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Beeston WwTW
Basis of Design

7th September 2023

Document Control

Issue Details

Rev.	Date	Purpose of Issue	Author	Checked	Approved
P01	07/09/2023	For Information	B. Hazard		

When updating from a previous issue:

- Changes from the previous issue are shown in ***bold italics***. At the next issue the sections in bold italics will revert to normal text and only changes for the next revision will be identified.
- A brief description of the change and the section to which it relates should be made in the Change Record table below.
- Where there are a significant number of changes the following note should be added:
- 'This issue has been significantly changed from the previous version. Changes have not been highlighted. Please review the document in its entirety.'
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Change Record

Rev.	Date	Description of Changes

Contents

Nomenclature

Abbreviation	Description
ACB	Air Circuit Breaker
AOD	Above Ordnance Datum
AS	Activated Sludge
BOD	Biological Oxygen Demand
BSP	British Standard Pipe
COD	Chemical Oxygen Demand
DfMA	Design for Manufacture and Assembly
DNO	Distribution Network Operator
DO	Dissolved Oxygen
DWF	Dry Weather Flow
FFT	Flow to Full Treatment
FOG	Fats, Oil, and Grease
GA	General Arrangement
GCS	Glass Coated Steel
H&S	Health and Safety
HMI	Human Machine Interface
ICA	Instrumentation, Control, and Automation
LED	Light Emitting Diode
LIMB	Local Isolators Marshalling Box
LV	Low Voltage
M&E	Mechanical and Electrical
MCC	Motor Control Centre
MLSS	Mixed Liquor Suspended Solids
OUR	Oxygen Uptake Rate
P&ID	Piping and Instrumentation Diagram
PID	Proportional Integral Differential
PLC	Programmable Logic Controller
RAS	Return Activated Sludge
RFQ	Request For Quotation
SAS	Surplus Activated Sludge
SBR	Sequencing Batch Reactor
SCADA	Supervisory Control And Data Acquisition
SLD	Single Line Diagram
SIL	Safety Integrity Level
SVI	Sludge Volume Index
TP	Termination Point
TSS	Total Suspended Solids
VSD	Variable Speed Drive
WIMES	Water Industry Management and Engineering Standards
WwTW	Wastewater Treatment Works
WWF	Wet Weather Flow

1. PROJECT OVERVIEW

A new WwTW is to be constructed at Beeston, Norwich to support a new mixed-use housing development based on 3,500 dwellings and associated non-domestic buildings. The works is to be constructed in 2 phases of 4,200 PE each.

Based on the information provided, we propose a full wastewater treatment plant with the core biological and settlement process being the te-cyc™ cyclic activated sludge technology. The proposed WwTW will also consist of an inlet works, feed and final effluent pumping stations, temporary influent buffer tank, tertiary solids removal, sludge holding and thickening facilities, and chemical dosing equipment. Figure 1 shows the proposed block diagram.

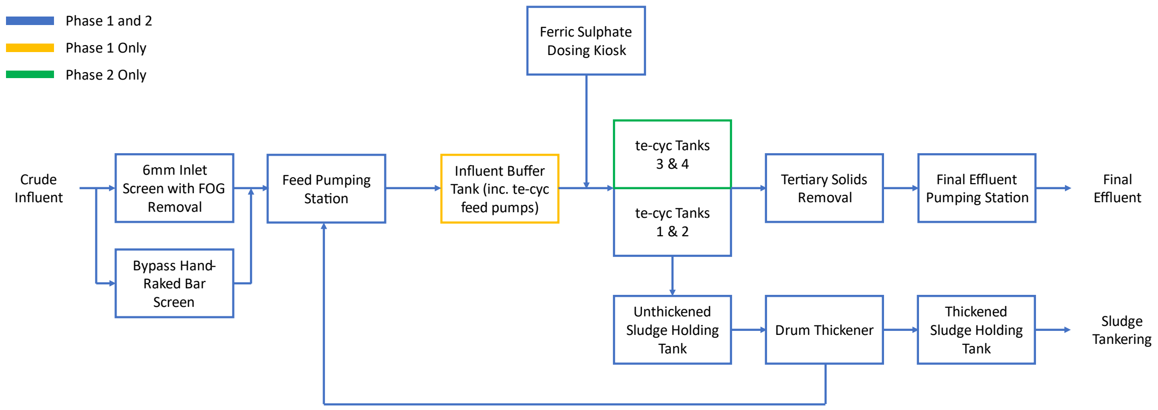


Figure 1: Proposed Beeston WwTW Block Diagram

Sizing of the process equipment has been based on the following flow and load information and required effluent quality parameters.

Table 1: Flow and Load Information

Parameter	Unit	Value
Population Equivalent	PE	8,400
Dry Weather Flow	m^3/d	1,092
Average Daily Flow (1.2x DWF)	m^3/d	1,310
Peak Flow (2.5x ADWF)	l/s	37.9
COD	kg/d	1,010
BOD	kg/d	504
TSS	kg/d	605
NH_4-N	kg/d	67
TN	kg/d	98
TP	kg/d	16

Table 2: Required Effluent Quality Parameters

Parameter	Unit	Value	Compliance
Dry Weather Flow	m^3/d	1,092	Maximum
BOD	mg/l	10	Maximum
TSS	mg/l	15	Maximum
NH_4-N	mg/l	1	Maximum
TN	mg/l	10	Annual Average
TP	mg/l	0.15	Annual Average

1.1 Purpose of this Document

This document is to provide ST Connect with the Basis of Design and Technical Solution for the new WwTW determined by Te-Tech at the time of quotation. It provides the basis for the quotation costing and establishment of any issues required to be considered during the detailed design of the project.

The contents of this document refer to the RFQ documentation provided with the enquiry and relate to our understanding of the requirements.

Every endeavour has been made to include all elements of work in this document. In the event that items of work are not included, we will be pleased to modify our extent of work to include the items missed.

