_F(1+\alpha)}{2R} \right]$$

where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_F}}$

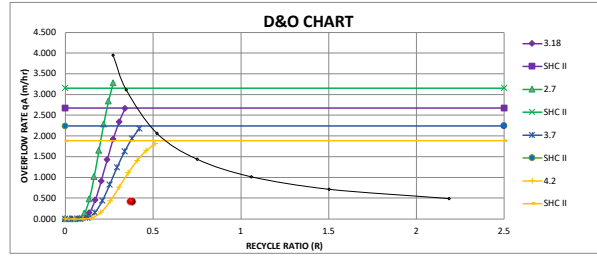
SHC II

$$q_{AmaxSHC II} = V_p e^{-nX_F}$$

**Annexure B6 – SST Capacity Check for Influent
Flow of 45 ML/d**

SST's - MLE Process @ 10 Days SRT

DSVI	100 ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)
SSVI	67 ml/g	
V_0/n	23.24 kgTSS/(m ² ·h)	
V_0	7.974 m/h	
n	0.343 m ³ /kgTSS	
f_n	1.8432	
ADWF	833 m ³ /h	20.0 MI/d
PDWF	m ³ /h	MI/d
PWWF	1536 m ³ /h	36.9 MI/d
$Q_{applied}$	833 m ³ /h	20.0 MI/d
Flux Rating	0.8	0% added to area for non-idealities
SST Area	1963 m ²	1963 m ²
SST diameter	25	
No. of SST's	4.0	
OPERATING POINT		
q_A	0.424 m/h	
q_R	0.159 m/h	
R	0.375 [Q_R/Q_A]	



X_F	3.18 kg/m ³
SAFE	
SST min Area:	311 m ²
R	0.375
SHC I	
R	α
0	1.000
0.034	0.938
0.068	0.875
0.102	0.812
0.137	0.748
0.171	0.683
0.205	0.614
0.239	0.542
0.273	0.463
0.307	0.373
0.341	0.260
0.375	0.000

X	q_A	q_R
0.000	0.000	1.858
3.183	1.351	1.351
6.365	2.701	0.844
X_A	11.660	4.949

X_F	2.7 kg/m ³
SAFE	
SST min Area:	264 m ²
R	0.301
SHC I	
R	α
0	1.000
0.027	0.941
0.055	0.881
0.082	0.820
0.110	0.757
0.137	0.693
0.164	0.625
0.192	0.552
0.219	0.473
0.247	0.382
0.274	0.267
0.301	0.000

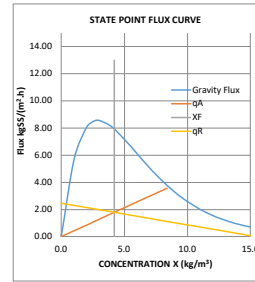
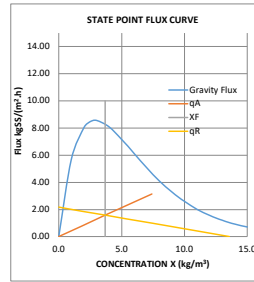
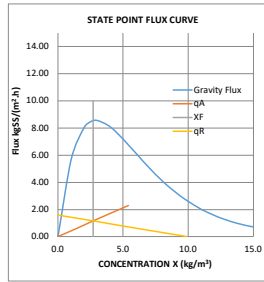
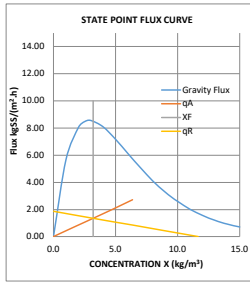
X	q_A	q_R
0.000	0.000	1.576
2.700	1.146	1.146
5.400	2.292	0.716
X_A	9.892	4.198

X_F	3.7 kg/m ³
SAFE	
SST min Area:	436 m ²
R	0.465
SHC I	
R	α
0	1.000
0.042	0.934
0.085	0.869
0.127	0.803
0.169	0.738
0.211	0.671
0.254	0.602
0.296	0.530
0.338	0.451
0.380	0.363
0.423	0.253
0.465	0.000

X	q_A	q_R
0.000	0.000	2.160
3.700	1.570	1.570
7.400	3.141	0.981
X_A	13.556	5.753

X_F	4.2 kg/m ³
SAFE	
SST min Area:	685 m ²
R	0.563
SHC I	
R	α
0	1.000
0.051	0.930
0.102	0.862
0.154	0.794
0.205	0.727
0.256	0.659
0.307	0.590
0.358	0.517
0.409	0.440
0.461	0.353
0.512	0.245
0.563	0.000

X	q_A	q_R
0.000	0.000	2.452
4.200	1.783	1.783
8.400	3.565	1.113
X_A	15.388	6.531



SHC II	
R	q_{Amax}
0	2.676
2.5	2.676

APPLIED FLUX (SLR) 1.35 kgTSS/(m²·h)

SHC II	
R	q_{Amax}
0	3.158
2.5	3.158

APPLIED FLUX (SLR) 1.15 kgTSS/(m²·h)

SHC II	
R	q_{Amax}
0	2.241
2.5	2.241

APPLIED FLUX (SLR) 1.57 kgTSS/(m²·h)

SHC II	
R	q_{Amax}
0	1.888
2.5	1.888

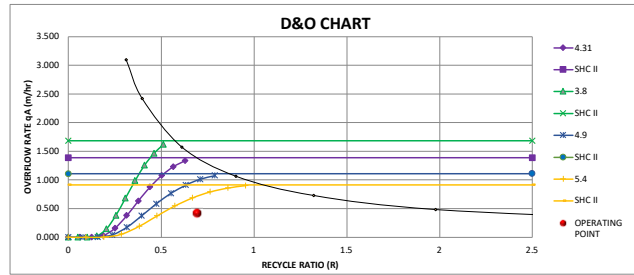
APPLIED FLUX (SLR) 1.78 kgTSS/(m²·h)

$$q_A = \frac{V_0}{R} \left(\frac{1+\alpha}{1-\alpha} \right) \exp \left[\frac{n(1-R)X_F(1+\alpha)}{2R} \right]$$

where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_F}}$

$$q_{AmaxSHC II} = V_0 e^{-nX_F}$$

DSVI	120 ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)
SSVI	80.4 ml/g	
V_0/n	18.76 kgTSS/(m ² ·h)	
V_0	7.121 m/h	
n	0.380 m ³ /kgTSS	
f_n	1.8432	
ADWF	833 m ³ /h	20.0 MI/d
PWWF	m ³ /h	MI/d
PWWF	1536 m ³ /h	36.9 MI/d
$Q_{applied}$	833 m ³ /h	20.0 MI/d
Flux Rating	0.8	0% added to area for non-idealities
SST Area	1963 m ²	1963 m ²
SST diameter	25	
No. of SST's	4.0	
OPERATING POINT		
q_A	0.424 m/h	
q_R	0.293 m/h	
R	0.691 [Q_R/Q_A]	



X_f	4.31	kg/m ³
	SAFE	
SST min Area:	600 m ²	
	0.00%	1.394
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.063	0.925	0.000
0.126	0.853	0.001
0.189	0.782	0.032
0.251	0.713	0.159
0.314	0.644	0.379
0.377	0.575	0.635
0.440	0.503	0.877
0.503	0.426	1.079
0.566	0.341	1.232
0.629	0.236	1.337
R_{crit}	0.691	0.000
	0.000	1.394

X	q_A	q_R
0.000	0.000	3.092 kgSS/(m ² ·h)
4.307	1.828	1.828 kgSS/(m ² ·h)
8.614	3.656	0.564 kgSS/(m ² ·h)
X_A	10.536	4.472

X_p	3.8	kg/m ³
SAFE		
SST min Area:	495	m ²
#DIV/0!		#DIV/0!
SHC I		
R	α	q_A (m/hr)
	0	#DIV/0!
	0.051	0.930
	0.103	0.861
	0.154	0.794
	0.205	0.727
	0.256	0.659
	0.308	0.590
	0.359	0.517
	0.410	0.440
	0.462	0.353
	0.513	0.245
R_{crit}	0.564	0.000