1.2 Associated Documentation

The basis of design should be read in conjunction with the following documentation:

Document / Drawing Ref	Title
General	
TE0131-TET-XX-XX-M3-Z-0001	Beeston WwTW Combined Master Model (Exported DWG From Autodesk Inventor)
TE0131-TET-XX-XX-CM-Z-0001	Beeston WwTW Navisworks Model
Mechanical	
TE0131-TET-XX-XX-DR-M-0001	General Arrangement Drawing (Plan View)
TE0131-TET-XX-XX-DR-M-0002	Elevation Drawing
TE0131-TET-XX-XX-DR-M-0003	Isometric View Drawing

2. SCOPE OF SUPPLY

The Beeston WwTW suggested scope of supply includes:

One	Package pre-treatment unit with 6mm perforated plate mechanical screen with grit and FOG removal and complete with local control panel (Huber or equal).
One	Manually raked bypass screen unit (Huber or equal).
One	Range of DN250 pre-treatment package inlet pipework, fittings, supports and manual isolation valves.
One	Range of DN250 screen package outlet pipework, fittings, supports and manual isolation valves.
Three	Submersible pre-treated influent feed pumps (duty/assist/standby) each rated 19 l/s at 10m TDH.
One	Range of DN150/DN250 pump discharge pipework, fittings, supports, non-return valves and manual isolation valves.
One	Range of level instrumentation (ultrasonic and float switches) with associated brackets and fixings.
One	Portable lifting davit for pump removal with davit sockets.
One	Local feed pump station control panel in weatherproof enclosure.
One	Range of local power, signal, control and earthing cabling for feed pump station.
One	GCS open top sectional influent buffer tank (Phase 1 only) 5.123m diameter x 5.63m Sidewall height with access manway and flanged inlet and outlet connections.
One	Range of influent buffer tank inlet, outlet and overflow pipework, fittings, supports and manual isolation valves.
One	Range of level instrumentation (ultrasonic and float switches) with associated brackets and fixings.
Two	Surface mounted pre-treated influent lift pumps (duty/standby for Phase 1 only) each rated 19 l/s at 8m TDH.
One	Set of davit sockets adjacent to pumps.
One	Range of DN250 lift pump suction and delivery pipework, fittings, supports, non-return valves and isolating valves.
One	Local lift pump station control panel in weatherproof enclosure.
One	Range of local power, signal, control and earthing cabling for lift pump station.

One ‘Te-Cyc’ Treatment plant comprising the following main elements:

- GCS open top sectional process tanks each 11.05m diameter x 6.33m sidewall height with access manway and flanged process connections.
- Process tank access steelwork and decanter supports.
- Prefabricated tubular selector assemblies and supports.
- Fine bubble air diffuser systems.
- Coarse bubble selector air diffusers.
- ‘Te-Cyc’ Decanter assemblies.
- Process air blowers with acoustic enclosures.
- Submersible RAS pumps and accessories.
- Submersible SAS pumps and accessories.
- Manual and actuated ‘Te-Cyc’ valves.
- ‘Te-Cyc’ air supply pipework, fittings and supports.
- RAS pipework, fittings and supports.
- SAS pipework, fittings and supports.
- SAS flow meter.
- Process tank hydrostatic level monitors.
- DO Monitors.
- Pre-treated influent flow meter.
- Pre-treated influent feed pipework, fittings and supports to selector inlets.
- Treated effluent pipework, fittings and supports.
- SAS pipework manifold, fittings and supports.
- Main control panel including ‘Te-Cyc’ control PLC hardware and software plus HMI software.
- Main control panel and air blower GRP kiosk including building services.
- ‘Te-Cyc’ Process tank local control panels with remote I/O modules.
- Power, signal and control cables to process air blowers.
- Power, signal and control cables to submersible RAS pumps.
- Power, signal and control cables to submersible SAS pumps.
- Power, signal and control cables to ‘Te-Cyc’ decanters.
- Power, signal and control cables to ‘Te-Cyc’ actuated valves.
- Power and signal cables to influent and SAS flow meters.
- Power and signal cables to level and DO monitors.
- Junction boxes for air blowers and submersible pumps.

- Junction boxes for instruments.
- Actuated valve distribution board.
- Emergency stop stations for air blowers.
- Earthing and bonding materials.

One Range on DN300 treated effluent outlet pipework, fittings, supports and manual isolation valves.

One Prefabricated tertiary feed pump suction tank with flanged connections.

One Range of level instrumentation (ultrasonic and float switches) with associated brackets and fixings.

Three Tertiary treatment feed pumps (duty/assist/standby) each rated 19/ls at 15m TDH.

One Range of DN200/D300 tertiary treatment feed pump suction and delivery pipework, fittings, supports, non-return valves and isolating valves.

One Local tertiary filter feed pump station control panel.

One Range of local power, signal, control and earthing cabling for tertiary filter feed pump station.

One GRP tertiary treatment pump station kiosk including building services.

One Range of DN300 treated effluent bypass pipework, fittings and supports.

One GCS open top sectional treated effluent buffer/tertiary filter washwater storage tank 3.416m diameter x 4.23m sidewall height with access manway and flanged inlet and outlet connections.

One Range of influent treated effluent/tertiary filter washwater storage tank inlet and outlet pipework, fittings and supports.

One Range of level instrumentation (ultrasonic and float switches) with associated brackets and fixings.

One Tertiary filtration package plant (Bluewater Bio or equal) comprising the following main elements:

- Multimedia pressure filters.
- Pipework and equipment skid.
- Filter wash pumps (duty/standby).
- Air scour blowers (duty/standby).
- Interconnecting pipework, fittings and supports.
- Manual and actuated valves.
- Instrumentation.

- Local control panel.
- Power, signal, control and earthing cabling.

Three Submersible final effluent feed pumps (duty/assist/standby) each rated 19 l/s at 20m TDH.

One Range of DN150/DN250 pump discharge pipework, fittings, supports, non-return valves and manual isolation valves.

One Range of level instrumentation (ultrasonic and float switches) with associated brackets and fixings.

One Portable lifting davit for pump removal with davit sockets.

One Local feed pump station control panel in weatherproof enclosure.

One Range of local power, signal, control and earthing cabling for final effluent feed pump station.

One Range of DN100 surplus sludge (SAS) feed pipework, fittings and supports.

One GCS sectional raw sludge holding tank 7.685m diameter x 6.33m sidewall height with GRP roof, access manways, flanged inlet and outlet connections and roof hatch access ladder and platform.

One Range of raw sludge holding tank inlet and outlet pipework, fittings and supports.

One Submersible mixer unit complete with associated mounting and lifting components.

One Range of level instrumentation (ultrasonic and float switches) with associated brackets and fixings.

One Sludge thickening package (Alfa Laval or equal) comprising the following main elements:

- Drum thickener unit.
- Polymer mixing valve.
- Thickened sludge hopper.
- Thickener support frame.

One Package polymer preparation unit with solution storage tank and duty/standby dosing pumps.

One Thickened sludge transfer pump.

One Range of DN100 pipework, fittings and supports.

One Local control panel for sludge thickening equipment.

One Range of local power, signal, control and earthing cabling for sludge thickening plant.

One GRP sludge thickening plant kiosk including building services.

One GCS sectional thickened sludge storage tank 4.269m diameter x 5.63m sidewall height with GRP roof, access manways, flanged inlet and outlet connections and roof hatch access ladder and platform.

One Range of thickened sludge storage tank inlet and outlet pipework, fittings and supports.

One Submersible mixer unit complete with associated mounting and lifting components.

One Range of level instrumentation (ultrasonic and float switches) with associated brackets and fixings.