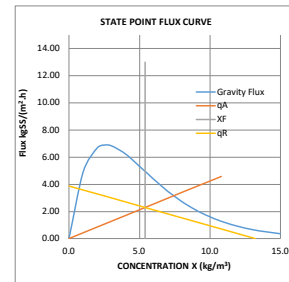
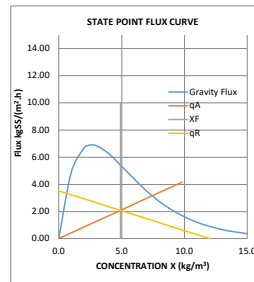
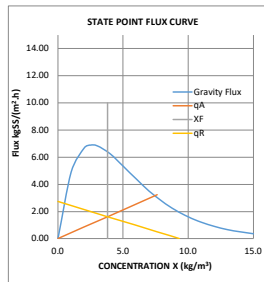
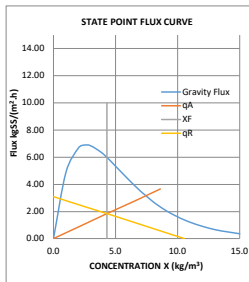
X	q_A	q_R
0.000	0.000	2.728 kgSS/(m ² ·h)
3.800	1.613	1.613 kgSS/(m ² ·h)
7.600	3.226	0.498 kgSS/(m ² ·h)
X_A	9.296	3.945

X _p	4.9	kg/m ³
SAFE		
SST min Area:	841	m ²
	0.345	0.99
SHC I		
R	α	q _A (m/hr)
	0	1.000
	0.079	0.918
	0.158	0.841
	0.237	0.767
	0.316	0.695
	0.395	0.625
	0.474	0.555
	0.553	0.484
	0.632	0.409
	0.711	0.326
	0.790	0.225
crit	0.869	0.000

X	q_A	q_R
0.000	0.000	3.518 kgSS/(m ² ·h)
4.900	2.080	2.080 kgSS/(m ² ·h)
9.800	4.159	0.642 kgSS/(m ² ·h)
X_A	11.986	5.087

X _e	5.4 kg/m ³	
	SAFE	
SST min Area:	1164 m ²	
	0.43%	0.73%
SHC I		
R	α	q _A (m/hr)
	0	#DIV/0!
	0.096	0.911
	0.191	0.829
	0.287	0.752
	0.382	0.679
	0.478	0.608
	0.573	0.537
	0.669	0.467
	0.765	0.393
	0.860	0.313
	0.956	0.216
R _{crit}	1.051	0.000

X	q_A	q_R
0.000	0.000	3.877 kgSS/(m ² ·h)
5.400	2.292	2.292 kgSS/(m ² ·h)
10.800	4.584	0.707 kgSS/(m ² ·h)
X_A	13.210	5.606



SHC II	
R	q_{Amax} (m/hr)
0	1.388
2.5	1.388

APPLIED FLUX (SLR) 1.83 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	1.683
2.5	1.683

APPLIED FLUX (SLR) 1.61 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	1.108
2.5	1.108

APPLIED FLUX (SLR) 2.08 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	0.917
2.5	0.917

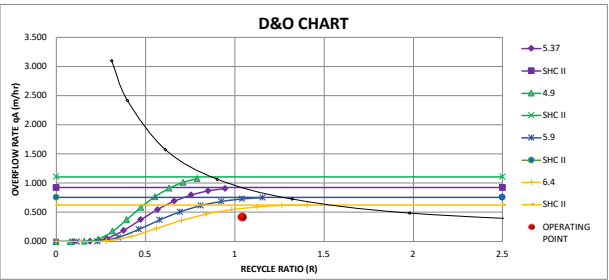
APPLIED FLUX (SLR) 2.29 kgTSS/(m²·h)

$$q_A = \frac{V_p}{R} \left(\frac{1+\alpha}{1-\alpha} \right) \exp \left[\frac{n(1-R)X_p(1+\alpha)}{2R} \right]$$

where $\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_p}}$

$$q_{AmaxSHC II} = V_p e^{-nX_p}$$

DSVI	120 ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)
SSVI	80.4 ml/g	
V_0/n	18.76 kgTSS/(m ² ·h)	
V_0	7.121 m ³ /h	
n	0.380 m ³ /kgTSS	
f_n	1.8432	
ADWF	833 m ³ /h	20.0 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	1536 m ³ /h	36.9 Ml/d
$Q_{applied}$	833 m ³ /h	20.0 Ml/d
Recycle Ratio R	Q_R m ³ /hr	1.041 867.1
Flux Rating	0.8	0% added to area for non-idealities
SST Area	1963 m ²	1963 m ²
SST diameter	25	
No. of SST's	4.0	
OPERATING POINT		
q_A	0.424 m/h	
q_R	0.442 m/h	
R	1.041 [Q_R/Q_A]	



X_f	5.37	kg/m ³
	SAFE	
SST min Area:	900 m ²	
	0.000	0.926
SHC I		
R	α	q_A (m/hr)
	0	1.000
	0.095	0.911
	0.189	0.829
	0.284	0.753
	0.378	0.679
	0.473	0.609
	0.568	0.538
	0.662	0.468
	0.757	0.394
	0.851	0.313
	0.946	0.216
R_{crit}	1.041	0.000

X	q_A	q_R
0.000	0.000	4.653 kgSS/(m ² ·h)
5.373	2.280	2.280 kgSS/(m ² ·h)
10.746	4.561	-0.093 kgSS/(m ² ·h)
X_A	10.536	4.472 0.000

X_f	4.9	kg/m ³
SST min Area:	SAFE	752 m ²
	#NUM!	#NUM!
SHC I		
R	α	q_A (m/hr)
0	1.000	#DIV/0!
0.079	0.918	0.000
0.158	0.841	0.002
0.237	0.767	0.043
0.316	0.695	0.177
0.395	0.625	0.376
0.474	0.555	0.585
0.553	0.484	0.768
0.632	0.409	0.911
0.711	0.326	1.013
0.790	0.225	1.078
R_{crit}	0.869	1.105

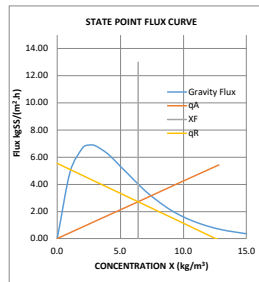
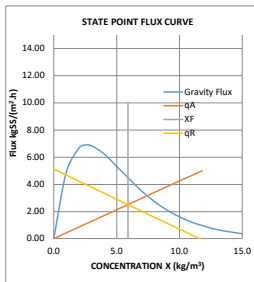
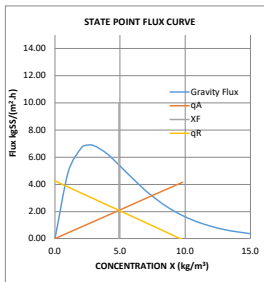
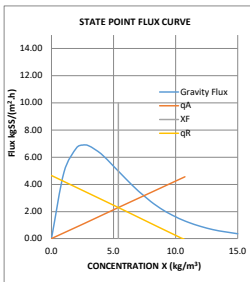
X	q_A	q_R
0.000	0.000	4.244 kgSS/(m ² ·h)
4.900	2.080	2.080 kgSS/(m ² ·h)
9.800	4.159	-0.084 kgSS/(m ² ·h)
X_A	9.609	4.078 0.000

X_f	5.9 kg/m ³	
	SAFE	
SST min Area:	1139 m ²	
	0.299	0.733
SHC I		
R	α	q_a (m/hr)
	0	1.000 #DIV/0!
	0.116	0.903 0.000
	0.231	0.815 0.006
	0.347	0.735 0.071
	0.463	0.660 0.211
	0.578	0.588 0.370
	0.694	0.518 0.510
	0.810	0.448 0.615
	0.925	0.376 0.687
	1.041	0.298 0.732
	1.157	0.205 0.754
R_{crit}	1.273	0.000 0.757

X	q_A	q_R
0.000	0.000	5.110 kgSS/(m ² ·h)
5.900	2.504	2.504 kgSS/(m ² ·h)
11.800	5.008	-0.102 kgSS/(m ² ·h)
X_A	11.570	4.910 0.000

X_f	6.4 kg/m ³	
SST min Area:	SAFE 1466 m ²	
	0.401	0.569
SHC I		
R	α	q_a (m/hr)
	0	1.000 #DIV/0!
	0.141	0.893 0.000
	0.281	0.799 0.011
	0.422	0.715 0.091
	0.563	0.638 0.228
	0.703	0.566 0.365
	0.844	0.496 0.472
	0.985	0.428 0.547
	1.125	0.358 0.594
	1.266	0.283 0.618
	1.407	0.194 0.627
R_{crit}	1.547	0.000 0.623

X	q_A	q_R
0.000	0.000	5.543 kgSS/(m ² ·h)
6.400	2.716	2.716 kgSS/(m ² ·h)
12.800	5.432	-0.110 kgSS/(m ² ·h)
X_A	12.550	5.327 0.000



SHC II	
R	q_{Amax} (m/hr)
0	0.926
2.5	0.926

APPLIED FLUX (SLR) 2.28 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	1.108
2.5	1.108

APPLIED FLUX (SLR) 2.08 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	0.758
2.5	0.758

APPLIED FLUX (SLR) 2.50 kgTSS/(m²·h)

SHC II	
R	q_{Amax} (m/hr)
0	0.627
2.5	0.627

APPLIED FLUX (SLR) 2.72 kgTSS/(m²·h)

SHC I

$$q_A = \frac{V_g}{R} \left(\frac{1+\alpha}{1-\alpha} \right) \exp \left[\frac{n(1-R)X_F(1+\alpha)}{2R} \right]$$

where

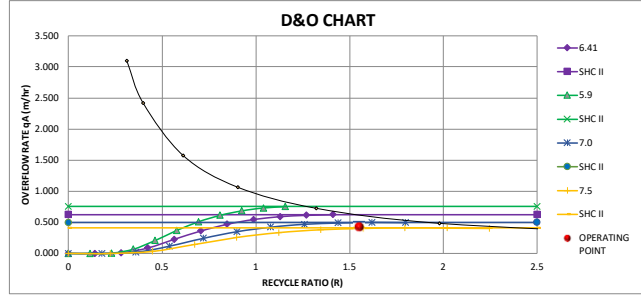
$$\alpha = \sqrt{1 - \frac{4R}{n(1+R)X_F}}$$

SHC II

$$q_{AmaxSHC II} = V_g e^{-nX_F}$$

SST's - MLE Process @ 25 Days SRT

DSVI	120 ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)
SSVI	80.4 ml/g	
V_0/n	18.76 kgTSS/(m ² .h)	
V_0	7.121 m/h	
n	0.380 m ³ /kgTSS	
fn	1.8432	
ADWF	833 m ³ /h	20.0 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	1536 m ³ /h	36.9 Ml/d
$Q_{applied}$	833 m ³ /h	20.0 Ml/d
Flux Rating	0.8	0% added to area for non-idealities
SST Area	1963 m ²	1963 m ²
SST diameter	25	
No. of SST's	4.0	
OPERATING POINT		
q_k	0.424 m/h	
q_b	0.659 m/h	
R	1.553 [Q_0/Q_k]	

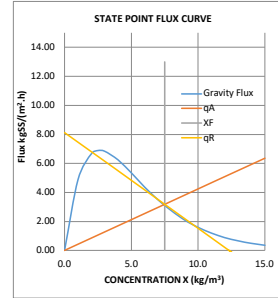
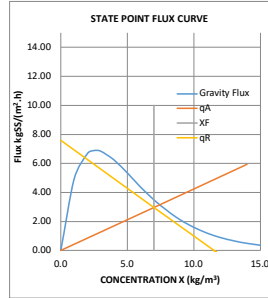
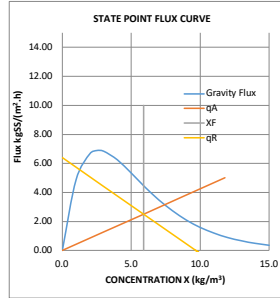
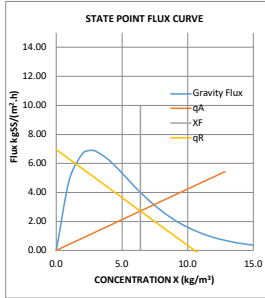


X_r	6.41	kg/m ³
SST min Area:	1334 m ²	
SHC I		
R	α	q_k (m/hr)
0	1.000	#DIV/0!
0.141	0.893	0.000
0.282	0.799	0.011
0.424	0.715	0.091
0.565	0.638	0.228
0.706	0.565	0.364
0.847	0.496	0.472
0.988	0.428	0.546
1.130	0.358	0.592
1.271	0.283	0.616
1.412	0.194	0.625
R_{crit}	1.553	0.000
X	q_k	q_b
0.000	0.000	6.945 kgSS/(m ² .h)
6.410	2.720	2.720 kgSS/(m ² .h)
12.819	5.441	-1.505 kgSS/(m ² .h)
X_r	10.536	4.472

X_r	5.9	kg/m ³
SST min Area:	1099 m ²	
SHC I		
R	α	q_k (m/hr)
0	1.000	#DIV/0!
0.116	0.903	0.000
0.231	0.815	0.006
0.347	0.735	0.071
0.463	0.660	0.211
0.578	0.588	0.370
0.694	0.518	0.510
0.810	0.448	0.615
0.925	0.376	0.687
1.041	0.298	0.732
1.157	0.205	0.754
R_{crit}	1.273	0.000
X	q_k	q_b
0.000	0.000	6.393 kgSS/(m ² .h)
5.900	2.504	2.504 kgSS/(m ² .h)
11.800	5.008	-1.385 kgSS/(m ² .h)
X_r	9.699	4.116

X_r	7.0	kg/m ³
SST min Area:	1674 m ²	
SHC I		
R	α	q_k (m/hr)
0	1.000	#DIV/0!
0.180	0.878	0.000
0.360	0.776	0.021
0.540	0.687	0.119
0.720	0.608	0.246
0.900	0.536	0.352
1.080	0.468	0.425
1.260	0.401	0.469
1.440	0.334	0.491
1.620	0.263	0.496
1.799	0.180	0.497
R_{crit}	1.979	0.000
X	q_k	q_b
0.000	0.000	7.585 kgSS/(m ² .h)
7.000	2.971	2.971 kgSS/(m ² .h)
14.000	5.942	-1.643 kgSS/(m ² .h)
X_r	11.507	4.884

X_r	7.5	kg/m ³
SST min Area:	2063 m ²	
SHC I		
R	α	q_k (m/hr)
0	1.000	#DIV/0!
0.225	0.862	0.000
0.449	0.751	0.036
0.674	0.659	0.145
0.898	0.579	0.257
1.123	0.507	0.336
1.347	0.440	0.382
1.572	0.376	0.405
1.796	0.312	0.413
2.021	0.245	0.411
2.245	0.167	0.403
R_{crit}	2.470	0.000
X	q_k	q_b
0.000	0.000	8.127 kgSS/(m ² .h)
7.500	3.183	3.183 kgSS/(m ² .h)
15.000	6.366	-1.761 kgSS/(m ² .h)
X_r	12.329	5.233



SHC II		
R	q_{amax} (m/hr)	
0	0.625	
2.5	0.625	
APPLIED FLUX (SLR)	2.72 kgTSS/(m ² .h)	

SHC II		
R	q_{amax} (m/hr)	
0	0.758	
2.5	0.758	
APPLIED FLUX (SLR)	2.50 kgTSS/(m ² .h)	

SHC II		
R	q_{amax} (m/hr)	
0	0.499	
2.5	0.499	
APPLIED FLUX (SLR)	2.97 kgTSS/(m ² .h)	

SHC II		
R	q_{amax} (m/hr)	
0	0.413	
2.5	0.413	
APPLIED FLUX (SLR)	3.18 kgTSS/(m ² .h)	