One DN150 thickened sludge tank outlet connection with manual isolation valve and Bauer type tanker connection.

One Packaged ferric storage and dosing unit within a GRP kiosk (Lintott or equal) comprising the following main elements:

- 2.5m3 storage tank.
- Integral bunded area.
- Dosing pumps (duty/standby).
- Level and monitoring instruments,
- Kiosk services.
- Signal marshalling.
- Local control panel.

One Range of dual contained ferric dosing pipework to point of application.

One Point of application enclosure.

One Safety shower (Hughes or equal) with 1500 litre overhead tank, tank heater and eye/facewash fountain.

One Range of local DN50/DN25 water feed pipework to safety shower.

One Range of site wide interconnecting power, control and signal cabling.

3. INLET WORKS

Flow will enter the treatment works via a pumped rising main (by others) and will be routed into an inlet screening package plant. For the inlet works package, we propose the HUBER Complete Plant Rotamat Ro5 which combines screening, grit removal, and FOG removal into a single unit. Figure 2 shows an indicative image of the Rotamat Ro5 unit. To ensure resilience, we also propose a small hand-raked bypass screen to be located next to the Ro5 screen in the event that the Ro5 becomes blocked or is out of service for maintenance.

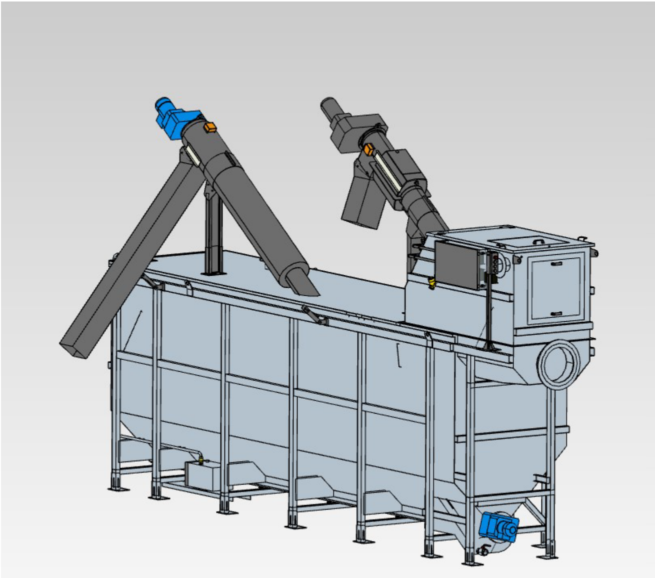


Figure 2: Huber Complete Plant Rotamat Ro5

Table 3: Huber Complete Plant Rotamat Ro5 Specification

Parameter	Unit	Value
Max Flow	l/s	40
Material	-	SS304L
Screen Size	mm	6
Inlet Connection Size	mm	250
Outlet Connection Size	mm	250
Overall Package Length	m	9.27
Overall Package Width	m	1.495
Overall Package Height	m	3.9

4. FEED PUMPING STATION

A below ground feed pumping station is required to pump the screened wastewater into the influent buffer tank. The centrate from the drum thickener will also return to the feed pumping station.

In phase 2 when the influent buffer tank is removed, the feed pumping station will feed the te-cyc tanks directly. A bypass line will be installed around the influent buffer tank in phase 1 to simplify the transition to phase 2.

The feed pumping station will contain 3 VSD controlled, submersible pumps in a duty/assist/standby arrangement and will be supplied with all associated valves, pipework, and level, flow, and pressure instrumentation.

The following table shows the feed pumping station specification which is based on the complete flow requirements for phases 1 and 2.

Table 4: Feed Pumping Station Specification

Parameter	Unit	Value
Number of Pumps	-	3
Pump Max Flow	l/s	18.95
Pump Operating Pressure	m H_2O	10
Pump Max Starts per Hour	starts/hr	15
Pump Station Diameter	m	2
Pump Station Depth	m	1.5

5. TEMPORARY INFLUENT BUFFER TANK AND TE-CYC FEED PUMPS (PHASE 1 ONLY)

During phase 1, only 2 te-cyc tanks will be installed, and therefore a buffer tank with te-cyc feed pumps is required to balance the flows when 1 of the te-cyc tanks is taken out of service for maintenance. Once the remaining two te-cyc tanks are built in phase 2, the buffer tank and te-cyc feed pumps can be decommissioned and removed.

The te-cyc feed pumps will be externally mounted and will be in a duty/standby arrangement. The pumps will be VSD controlled and will be supplied with all associated valves, pipework, and flow and pressure instrumentation. The associated level instrumentation will be installed at low level on the buffer tank.

The following table shows the influent buffer tank and te-cyc feed pump specification which is based on the flow requirements for phase 1.

Table 5: Temporary Influent Buffer tank te-cyc feed pumps specification

Parameter	Unit	Value
Number of Pumps	-	2
Pump Max Flow	l/s	18.95
Pump Operating Pressure	m H_2O	10
Buffer Tank Volume Required	m^3	100
Buffer Tank Diameter	m	5.123
Buffer Tank Depth	m	5.63

6. CHEMICAL DOSING

To achieve the 0.15 mg/l total phosphorus consent, enhanced biological phosphorus removal will be employed within the te-cyc process and combined with top-up chemical dosing. The preferred chemical for phosphorus precipitation is ferric sulphate, however other P precipitant chemicals can be used, e.g. ferric chloride, aluminium sulphate, etc.

A self-contained chemical dosing package will be provided that is suitable to deliver the estimated ferric dosing rate detailed in Table 6. The dosing package will include a storage tank, duty/standby dosing pumps, and all associated valves, pipework, instrumentation, and bunding.

We propose 1 point of application which will be the common te-cyc inlet line. Ferric will be pumped from the dosing package to the point of application via dual contained hose. At the point of application there will be a dosing enclosure that will contain the appropriate valving and leak detection.

A safety shower and eyebath will also be provided and will be installed local to the dosing package.

The rate at which ferric sulphate (or other suitable chemical) is dosed into the te-cyc inlet line will be controlled by the dosing package.

For flow proportional dosing control, the te-cyc inlet flowmeter will provide a 4-20mA analogue signal that will be repeated from the main works control panel PLC to the dosing package PLC.

Fault and high and low level alarms from the inlet flowmeter will also be repeated to the dosing package PLC to inhibit or commence dosing as necessary.

Table 6: Ferric Sulphate Dosing Calculations

Parameter	Unit	Value
Dry Weather Flow	m^3/d	1,310
te-cyc Inlet BOD Load	kg/d	504
Inlet Phosphorus Load	kg/d	16
Inlet Phosphorus Concentration	mg/l	12.21
P Biologically Incorporated into Biomass	% of Inlet BOD	2
Target Phosphorus Concentration	mg/l	0.15
Outlet Phosphorus Load	kg/d	0.2
Phosphorus to Precipitate	kg/d	5.72
Design Ferric Dose Rate	kg Fe^{3+} / kg P	1.8
Over-Dosage Factor	-	1.5
Ferric Dose Rate Required	kg Fe^{3+} / d	15.45
Ferric Solution Concentration (as Fe^{3+} ion)	-	12.5 %
Ferric Consumption	kg/d	124
	te/y	45.1
Specific Gravity	kg/l	1.55
Ferric Solution Flowrate Required	l/d	79.8
	l/hr	3.32
Storage Tank Days Storage	days	30
Storage Tank Volume Required	m^3	2.394
Chosen Storage Tank Volume	m^3	2.5

7. TE-CYC PROCESS

7.1 Inlet Line

The temporary te-cyc feed pumps in phase 1 and the feed pumping station in phase 2 will feed the common te-cyc inlet line. On the common te-cyc inlet line will be the chemical dosing point of application enclosure, and the te-cyc inlet flow meter. Downstream of the flowmeter, the pipe will split into individual lines to feed each tank.

On the inlet line to each individual te-cyc tank is a motorised isolation valve, a drain valve, and manual isolation valves. The motorised valves on each inlet line will either be fully open or fully closed depending on which phase of the operating cycle the particular tank is in. If the tank is in the Fill/Aerate phase, then the motorised isolation valve will be fully open; if the tank is in the Settle or Decant phase, then the valve will be fully closed.

The te-cyc inlet valves will have integral fully open and fully closed limit switches. At the end of a Fill/Aerate cycle, before the inlet valve is called to close, the inlet valve of the tank about to start the Fill/Aerate cycle is called to open and must return a fully open signal. If the fully open signal is not returned by a set delay time, then an alarm will be raised, the tank with the faulty valve will be automatically taken out of service, and maintenance mode will automatically commence.

When a valve is called to close and a fully closed signal is not returned within a set delay time, then an alarm will be raised, the tank with the faulty valve will be automatically taken out of service, and maintenance mode will automatically commence.

7.2 Reactor Tanks (Incl. Selector Zone and Access Steelwork)

For this project, we propose installing 4 te-cyc reactor tanks fabricated in glass-coated steel. The tanks will be separated into two distinct zones: the anaerobic selector zone and the main aeration zone.

The selector zone accounts for approximately 10% of the overall tank volume and consists of six vertical tubes connected by interconnecting pipes located alternatively at high-level and low-level to generate a plug flow-path. The selector zone is located within the main tank.

Table 7 shows the te-cyc reactor tank and selector zone specifications, and Table 8 shows the details of the tank penetrations.

Table 7: te-cyc Reactor Tank and Selector Zone Specification

Parameter	Unit	Value
te-cyc Reactor Tank		
Diameter	m	11.954
Total Height	m	6.33
Top Water Level	m	6
Bottom Water Level	m	5.1
Selector Zone		
Number of Selector Tubes	-	6
Tube Diameter	mm	1.35
Tube Height	m	6
Interconnecting Pipe Diameter	mm	600

Table 8: Tank Penetrations

Description	Diameter
Decanter Outlet Line	300mm
Level Instrument Mounting Plate Penetration	200mm
Common RAS and SAS Outlet Line	100mm
Drain Line	80mm
Access Manway	800mm

The tanks will be arranged in a 2x2 formation with a central raised platform that will provide access to the main te-cyc components located at high level as well as to each selector chamber. The area of platform next to the selector zone will have a floor level of 5.13m from the base slab level. This leaves approximately 1.2m of tank wall above the platform floor that will be used as handrailing to save on steelwork cost.

The area of platform next to the decanters will have a floor level of approximately 6.33m from the base slab and will be connected to the lower section of platform by via a small staircase. There will be two sections of this raised platform; one section to allow access to the decanter motors and gearboxes for tanks 1 and 2, and the other section to allow access to the decanter motors and gearboxes for tanks 3 and 4. The handrailing around these raised sections will be 1.5m high. These will also be the highest structure on the site with the top of the handrailing being 7.83m from the slab level.

Davit sockets will be supplied at various locations on the raised platforms to allow for lifting and maintenance of the high level equipment.

7.3 Process Air

During the Fill/Aerate phase of the te-cyc operating cycle, air will be supplied to the main aeration zones of the tanks in that phase. In normal operation, two tanks will be aerated at any one time.

Three positive displacement air blowers will be provided; Blower 1 will feed te-cyc tanks 1 and 2, Blower 3 will feed te-cyc tanks 3 and 4, and Blower 2 is the common standby that can be used in place of Blower 1 or 3. In addition to being used when Blowers 1 or 3 are in maintenance or fault, the standby blower will be automatically used in place of Blower 1 or 3 to minimise risk of failure of two or more blowers at the same time. Typical control for this is to set each blower with offset run time in the region of 40%, 50%, and 60% respectively.

All blowers are VSD controlled and have been sized based on the duty shown in Table 9.

Table 9: Blower Pump Duty

Parameter	Unit	Blower
Flow	Nm^3/h	548
Pressure	barg	0.7

Two actuated butterfly valves will be provided on the discharge pipework of the standby blower to direct the flow to the appropriate tanks when replacing Blower 1 or 3.

For personnel protection, the main sections will be partially lagged for pipework that reaches over 55°C. There will be several 50mm manual condensate drain ball valves provided at low points along the air pipework.

At the te-cyc tanks, the main air pipework lines will split off into feed lines for each individual tank. At the te-cyc tank, the individual feed line will split between the selector zone and aeration zone. On each split will be an actuated butterfly valve. Immediately downstream of the aeration zone actuated valve will be a reduced branch with a solenoid valve that will open when required to vent pressurised air to the atmosphere.

Following the vent pipework take-off point, the aeration zone pipework will continue and will be routed towards the base of the tank where it will connect to the main fine-bubble diffuser manifold.

The air pipework to the selector zone will feed a manifold that will have branches leading to each of the six selector chambers. At the top of each branch will be a ball valve that will be adjusted during commissioning to ensure an even air flow to each selector chamber. Each branch will lead to the bottom of its respective selector chamber where it will terminate in a manifold consisting of three coarse bubble diffusers that will be fixed to the tank base slab.

7.3.1 Aeration Control

During the Fill/Aerate phase, air will be applied to the aeration zone of the particular te-cyc tank by the air blower and via the fine-bubble diffusers. The rate and duration of aeration will be controlled by the PLC and follow a specific mode of operation that is selected by the operator. These modes are:

- Pulse Aeration Mode
- Blower Profile Mode
- DO (Dissolved Oxygen) Profile

- OUR (Oxygen Uptake Rate) Control Mode

The selection of these modes and the parameters within are unique to each te-cyc tank. Therefore, it is possible to operate each of the te-cyc tanks in different aeration modes, to allow for a greater degree of operational flexibility.