SHC I

$$q_A = \frac{V_0}{R} \frac{(1+\alpha)}{(1-\alpha)} \exp \left[\frac{-n(1-R)X_r(1+\alpha)}{2R} \right]$$

where

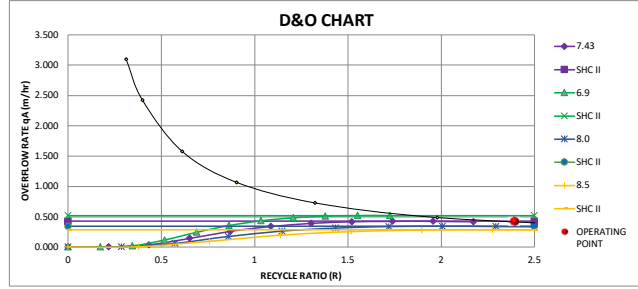
$$\alpha = \frac{1 - \frac{4R}{n(1+R)X_r}}{2}$$

SHC II

$$q_{AmaxSHC II} = V_0 e^{-nX_r}$$

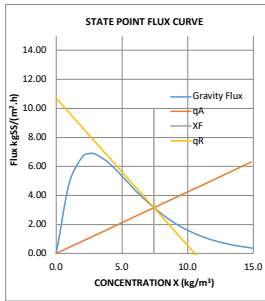
SST's - MLE Process @ 30 Days SRT

DSVI	120 ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)
SSVI	80.4 ml/g	
V_0/n	18.76 kgTSS/(m ² .h)	
V_0	7.121 m/h	
n	0.380 m ³ /kgTSS	
fn	1.8432	
ADWF	833 m ³ /h	20.0 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	1536 m ³ /h	36.9 Ml/d
$Q_{applied}$	833 m ³ /h	20.0 Ml/d
Flux Rating	0.8	0% added to area for non-idealities
SST Area	1963 m ²	1963 m ²
SST diameter	25	
No. of SST's	4.0	
OPERATING POINT		
q_k	0.424 m/h	
q_b	1.015 m/h	
R	2.391 [Q_0/Q_k]	



X_r	7.43	kg/m ³
	FAIL	
SST min Area:	1964 m ²	
	0.000	0.4
SHC I		
R	α	q_k (m/hr)
0	1.000	#DIV/0!
0.217	0.864	0.000
0.435	0.755	0.033
0.652	0.663	0.142
0.870	0.583	0.256
1.087	0.511	0.338
1.304	0.444	0.388
1.522	0.380	0.414
1.739	0.316	0.424
1.957	0.248	0.423
2.174	0.169	0.415
R_{crit}	2.391	0.000 0.403

X	q_k	q_b
0.000	0.000	10.694 kgSS/(m ² .h)
7.430	3.153	3.153 kgSS/(m ² .h)
14.859	6.307	-4.388 kgSS/(m ² .h)
X_r	10.536	4.472 0.000 kgSS/(m ² .h)

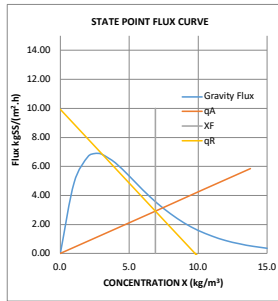


R	q_{amax} (m/hr)
0	0.424
2.5	0.424

APPLIED FLUX (SLR) 3.15 kgTSS/(m².h)

X_r	6.9	kg/m ³
SAFE		
SST min Area:	1607	m ²
	#DIV/0!	#DIV/0!
SHC I		
R	α	q_k (m/hr)
0	1.000	#DIV/0!
0.172	0.881	0.000
0.345	0.780	0.019
0.517	0.692	0.114
0.690	0.614	0.243
0.862	0.541	0.355
1.035	0.473	0.433
1.207	0.406	0.482
1.380	0.339	0.508
1.552	0.267	0.518
1.725	0.183	0.517
R_{crit}	1.897	0.000
		0.508

X	q_k	q_b
0.000	0.000	9.932 kgSS/(m ² .h)
6.900	2.928	2.928 kgSS/(m ² .h)
13.800	5.857	-4.075 kgSS/(m ² .h)
X_r	9.785	4.153 0.000 kgSS/(m ² .h)

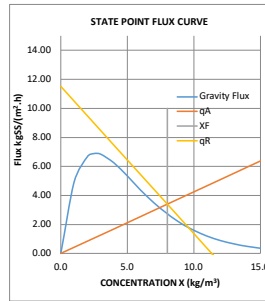


R	q_{amax} (m/hr)
0	0.519
2.5	0.519

APPLIED FLUX (SLR) 2.93 kgTSS/(m².h)

X_r	8.0	kg/m ³
SST min Area:	2479 m ²	
	0.267	0.331
SHC I		
R	α	q_k (m/hr)
0	1.000	#DIV/0!
0.287	0.841	0.001
0.573	0.721	0.059
0.860	0.625	0.173
1.147	0.544	0.261
1.434	0.473	0.312
1.720	0.409	0.335
2.007	0.348	0.342
2.294	0.288	0.339
2.581	0.225	0.330
2.867	0.153	0.319
R_{crit}	3.154	0.000 0.306

X	q_k	q_b
0.000	0.000	11.515 kgSS/(m ² .h)
8.000	3.395	3.395 kgSS/(m ² .h)
16.000	6.791	-4.724 kgSS/(m ² .h)
X_r	11.345	4.815 0.000 kgSS/(m ² .h)

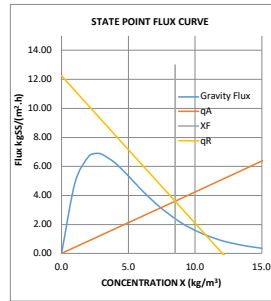


R	q_{amax} (m/hr)
0	0.342
2.5	0.342

APPLIED FLUX (SLR) 3.40 kgTSS/(m².h)

X_r	8.5	kg/m ³
SST min Area:	2958 m ²	
	0.355	0.2
SHC I		
R	α	q_a (m/hr)
	0	1.000 #DIV/0!
	0.379	0.812 0.004
	0.759	0.682 0.092
	1.138	0.583 0.196
	1.518	0.503 0.254
	1.897	0.434 0.278
	2.277	0.372 0.282
	2.656	0.315 0.277
	3.036	0.260 0.268
	3.415	0.203 0.256
	3.795	0.138 0.243
R_{crit}	4.174	0.000 0.231

X	q_k	q_b
0.000	0.000	12.235 kgSS/(m ² .h)
8.500	3.608	3.608 kgSS/(m ² .h)
17.000	7.215	-5.020 kgSS/(m ² .h)
X_r	12.054	5.116 0.000 kgSS/(m ² .h)



R	q_{amax} (m/hr)
0	0.283
2.5	0.283

APPLIED FLUX (SLR) 3.61 kgTSS/(m².h)

SHC I

$$q_A = \frac{V_0}{R} \frac{(1+\alpha)}{(1-\alpha)} \exp \left[\frac{-n(1-R)X_r(1+\alpha)}{2R} \right]$$

where

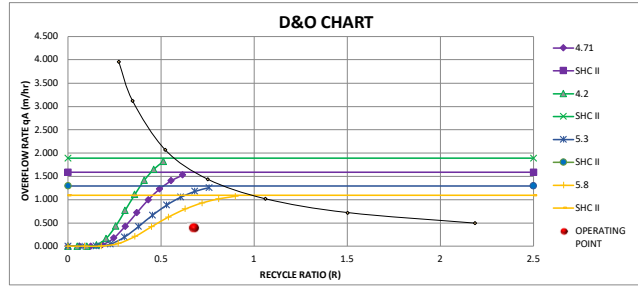
$$\alpha = \sqrt{1 - \frac{4R}{n(1-R)X_r}}$$

SHC II

$$q_{AmaxSHC II} = V_0 e^{-nX_r}$$

SST's - UCT Process @ 10 Days SRT

DSVI	100 ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)
SSVI	67 ml/g	
V_0/n	23.24 kgTSS/(m ² .h)	
V_0	7.974 m ³ /h	
n	0.343 m ³ /kgTSS	
fn	1.2288	
ADWF	810 m ³ /h	19.4 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	996 m ³ /h	23.9 Ml/d
$Q_{applied}$	810 m ³ /h	19.4 Ml/d
Flux Rating	0.8	25% added to area for non-idealities
SST Area	2016 m ²	2519 m ²
SST diameter	32.7	
No. of SST's	3	
OPERATING POINT		
q_k	0.402 m/h	
q_b	0.272 m/h	
R	0.677 [Q_b/Q_k]	