Pulse Aeration Mode

In Pulse Aeration Mode, the blowers will operate on a run and an idle timer, and at a certain blower capacity. All three parameters are operator adjustable set-points. Please note that in this mode there is no feedback control from the te-cyc tank DO sensors.

Blower Profile Mode

In Blower Profile Mode, up to 5 blower capacity and duration set points can be set to build up a profile for the Aeration phases. Different blower profiles can be created for the 3 Operating Cycle Modes (DWF, WWF, and Maintenance Cycle). Please note that in this mode there is no feedback control from the te-cyc tank DO sensors.

DO Profile Mode

In DO Profile Mode, up to two DO concentration and duration set points can be set to build up a profile for the Aeration phases. Different blower profiles can be created for the three Operating Cycle Modes (DWF, WWF, and Maintenance Cycle).

In this mode the actual DO concentration in the Aeration Zones of the te-cyc tanks is measured using the te-cyc tank DO sensors. The speed of the te-cyc tank blower motors is varied using a PID loop so that the actual measured DO concentration matches the required DO concentration set in the DO profile within a certain tolerance band.

If the measured DO concentration exceeds the upper limit of the tolerance band and does not decrease to within the range of the tolerance band within an adjustable time, then the blower is stopped. When the measured DO concentration falls back to within the tolerance band, the blower will be called to run again following the original aeration control.

If the measured DO concentration is below the lower limit of the tolerance band and does not increase to within the range of the tolerance band within an adjustable time, then the blower will be stopped, an alarm will be raised, and the te-cyc standby blower will be called to run. If there are any issues with the standby blower, including the DO concentration still failing to increase, then a critical alarm will be raised, and an operator will need to intervene.

OUR Control Mode

The OUR Control Mode is an automated DO profile mode which considers the actual oxygen uptake rate of the biomass. In contrast to the DO Profile Mode, here the first set-point of the DO profile is automatically calculated instead of manually inputted.

The OUR Control works as follows – at the beginning of the controlled aeration phase, DO Profile Mode is activated and aeration starts with the first DO set-point. After a pre-set delay time (OUR calculation delay), a high aeration period is initiated. The duration of this high aeration period is an adjustable set-point.

After the high aeration period, the minimum DO concentration in the tank should be at least 2.5 mgDO/l. In case the DO concentration is less than 2.5 mgDO/l, the high aeration phase is automatically extended until the DO concentration is at least 2.5 mgDO/l. At this time the blower is switched off and the calculation of the oxygen uptake rate is initiated. After calculation of the actual OUR, the aeration time for the first DO set-point is automatically calculated.

In case the actual OUR is less than or equal to the minimum OUR set-point, the aeration time for the first DO set-point will be zero, so for the remaining time of the first DO set-point the blower will not start. In case the actual OUR is higher or equal the parameter OUR max, the aeration time for the first DO set-point will be the available remaining time, so blower will start aeration.

In the case that the actual OUR is between the minimum and maximum OUR set-points, the aeration time for the first DO set-point will be calculated. At the end of aeration with set-point 1, the tank will be aerated for the remaining time of the controlled aeration phase with the second DO set-point.

7.3.2 Selector Zone Aeration

To prevent excessive solids settlement in the selector zone, the chambers can be aerated for several minutes each day to provide turbulence to the wastewater without significantly effecting the anaerobic conditions. When selected to, during the very start of the settle phase, the motorised selector aeration valve will open for several minutes to aerate the selector zone.

7.3.3 Air Line Venting

At the end of the Fill/Aerate phase, the air pipework solenoid valve will open to vent the pressurised air to atmosphere. This is to prevent air being released via the diffusers and disturbing the sludge layer during the decanting phase as the water level drops. Before the Fill/Aerate phase begins again, the vent valve will close.

7.4 Decanters and Discharge Line

Each te-cyc tank will contain one decanter that will be used in the decant phase of the te-cyc operating cycle to remove approximately the top third of clear treated effluent. The decanter will be driven by a 0.55kW VSD motor connected to a gearbox and will be fabricated in 304 stainless steel.

The decanter outlet line will penetrate the tank wall and will connect to the common outlet line which will be routed to the tertiary solids removal package. Flow from the decanter to the tertiary solids removal package will be gravity driven.

During the Fill/Aerate phase and most of the settlement phase, the decanter sits just above the top water level in its “Parked Position”. Towards the end of the settlement phase, the decanter is driven downwards quickly until the water surface is reached. This is determined by a capacitance probe on the decanter. This is to ensure that the decanter can immediately begin decanting at the start of the decant phase, ensuring a continuous effluent.

When the decant phase begins, the decanter is driven downwards drawing off the top layer of clear treated effluent, until the level in the tank reaches the bottom water level. The level of water in the tank is monitored by dual validating hydrostatic level sensors mounted on the side of the tank. The speed at which the decanter is lowered into the water is calculated at the start of the decant phase, based on the initial water level, to ensure that there is a constant effluent stream for the whole decant phase.

The decanter is driven by a variable speed motor, and in the control software, there is the option to run the decanter in Ramp mode. In this mode, the rate at which the decanter is lowered into the water will begin quickly where the treated effluent is clearest and then continuously slow down towards the end of the Decant cycle when the decanter is near the bottom water level so as not to disturb the sludge layer on the base of the tank. In ramp mode, the initial decanter lowering speed is related to an operator adjustable “Ramp Factor” which is a variable between -0.99 and 1.

Once the water level has reached the bottom water level set point as determined by the hydrostatic level sensors, the decanter stops lowering and the decanter motor reverses direction. The decanter then quickly rises back up to its parked position.

Figure 3 shows a diagram of the te-cyc decanter with the relative positions of the parked position, top water level, and bottom water level.

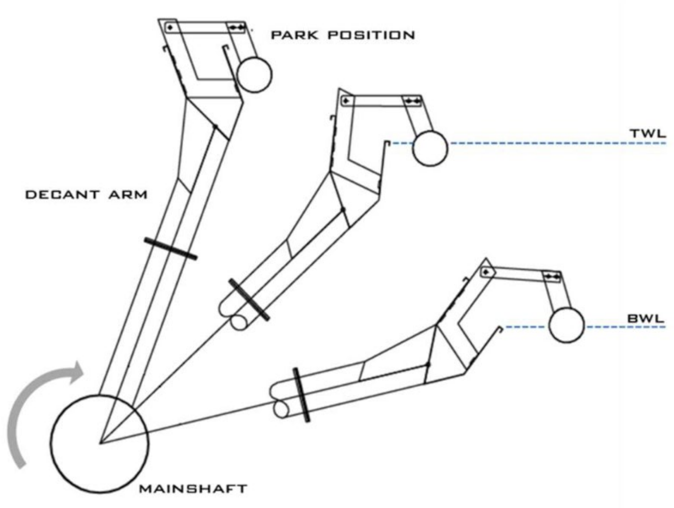


Figure 3: te-cyc Decanter Diagram

The decanter is equipped with three magnetic limit switches that will activate when the decanter is at the low level, high level, or the parked position. If the low level limit switch is activated in either manual or automatic operation, the decanter motor will be prevented from lowering the decanter any further. If the high level limit switch is reached, the decanter motor will be prevented from raising the decanter and further. In normal operation, the decanter should only ever move between the bottom water level and the parked position limit switch and so the high and low level switches should only be activated when adjusting the decanter or carrying out maintenance work.

In case the decanter reaches the lower end position in automatic control, e.g. due to a wrong calibration of a level probe, the decanter will be stopped and automatically driven back to the park position.

7.5 RAS and SAS Pumps

Each te-cyc tank will have one RAS pump to return mixed liquor during the Fill/Aerate phase and a SAS pump to remove sludge towards the end of the Decant phase.

Whilst both pumps are VSD, the motor speeds will be adjusted and set during commissioning and will be generally fixed throughout operation of the plant.

The RAS and SAS pumps have been sized based on the duties shown in Table 10.

Table 10: RAS and SAS Pump Duties

Parameter	Unit	RAS Pump	SAS Pump
Flow	m^3/h	8.8	13.9
Head	m H_2O	2	5

For each te-cyc tank, both pumps will be located external to the tank and will share a single common inlet line that penetrates the tank at low level and turns down into a sump within the tank. We assume that the sump will be provided by the civil subcontractor, and we will work with them to establish the design.

The RAS and SAS pumps and associated local upstream and downstream equipment and fittings for each te-cyc tank will be skid mounted using a DfMA approach to reduce time on site and ease installation.

The SAS line from each SAS pump discharge will connect to a common SAS line which will be routed to the unthickened sludge tank.

On the common SAS line will be an electromagnetic flowmeter to measure the SAS flowrate.

7.5.1 RAS Pump Control

Control of the RAS pump will be linked to the inlet motorised isolation valve of the corresponding te-cyc tank. In normal operation, whenever the inlet valve is opened, the RAS pump will be started and will run at the speed set during commissioning. When the inlet valve closes, the RAS pump will stop.

7.5.2 SAS Pump Control

Towards the end of the Decant phase, sludge that has settled towards the base of the tank will be removed by the SAS pump and will be regarded as SAS. The SAS pump flow rate will be set during commissioning. The volume of SAS to be removed during this period will be set at the HMI. From the SAS pump flowrate and the volume of SAS to be removed values, the start time of the SAS pump will be calculated. The actual volume of SAS being removed is totalised using the measurement from the SAS flowmeter on the common line, and once this value reaches the required volume of SAS to be removed, the SAS pump will stop.

8. TERTIARY SOLIDS REMOVAL

To meet the 0.15 mg/l total phosphorus consent, tertiary solids removal is required to guarantee performance. We propose installing a FilterClear pressurised mixed media filter package supplied by Bluewater Bio; however, we are happy to work with ST Connect if an alternative tertiary solids removal process is preferred.

The FilterClear package consists of the filter vessels and media, feed tank, clean backwash tank, feed pump, backwash pumps, associated valves and instruments, and local control panel.

Figure 4: FilterClear Mixed Media Filter Package

Treated effluent from the te-cyc plant will flow via gravity into the FilterClear feed tank and from here the feed pumps will pump the effluent into the pressurised media vessels.

Treated effluent from the filters fills the clean backwash tank before overflowing to the final effluent pumping station. There is also an overflow from the feed tank which bypasses the media filters and backwash tank in the event of the filters being offline for maintenance.

Periodically, the filters will be backwashed with treated effluent from the clean backwash tank via the backwash pump. Dirty backwash water will be discharged by gravity to the feed pumping station (via buried pipe).

Table 11: FilterClear Mixed Media Filter Package Specification

Parameter	Unit	Value
Water Characteristics		
Specified maximum flow rate	m^3/day	3,273
Specified average flow rate	m^3/day	1,091
Design maximum flow rate through filters	m^3/day	3,604
Design average flow rate through filter vessels	m^3/day	1,135

Specified maximum SS loading	kg/hour	5.45
Average SS to FilterClear	mg/l	20
Maximum SS to FilterClear	mg/l	40
Filter Vessel		
Total number of filter vessels	Nr	3
Diameter of vessels	mm	1,800
Filter Run Time		
Run time at average design conditions	hours	31
Run time at peak design conditions	hours	4
Backwash duration (per backwash, incl. air scour)	mins	21
Backwash pumps		
Type	-	Centrifugal (VSD)
Number of duty pumps	Nr	1
Number of standby pumps	Nr	1
Capacity of each pump	m^3/hour	153
Backwash blower		
Type	-	Soft Start
Number of duty blowers	Nr	1
Number of standby blowers	Nr	1
Air flow rate at atmospheric pressure per duty blower	m^3/hour	205
Backwash volume (per backwash)		
Volume of dirty backwash water per backwash	m^3	16.5
Required dirty tank emptying time	hrs	1.2
Required return flow rate	m^3/h	14
Required return flow rate	l/s	3.8
Drain down before air scouring		
Estimated drain down volume	m^3	2.5
Estimated drain down time	min	5
Average drain down flow rate	l/s	8
Estimated max drain down flow rate	l/s	17

9. FINAL EFFLUENT PUMPING STATION

A below ground final effluent pumping station is required to pump the final effluent to the outfall.

The feed pumping station will contain 3 VSD controlled, submersible pumps in a duty/assist/standby arrangement and will be supplied with all associated valves, pipework, and level, flow, and pressure instrumentation.

The following table shows the feed pumping station specification which is based on the complete flow requirements for phases 1 and 2.

Table 12: Final Effluent Pumping Station Specification

Parameter	Unit	Value
Number of Pumps	-	3
Pump Max Flow	l/s	18.95
Pump Operating Pressure	m H_2O	20
Pump Max Starts per Hour	starts/hr	15
Pump Station Diameter	m	2
Pump Station Depth	m	1.5

10. SLUDGE TREATMENT

SAS from the te-cyc process will be sent to an unthickened sludge holding tank before being thickened by a drum thickener package plant. The thickened sludge will be sent to a thickened sludge holding tank which will periodically need emptying via a sludge tanker. The centrate from the drum thickener will be returned to the feed pumping station.

To aid in sludge thickening, polymer will be dosed from dosing equipment included in the drum thickener package.