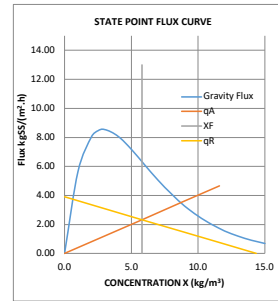
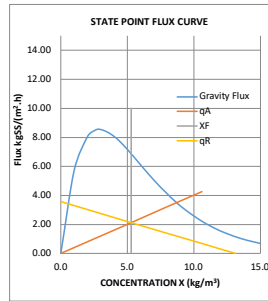
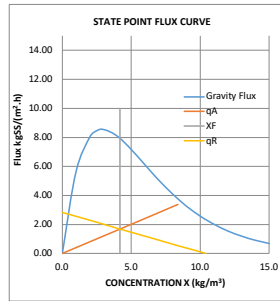
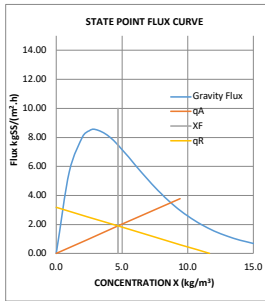


X_f	4.71	kg/m ³
SST min Area:	511 m ²	
	0.000	1.593
SHC I		
R	α	q_k (m/hr)
0	1.000	#DIV/0!
0.062	0.925	0.000
0.123	0.854	0.001
0.185	0.783	0.035
0.246	0.715	0.176
0.308	0.646	0.425
0.369	0.576	0.717
0.431	0.504	0.994
0.493	0.427	1.227
0.554	0.342	1.404
0.616	0.237	1.526
R_{crit}	0.677	0.000
X		
0.000	0.000	3.175 kgSS/(m ² .h)
4.709	1.893	1.893 kgSS/(m ² .h)
9.417	3.785	0.611 kgSS/(m ² .h)
X_c	11.660	4.687

X_f	4.2	kg/m ³
SST min Area:	429 m ²	
	0.000	1.593
SHC I		
R	α	q_k (m/hr)
0	1.000	#DIV/0!
0.051	0.930	0.000
0.102	0.862	0.001
0.154	0.794	0.027
0.205	0.727	0.163
0.256	0.659	0.430
0.307	0.590	0.768
0.358	0.517	1.109
0.409	0.440	1.409
0.461	0.353	1.646
0.512	0.245	1.816
R_{crit}	0.563	0.000
X		
0.000	0.000	2.832 kgSS/(m ² .h)
4.200	1.688	1.688 kgSS/(m ² .h)
8.400	3.377	0.545 kgSS/(m ² .h)
X_c	10.401	4.181

X_f	5.3	kg/m ³
SST min Area:	692 m ²	
	0.334	1.171
SHC I		
R	α	q_k (m/hr)
0	1.000	#DIV/0!
0.076	0.919	0.000
0.152	0.843	0.002
0.227	0.770	0.045
0.303	0.699	0.194
0.379	0.629	0.421
0.455	0.559	0.665
0.530	0.487	0.881
0.606	0.412	1.053
0.682	0.329	1.176
0.758	0.227	1.256
R_{crit}	0.833	0.000
X		
0.000	0.000	3.573 kgSS/(m ² .h)
5.300	2.130	2.130 kgSS/(m ² .h)
10.600	4.261	0.687 kgSS/(m ² .h)
X_c	13.125	5.276

X_f	5.8	kg/m ³
SST min Area:	929 m ²	
	0.434	0.872
SHC I		
R	α	q_k (m/hr)
0	1.000	#DIV/0!
0.090	0.913	0.000
0.180	0.833	0.003
0.270	0.757	0.057
0.360	0.684	0.210
0.450	0.613	0.419
0.540	0.543	0.626
0.630	0.472	0.798
0.720	0.398	0.927
0.810	0.317	1.016
0.900	0.219	1.069
R_{crit}	0.990	0.000
X		
0.000	0.000	3.911 kgSS/(m ² .h)
5.800	2.331	2.331 kgSS/(m ² .h)
11.600	4.663	0.752 kgSS/(m ² .h)
X_c	14.363	5.773



SHC II	
R	q_{amax} (m/hr)
0	1.585
2.5	1.585
APPLIED FLUX (SLR)	
	1.89 kgTSS/(m ² .h)

SHC II	
R	q_{amax} (m/hr)
0	1.888
2.5	1.888
APPLIED FLUX (SLR)	
	1.69 kgTSS/(m ² .h)

SHC II	
R	q_{amax} (m/hr)
0	1.294
2.5	1.294
APPLIED FLUX (SLR)	
	2.13 kgTSS/(m ² .h)

SHC II	
R	q_{amax} (m/hr)
0	1.090
2.5	1.090
APPLIED FLUX (SLR)	
	2.33 kgTSS/(m ² .h)

SHC I

$$q_A = \frac{V_0}{R} \frac{(1+\alpha)}{(1-\alpha)} \exp \left[\frac{-n(1-R)X_f(1+\alpha)}{2R} \right]$$

where

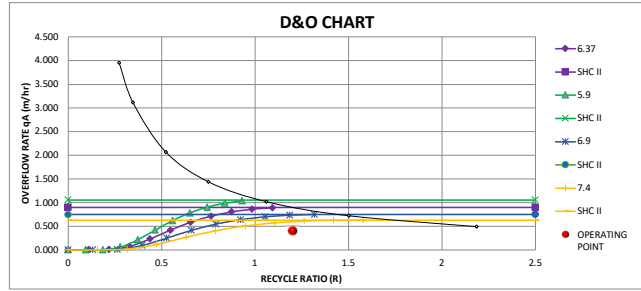
$$\alpha = \frac{1}{1 + \frac{4R}{n(1-R)X_f}}$$

SHC II

$$q_{amaxSHC II} = V_0 e^{-nX_f}$$

SST's - UCT Process @ 15 Days SRT

DSVI	100 ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)
SSVI	67 ml/g	
V_0/n	23.24 kgTSS/(m ² .h)	
V_0	7.974 m ³ /h	
n	0.343 m ³ /kgTSS	
f_n	1.2288	
ADWF	810 m ³ /h	19.4 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	996 m ³ /h	23.9 Ml/d
$Q_{applied}$	810 m ³ /h	19.4 Ml/d
Flux Rating	0.8	25% added to area for non-idealities
SST Area	2016 m ²	2519 m ²
SST diameter	32.7	
No. of SST's	3	
OPERATING POINT		
q_k	0.402 m/h	
q_b	0.483 m/h	
R	1.203 [Q_0/Q_k]	

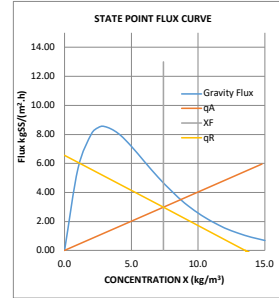
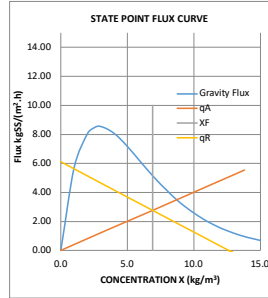
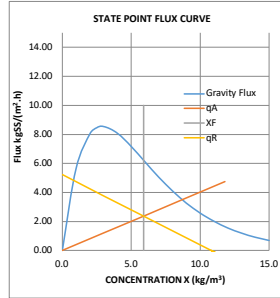
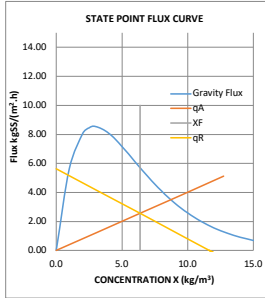


X_r	6.37	kg/m ³
SST min Area:	903 m ²	
	0.000 0.897	
SHC I		
R	α	q_k (m/hr)
0	1.000	#DIV/0!
0.109	0.905	0.000
0.219	0.819	0.006
0.328	0.740	0.074
0.437	0.665	0.230
0.547	0.594	0.416
0.656	0.524	0.583
0.765	0.454	0.712
0.875	0.381	0.803
0.984	0.303	0.860
1.093	0.208	0.890
R_{crit}	1.203	0.000 0.897
X		
	q_k	q_b
0.000	0.000	5.637 kgSS/(m ² .h)
6.367	2.559	2.559 kgSS/(m ² .h)
12.734	5.118	-0.519 kgSS/(m ² .h)
X_r	11.660	4.687 0.000 kgSS/(m ² .h)

X_r	5.9	kg/m ³
SST min Area:	769 m ²	
	#NULM! #NULM!	
SHC I		
R	α	q_k (m/hr)
0	1.000	#DIV/0!
0.093	0.912	0.000
0.186	0.831	0.003
0.279	0.754	0.060
0.372	0.681	0.214
0.466	0.610	0.419
0.559	0.540	0.618
0.652	0.469	0.782
0.745	0.395	0.904
0.838	0.315	0.986
0.931	0.217	1.035
R_{crit}	1.024	0.000 1.054
X		
	q_k	q_b
0.000	0.000	5.224 kgSS/(m ² .h)
5.900	2.372	2.372 kgSS/(m ² .h)
11.800	4.743	-0.481 kgSS/(m ² .h)
X_r	10.805	4.343 0.000 kgSS/(m ² .h)

X_r	6.9	kg/m ³
SST min Area:	1102 m ²	
	0.275 0.731	
SHC I		
R	α	q_k (m/hr)
0	1.000	#DIV/0!
0.132	0.896	0.000
0.264	0.805	0.010
0.395	0.722	0.094
0.527	0.646	0.249
0.659	0.573	0.411
0.791	0.504	0.543
0.922	0.435	0.637
1.054	0.364	0.698
1.186	0.288	0.732
1.318	0.198	0.747
R_{crit}	1.449	0.000 0.744
X		
	q_k	q_b
0.000	0.000	6.109 kgSS/(m ² .h)
6.900	2.774	2.774 kgSS/(m ² .h)
13.800	5.547	-0.562 kgSS/(m ² .h)
X_r	12.637	5.080 0.000 kgSS/(m ² .h)

X_r	7.4	kg/m ³
SST min Area:	1358 m ²	
	0.374 0.537	
SHC I		
R	α	q_k (m/hr)
0	1.000	#DIV/0!
0.158	0.886	0.000
0.316	0.789	0.017
0.474	0.702	0.116
0.632	0.625	0.266
0.790	0.552	0.403
0.947	0.483	0.504
1.105	0.416	0.570
1.263	0.347	0.609
1.421	0.274	0.626
1.579	0.188	0.629
R_{crit}	1.737	0.000 0.621
X		
	q_k	q_b
0.000	0.000	6.552 kgSS/(m ² .h)
7.400	2.975	2.975 kgSS/(m ² .h)
14.800	5.949	-0.603 kgSS/(m ² .h)
X_r	13.553	5.448 0.000 kgSS/(m ² .h)



SHC II	
R	q_{amax} (m/hr)
0	0.898
2.5	0.898
APPLIED FLUX (SLR)	
	2.56 kgTSS/(m ² .h)

SHC II	
R	q_{amax} (m/hr)
0	1.054
2.5	1.054
APPLIED FLUX (SLR)	
	2.37 kgTSS/(m ² .h)

SHC II	
R	q_{amax} (m/hr)
0	0.748
2.5	0.748
APPLIED FLUX (SLR)	
	2.77 kgTSS/(m ² .h)

SHC II	
R	q_{amax} (m/hr)
0	0.630
2.5	0.630
APPLIED FLUX (SLR)	
	2.97 kgTSS/(m ² .h)

SHC I

$$q_A = \frac{V_0}{R} \frac{(1+\alpha)}{(1-\alpha)} \exp \left[\frac{-n(1-R)X_r(1+\alpha)}{2R} \right]$$

where

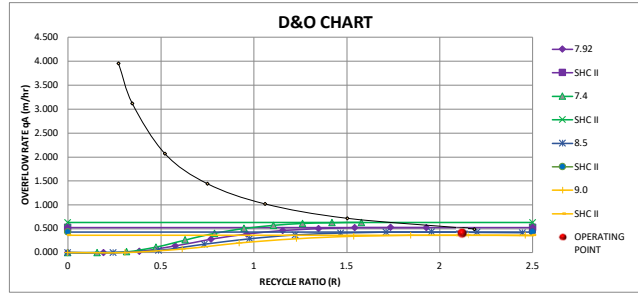
$$\alpha = \frac{1}{1 + \frac{4R}{n(1-R)X_r}}$$

SHC II

$$q_{AmaxSHC II} = V_0 e^{-nX_r}$$

SST's - UCT Process @ 20 Days SRT

DSVI	100 ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)
SSVI	67 ml/g	
V_0/n	23.24 kgTSS/(m ² .h)	
V_0	7.974 m ³ /h	
n	0.343 m ³ /kgTSS	
f_n	1.2288	
ADWF	810 m ³ /h	19.4 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	996 m ³ /h	23.9 Ml/d
$Q_{applied}$	810 m ³ /h	19.4 Ml/d
Flux Rating	0.8	25% added to area for non-idealities
SST Area	2016 m ²	2519 m ²
SST diameter	32.7	
No. of SST's	3	
OPERATING POINT		
q_k	0.402 m/h	
q_b	0.852 m/h	
R	2.121 [Q_0/Q_k]	



X_r	7.92	kg/m ³
SST min Area:	SAFE	1540 m ²
	0.000	0.509
SHC I		
R	α	q_k (m/hr)
0	1.000	#DIV/0!
0.193	0.873	0.000
0.386	0.768	0.028
0.578	0.679	0.142
0.771	0.599	0.280
0.964	0.527	0.389
1.157	0.459	0.461
1.350	0.393	0.502
1.542	0.328	0.521
1.735	0.258	0.526
1.928	0.176	0.521
R_{crit}	2.121	0.000

X	q_k	q_b
0.000	0.000	9.940 kgSS/(m ² .h)
7.924	3.185	3.185 kgSS/(m ² .h)
15.848	6.370	-3.570 kgSS/(m ² .h)
X_r	11.660	4.687

X_r	7.4	kg/m ³
SST min Area:	SAFE	1286 m ²
	#NULM!	#NULM!
SHC I		
R	α	q_k (m/hr)
0	1.000	#DIV/0!
0.158	0.886	0.000
0.316	0.789	0.017
0.474	0.702	0.116
0.632	0.625	0.266
0.790	0.552	0.403
0.947	0.483	0.504
1.105	0.416	0.570
1.263	0.347	0.609
1.421	0.274	0.626
1.579	0.188	0.629
R_{crit}	1.737	0.000

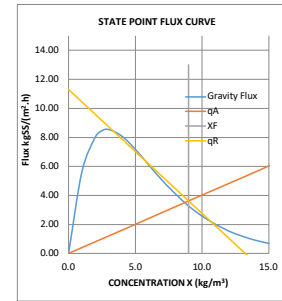
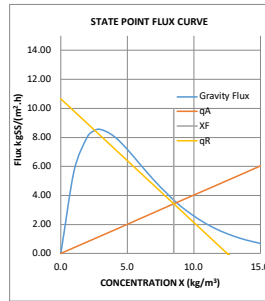
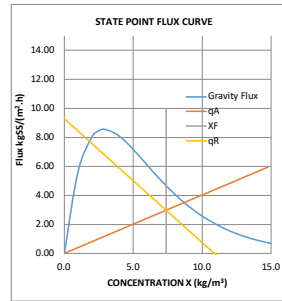
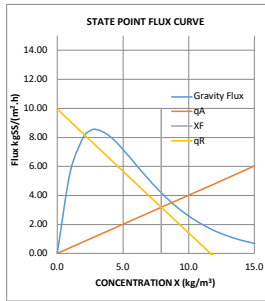
X	q_k	q_b
0.000	0.000	9.283 kgSS/(m ² .h)
7.400	2.975	2.975 kgSS/(m ² .h)
14.800	5.949	-3.334 kgSS/(m ² .h)
X_r	10.889	4.377