The unthickened and thickened sludge holding tanks will be roofed cylindrical glass coated steel tanks and the drum thickener package will be housed within a suitable sized kiosk.

For the drum thickener, we propose the ALDRUM Sludge Thickener Midi supplied by Alfa Laval. We envisage that the drum thickener will run for 8 hours per day only on weekdays.

Figure 5: ALDRUM Sludge Thickener Midi

Table 13: Sludge Management Specification

Parameter	Unit	Value
Sludge Production		
Total Sludge Production	kg/d	543
Surplus Sludge Total	m^3/d	83.4
MLSS of Surplus Sludge	mg/l	6,514
Unthickened Sludge Strorage Tank		
Days Storage	days	3
Required Tank Volume	m^3	250
Tank Height	m	6.33
Tank Diameter	m	7.685
Drum Thickener		
Thickened Sludge %DS	%	5
Thickened Sludge Solids Concentration	mg/l	50,000
Thickened Sludge Flowrate	m^3/d	10.3
Thickened Sludge Solids Load	kg/d	514
Solids Recovery	%	95
Centrate Solids Concentration	mg/l	400

Centrate Flowrate	m^3/d	73.1
Centrate Solids Load	m^3/d	29.2
Polymer Dose Rate	kg/tDS	3
Daily Polymer Dose	kg/d	1.54
Annual Polymer Usage	kg/y	563
Thickened Sludge Strorage Tank		
Days Storage	days	7
Required Tank Volume	m^3	71.9
Tank Height	m	5.63
Tank Diameter	m	4.269

11. ESTIMATED POWER CONSUMPTION

Item	Installed Power	Absorbed Power	Runtime per Day	Daily Absorbed Power
	kW	kW	hr/day	kWh/d
Inlet screen package (Huber)	4.37	2.6	24	2.6
Screened influent feed pump No. 1	4	3.1	24	3.1
Screened influent feed pump No. 2	4	3.1	24	3.1
Screened influent feed pump No. 3	4	3.1	0	0
Interstage pump No. 1	3	2.48	24	2.48
Interstage pump No. 2	3	2.48	0	0
Process air blower No. 1	22	16.4	24	16.4
Process air blower No. 2	22	16.4	24	16.4
Process air blower No. 3	22	16.4	0	0
RAS pump No. 1	1.5	0.9	12	0.45
RAS pump No. 2	1.5	0.9	12	0.45
RAS pump No. 3	1.5	0.9	12	0.45
RAS pump No. 4	1.5	0.9	12	0.45
SAS pump No. 1	2.2	1.4	2	0.12
SAS pump No. 2	2.2	1.4	2	0.12
SAS pump No. 3	2.2	1.4	2	0.12
SAS pump No. 4	2.2	1.4	2	0.12
Decanter No. 1	0.55	0.41	6	0.10
Decanter No. 2	0.55	0.41	6	0.10
Decanter No. 3	0.55	0.41	6	0.10
Decanter No. 4	0.55	0.41	6	0.10
Tertiary feed pump No. 1	4	3.49	24	3.49
Tertiary feed pump No. 2	4	3.49	24	3.49
Tertiary feed pump No. 3	4	3.49	0	0
Tertiary filter package backwash and air scour	19	14.3	2	1.19
Treated effluent pump No. 1	7.5	6.33	24	6.33
Treated effluent pump No. 2	7.5	6.33	24	6.33
Treated effluent pump No. 3	7.5	6.33	0	0
Ferric dosing package	2.2	1.4	24	1.4
Raw sludge tank mixer	1.5	0.9	4	0.15
Drum thickener	0.37	0.33	6	0.08
Polymer dosing package	2.2	1.4	6	0.35
Thickened sludge transfer pump	3	2.48	6	0.62
Thickened sludge tank mixer	1.1	0.9	4	0.15
MCC/blower kiosk building services	3	2.25	24	2.25
Tertiary feed kiosk building services	3	2.25	24	2.25
Sludge treatment kiosk building services	3	2.25	24	2.25
Actuated valves	5	3.75	24	3.75
Plant lighting	3	2.25	12	1.13
TOTALS	**186**			**82**
	kW			**kWh/d**

12. TE-CYC PROCESS DESIGN

To meet the works consent requirements and cater for flow and load design parameters provided, Te-Tech Process Solutions have prepared a solution based upon a single stage **te-cyc**TM advanced cyclic activated sludge process.

We are confident that the **te-cyc**TM design would provide **ST Connect** with a resilient and robust process solution to achieve or exceed the required consent standards, in a simple single stage treatment, providing capital and operational cost efficiencies.

12.1 te-cycTM Basin Design

Four **te-cyc**TM tanks will be provided based on the design data detailed below. The four-tank system is able to operate with one tank out of service, e.g. for maintenance.

Sludge stabilization will be achieved simultaneously in the **te-cyc**TM process tanks.

Hydraulic Design	Unit	Normal Operation	Wet Weather Flow Operation
Number of Basins in Operation		4	4
Cycles (in order)			
Fill / Aerate	h	2	1.5
Settle	h	1	0.75
Decant	h	1	0.75
Total Cycle Time	h	4*	3*
Cycles per Day	-	6	8

To avoid starting the* ***te-cyc**TM* *cycle time at the same time every day, the control software automatically shifts the cycle time several minutes each day.*

Tank Dimensions	Unit	Value
Diameter	m	11.954
Top Water Level	m	6
Bottom Water Level	m	5.1
Decanting Depth	m	0.9
Volume per Tank	m^3	673
Number of Tanks	-	4
Total Volume	m^3	2,694

12.2 Sludge Production

Sludge Production	Unit	Value
Selected Aerobic Sludge Age	d	10.5
Selected Total Sludge Age	d	21
Biological Sludge Production	kg/d	505
Chemical Sludge Production	kg/d	39
Surplus Sludge Total	m^3/d	83
MLSS of Surplus Sludge	mg/l	6,514

12.3 Air Diffusers

A floor mounted grid system of membrane diffusers supplies the necessary process oxygen. Mixing and oxygen transfer are achieved simultaneously. Provision is made for effective mixing at minimum energy input and oxygen transfer in order to achieve the degree of anoxicity demanded by the process. The selector is also equipped with diffusers to allow for mixing if required for process optimisation reasons during low load periods.

Process Oxygen	Unit	Value
Process Oxygen incl fc, fn	kg O_2/d	1,058
Process Oxygen incl fc, fn	kg O_2/h. basin	22

Standard Oxygen	Unit	Value
Design Temperature, T	°C	35
O_2 Concentration in basin	mg/l	2.0
O_2 Saturation at T°C	mg/l	6.9
Alpha	-	0.65
Standard Oxygen	kg O_2/d	2,293
Standard Oxygen incl fc, fn	kg O_2/h. basin	48

12.4 Process Blowers

The process blowers are configured to provide a maximum of flexibility at lowest cost. The blower station is arranged to interact with the reactor basins as follows.