X_r	8.5	kg/m ³
SST min Area:	SAFE	1889 m ²
	0.260	0.420
SHC I		
R	α	q_k (m/hr)
0	1.000	#DIV/0!
0.245	0.855	0.000
0.489	0.741	0.048
0.734	0.648	0.174
0.978	0.567	0.291
1.223	0.495	0.367
1.467	0.429	0.409
1.712	0.366	0.428
1.956	0.304	0.432
2.201	0.238	0.426
2.445	0.162	0.416
R_{crit}	2.690	0.000

X	q_k	q_b
0.000	0.000	10.663 kgSS/(m ² .h)
8.500	3.417	3.417 kgSS/(m ² .h)
17.000	6.833	-3.829 kgSS/(m ² .h)
X_r	12.508	5.028

X_r	9.0	kg/m ³
SST min Area:	FAIL	2228 m ²
	0.340	0.364
SHC I		
R	α	q_k (m/hr)
0	1.000	#DIV/0!
0.308	0.834	0.002
0.615	0.712	0.075
0.923	0.615	0.201
1.230	0.534	0.292
1.538	0.464	0.340
1.845	0.400	0.360
2.153	0.340	0.364
2.460	0.281	0.358
2.768	0.220	0.347
3.075	0.149	0.334
R_{crit}	3.383	0.000

X	q_k	q_b
0.000	0.000	11.290 kgSS/(m ² .h)
9.000	3.618	3.618 kgSS/(m ² .h)
18.000	7.235	-4.055 kgSS/(m ² .h)
X_r	13.244	5.323



R	q_{amax} (m/hr)
0	0.526
2.5	0.526

APPLIED FLUX (SLR) 3.19 kgTSS/(m².h)

R	q_{amax} (m/hr)
0	0.630
2.5	0.630

APPLIED FLUX (SLR) 2.97 kgTSS/(m².h)

R	q_{amax} (m/hr)
0	0.432
2.5	0.432

APPLIED FLUX (SLR) 3.42 kgTSS/(m².h)

R	q_{amax} (m/hr)
0	0.364
2.5	0.364

APPLIED FLUX (SLR) 3.62 kgTSS/(m².h)

SHC I

$$q_A = \frac{V_0}{R} \frac{(1+\alpha)}{(1-\alpha)} \exp \left[\frac{-n(1-R)X_r(1+\alpha)}{2R} \right]$$

where

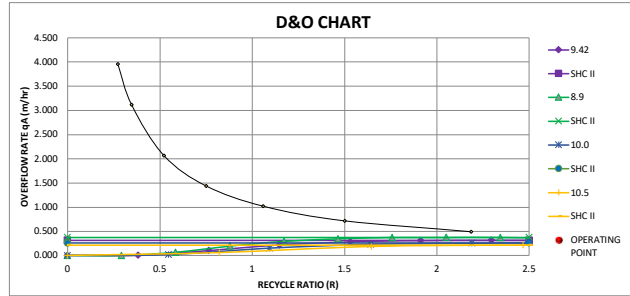
$$\alpha = \sqrt{1 - \frac{4R}{n(1-R)X_r}}$$

SHC II

$$q_{AmaxSHC II} = V_0 e^{-nX_r}$$

SST's - UCT Process @ 25 Days SRT

DSVI	100 ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)
SSVI	67 ml/g	
V_0/n	23.24 kgTSS/(m ² .h)	
V_0	7.974 m ³ /h	
n	0.343 m ³ /kgTSS	
f_n	1.2288	
ADWF	1042 m ³ /h	25.0 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	1280 m ³ /h	30.7 Ml/d
$Q_{applied}$	1042 m ³ /h	25.0 Ml/d
Flux Rating	0.8	25% added to area for non-idealities
SST Area	2016 m ²	2519 m ²
SST diameter	32.7	
No. of SST's	3	
OPERATING POINT		
q_k	0.517 m/h	
q_b	2.176 m/h	
R	4.210 [Q_0/Q_k]	



X_r	9.42 kg/m ³
SST min Area:	3310 m ²
	0.000 0.250
SHC I	
R	α q_k (m/hr)
0	1.000 #DIV/0!
0.383	0.811 0.005
0.765	0.681 0.104
1.148	0.582 0.220
1.531	0.501 0.284
1.914	0.433 0.310
2.296	0.371 0.315
2.679	0.314 0.309
3.062	0.259 0.298
3.444	0.202 0.284
3.827	0.137 0.270
R_{crit}	4.210 0.000 0.256

X	q_k	q_b
0.000	0.000	25.370 kgSS/(m ² .h)
9.422	4.870	4.870 kgSS/(m ² .h)
18.845	9.739	-15.631 kgSS/(m ² .h)
X_r	11.660	6.026 0.000 kgSS/(m ² .h)

X_r	8.9 kg/m ³
SST min Area:	2767 m ²
	#NULM! #NULM!
SHC I	
R	α q_k (m/hr)
0	1.000 #DIV/0!
0.293	0.838 0.001
0.586	0.718 0.069
0.879	0.622 0.196
1.172	0.541 0.292
1.466	0.470 0.346
1.759	0.406 0.370
2.052	0.345 0.376
2.345	0.286 0.372
2.638	0.224 0.362
2.931	0.152 0.349
R_{crit}	3.224 0.000 0.335

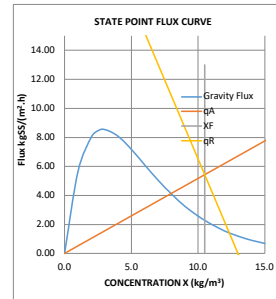
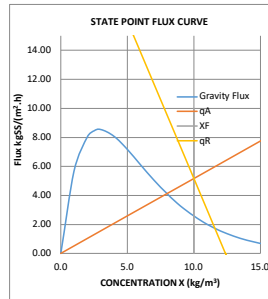
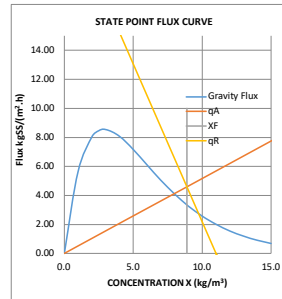
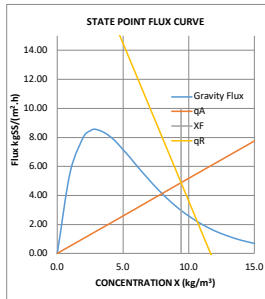
X	q_k	q_b
0.000	0.000	23.963 kgSS/(m ² .h)
8.900	4.600	4.600 kgSS/(m ² .h)
17.800	9.199	-14.764 kgSS/(m ² .h)
X_r	11.014	5.692 0.000 kgSS/(m ² .h)

X_r	10.0 kg/m ³
SST min Area:	4686 m ²
	0.240 0.222
SHC I	
R	α q_k (m/hr)
0	1.000 #DIV/0!
0.548	0.766 0.021
1.095	0.625 0.152
1.643	0.525 0.232
2.190	0.447 0.256
2.738	0.382 0.256
3.285	0.326 0.246
3.833	0.274 0.232
4.380	0.225 0.218
4.928	0.175 0.204
5.475	0.118 0.191
R_{crit}	6.023 0.000 0.179

X	q_k	q_b
0.000	0.000	26.925 kgSS/(m ² .h)
10.000	5.168	5.168 kgSS/(m ² .h)
20.000	10.336	-16.589 kgSS/(m ² .h)
X_r	12.375	6.396 0.000 kgSS/(m ² .h)

X_r	10.5 kg/m ³
SST min Area:	5370 m ²
	0.320 0.134
SHC I	
R	α q_k (m/hr)
0	1.000 #DIV/0!
0.823	0.706 0.062
1.645	0.556 0.188
2.468	0.458 0.217
3.290	0.385 0.211
4.113	0.327 0.196
4.936	0.277 0.180
5.758	0.232 0.164
6.581	0.190 0.151
7.403	0.147 0.139
8.226	0.099 0.128
R_{crit}	9.049 0.000 0.119

X	q_k	q_b
0.000	0.000	28.272 kgSS/(m ² .h)
10.500	5.427	5.427 kgSS/(m ² .h)
21.000	10.853	-17.418 kgSS/(m ² .h)
X_r	12.994	6.716 0.000 kgSS/(m ² .h)



SHC II	
R	q_{amax} (m/hr)
0	0.315
2.5	0.315
APPLIED FLUX (SLR)	4.87 kgTSS/(m ² .h)

SHC II	
R	q_{amax} (m/hr)
0	0.376
2.5	0.376
APPLIED FLUX (SLR)	4.60 kgTSS/(m ² .h)

SHC II	
R	q_{amax} (m/hr)
0	0.258
2.5	0.258
APPLIED FLUX (SLR)	5.17 kgTSS/(m ² .h)

SHC II	
R	q_{amax} (m/hr)
0	0.217
2.5	0.217
APPLIED FLUX (SLR)	5.43 kgTSS/(m ² .h)

$$q_A = \frac{V_0}{R} \frac{(1+\alpha)}{(1-\alpha)} \exp \left[\frac{-n(1-R)X_r(1+\alpha)}{2R} \right]$$

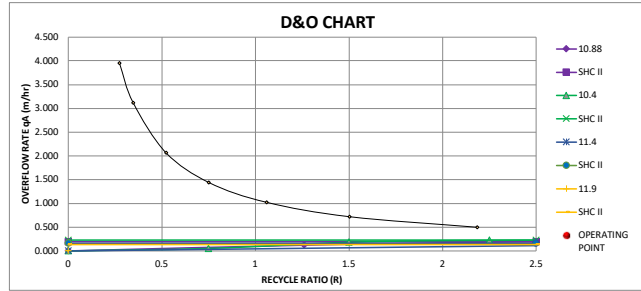
where

$$\alpha = \frac{1}{1 + \frac{4R}{n(1-R)X_r}}$$

$$q_{AmaxSHC II} = V_0 e^{-nX_r}$$

SST's - UCT Process @ 30 Days SRT

DSVI	100 ml/g	(Range 50-200ml/g; >150ml/g = bulking sludge)
SSVI	67 ml/g	
V_0/n	23.24 kgTSS/(m ² .h)	
V_0	7.974 m/h	
n	0.343 m ³ /kgTSS	
f_n	2	
ADWF	1042 m ³ /h	25.0 Ml/d
PDWF	m ³ /h	Ml/d
PWWF	2083 m ³ /h	50.0 Ml/d
$Q_{applied}$	1042 m ³ /h	25.0 Ml/d
Flux Rating	0.8	25% added to area for non-idealities
SST Area	2016 m ²	2519 m ²
SST diameter	32.7	
No. of SST's	3	
OPERATING POINT		
q_k	0.517 m/h	
q_k	7.163 m/h	
R	13.860 [Q_0/Q_k]	



X_r	10.88	kg/m ³
	FAIL	
SST min Area:	5499 m ²	
	0.001	0.0
SHC I		
R	α	q_k (m/hr)
		#DIV/0!
	0	1.000
	1.260	0.634
	2.520	0.482
	3.780	0.390
	5.040	0.325
	6.300	0.273
	7.560	0.230
	8.820	0.192
	10.080	0.157
	11.340	0.121
	12.600	0.082
R_{crit}	13.860	0.000

X	q_k	q_k
0.000	0.000	83.521 kgSS/(m ² .h)
10.876	5.621	5.621 kgSS/(m ² .h)
21.751	11.241	-72.280 kgSS/(m ² .h)
X_c	11.660	6.026

X_r	10.4	kg/m ³
FAIL		
SST min Area:	4629	m ²
	#DIV/0!	#DIV/0!
SHC I		
R	α	q_k (m/hr)
0	1.000	#DIV/0!
0.750	0.721	0.051
1.500	0.572	0.182
2.250	0.473	0.223
3.001	0.399	0.222
3.751	0.339	0.209
4.501	0.287	0.193
5.251	0.241	0.178
6.001	0.197	0.164
6.751	0.153	0.152
7.501	0.103	0.141
R_{crit}	8.251	0.000
		0.131

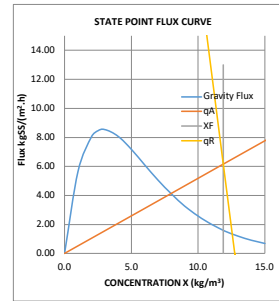
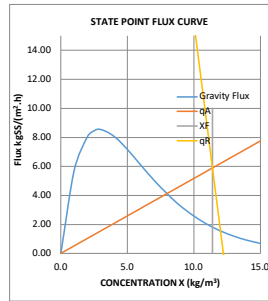
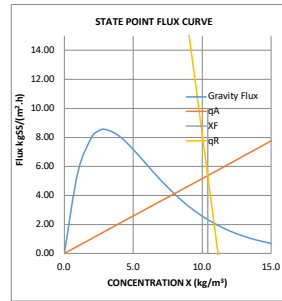
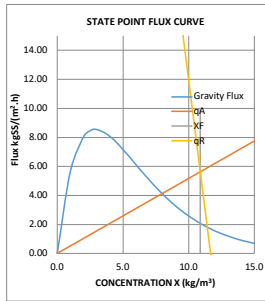
X	q_k	q_k
0.000	0.000	79.868 kgSS/(m ² .h)
10.400	5.375	5.375 kgSS/(m ² .h)
20.800	10.750	-69.119 kgSS/(m ² .h)
X_c	11.150	5.763

X_r	11.4	kg/m ³
SST min Area:	14939 m ²	
SHC I	0.21	0.9
R	α	q_a (m/hr)
0	1.000	#DIV/0!
3.980	0.427	0.152
7.960	0.302	0.106
11.940	0.237	0.079
15.920	0.194	0.062
19.900	0.162	0.051
23.880	0.135	0.043
27.860	0.112	0.038
31.840	0.091	0.033
35.820	0.070	0.030
39.800	0.047	0.027
R_{crit}	43.781	0.000

X	q_k	q_k
0.000	0.000	87.548 kgSS/(m ² .h)
11.400	5.892	5.892 kgSS/(m ² .h)
22.800	11.783	-75.765 kgSS/(m ² .h)
X_c	12.223	6.317

X_r	11.9	kg/m ³
FAIL		
SST min Area:	7744	m ²
	0.293	0.006
SHC I		
R	α	q_k (m/hr)
0	1.000	#DIV/0!
-4.515	#NUM!	#NUM!
-9.030	#NUM!	#NUM!
-13.545	#NUM!	#NUM!
-18.060	#NUM!	#NUM!
-22.575	#NUM!	#NUM!
-27.089	#NUM!	#NUM!
-31.604	#NUM!	#NUM!
-36.119	#NUM!	#NUM!
-40.634	#NUM!	#NUM!
-45.149	#NUM!	#NUM!
R_{crit}	-49.664	0.000 -0.022

X	q_k	q_k
0.000	0.000	91.388 kgSS/(m ² .h)
11.900	6.150	6.150 kgSS/(m ² .h)
23.800	12.300	-79.088 kgSS/(m ² .h)
X_c	12.759	6.594



SHC II	
R	q_{amax} (m/hr)
0	0.191
2.5	0.191
APPLIED FLUX (SLR)	5.62 kgTSS/(m ² .h)

SHC II	
R	q_{amax} (m/hr)
0	0.225
2.5	0.225
APPLIED FLUX (SLR)	5.37 kgTSS/(m ² .h)

SHC II	
R	q_{amax} (m/hr)
0	0.160
2.5	0.160
APPLIED FLUX (SLR)	5.89 kgTSS/(m ² .h)

SHC II	
R	q_{amax} (m/hr)
0	0.135
2.5	0.135
APPLIED FLUX (SLR)	6.15 kgTSS/(m ² .h)

$$q_A = \frac{V_0}{R} \frac{(1+\alpha)}{(1-\alpha)} \exp \left[\frac{-n(1-R)X_p(1+\alpha)}{2R} \right]$$

where

$$\alpha = \frac{1}{1 + \frac{4R}{n(1-R)X_p}}$$

$$q_{AmaxSHC II} = V_0 e^{-nX_p}$$

Annexure C – Detailed Operational Costs

[illegible]