The blower set operates via the OUR (Oxygen Uptake Rate) control system. During low loaded periods blower operation time is reduced automatically using OUR.

5 blowers (4 duty + 1 standby) are required for the proposed solution. All blowers are VSD controlled.

Process Blowers	Unit	Value
Total Air Required	Nm^3/d	26,300
Air per Basin Required	Nm^3/d	6,575
	Nm^3/h	548
Number of Duty Blowers	-	2
Number of Standby Blowers	-	1
Capacity per Blower	Nm^3/h	548
Pressure Increase per Blower	mbar	700

12.5 Decanters

Each basin contains 1 No. decanter based on the data provided below.

Decanters	Unit	Value
Decanters per Basin	-	1
Total No. of Decanters in Operation	-	4
Decanter Width	m	1.3

12.6 Design Clarifications

The **te-cyc™** process design is based upon the following design assumptions and clarifications:

- The range of pH value in the influent to **te-cyc™** will not exceed pH = 6.8 – 7.5.
- The influent may not contain toxic or inhibiting substances, which will inhibit biological activity, especially nitrification.

13. TE-CYC PROCESS DESCRIPTION

The **te-cyc™** System is the most advanced SBR system worldwide using cyclic activated sludge technology to treat wastewater. **te-cyc™** is a sequencing batch reactor technology combining all treatment steps including treatment of wastewater as well as settling of sludge in one basin.

The main difference of **te-cyc™** to other SBR systems is a biological **SELECTOR** on the front end of the reactor with sludge recycling from the main aeration part to suppress bulking sludge. It also allows for co-current nitrification/denitrification in the aerated part of the tank and enhanced biological phosphorus removal.

The second key advantage compared to conventional SBR systems is the **OUR** (Oxygen Uptake Rate) control system to regulate aeration intensity according to the actual demands (flow and loads) of the process.

The third main feature is an advanced high-rate motor driven **DECANTER** to withdraw solid free and scum free treated effluent from the basins.

The combined features of the **te-cyc™** technology provide unique process advantages compared to conventional technologies, including:

- Single stage treatment with no requirement for separate primary or final settlement stages.
- Small footprint, typically 50% less than many alternative solutions.
- Significant energy savings compared to conventional SBRs or AS plants enhanced by the OUR process control system.
- Reduced chemical consumption.
- Capital cost savings.
- Simultaneous nitrification / denitrification.
- Biological Phosphorous removal.
- Simple, low maintenance operation.
- Available in standard package and modular off-site manufactured units.
- Versatile and resilient to flow and load fluctuations.

13.1 Biological Selector Zone

The incorporation of a biological ***Selector*** within the **te-cyc^{TM}** process distinguishes it from all other technologies. The incorporation of this process feature removes the need for an anoxic mixing sequence. The biological ***Selector*** simplifies the operation of the process and ensures the biological selection of predominantly flock-forming micro-organisms.

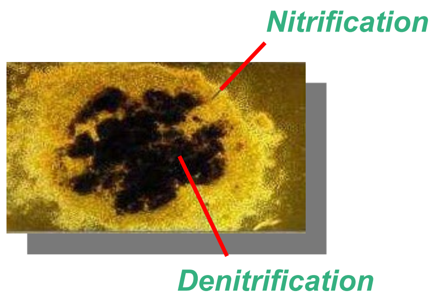
The biological ***Selector*** operates under essentially anoxic to anaerobic reaction conditions, the readily degradable soluble organic fraction of the wastewater (COD and BOD) is rapidly removed by enzymatic transfer mechanisms of the bacteria.

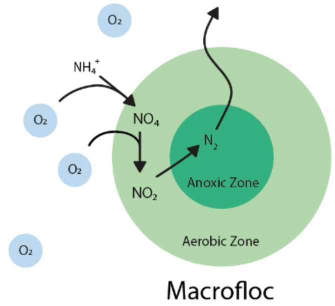
High sludge loading in the ***Selector*** supresses the growth of filamentous bacteria, primarily because the filamentous bacteria have a larger specific surface than the flock forming bacteria. Consequently, filamentous bacteria grow better than the flock forming bacteria under low food supply (F/M ratio or sludge loading). The selector generates high food supply for the bacteria; hence the advantage of the filamentous bacteria is lost and the flock forming bacteria grow better than the filamentous bacteria. Typical SVI values of the **te-cyc^{TM}** process are below 100 ml/g, with experience at some reference plants at 50 ml/g.

These conditions enable the creation of ***'macroflocs'***, which due to their size, create an internal gradient with respect to aerobic and anoxic / aerobic environments.

The flock forming bacteria allow for co-current nitrification/denitrification in the aerated part of the **te-cyc^{TM}** basin. Nitrification takes place on the surface of the flock; denitrification occurs inside the flock. Therefore, no mixers or additional cycles for denitrification are required, which simplifies the process.

The combination of anaerobic ***Selector*** and aerobic conditions (the aerated part of the **te-cyc^{TM}** reactor) increases the growth of phosphorus-accumulating organisms (PAOs). These bacteria can take up more phosphorus, enabling "enhanced biological phosphorus uptake" (bio-P).





13.2 OUR Control

The ***OUR*** (Oxygen Uptake Rate) process control uses dissolved oxygen measurement to provide process oxygen supply according to flow and load. In this way, the oxygen demand of the biomass is measured within the actual process basin and is subsequently used as a control parameter to automatically regulate the duration of the aeration cycle and the rate of aeration.

Process oxygen requirements in a facility can be easily measured by this oxygen uptake rate of the biomass. This methodology provides a true in-basin method for the efficient use of energy providing significant energy cost savings over alternative process solutions.

13.3 Decanter

In the decant phase, the mechanically driven decant weir moves from the top water level to the bottom water level to remove approximately one third of the reactor volume which will be clear treated effluent. The decant weir also features a scum guard which prevent floating solids from discharging into the treated effluent. At the end of the decant phase, the decant weir is returned to its parking position. Towards the end of the decant phase, a portion of the settled surplus sludge at the base of the reactor is discharged. The rate at which the decant weir is lowered and, hence, the rate of treated wastewater discharge, can be varied during the decant phase.

13.4 te-cyc™ Process Cycles

The **te-cyc™** process specifically refers to the use of variable volume treatment in combination with a biological ***Selector*** and ***OUR*** process control. The following process sequences are part of the technology:

13.4.1 FILL - AERATION Cycle

Aeration is the period when the process air is switched on with influent in the basin. The aeration mode can be adapted individually in the SCADA system according to the actual requirements based on flow and load variations. During the fill/aeration cycle the water level inside the basin increases from bottom water level to top water level according to actual flow. Less than design load operation typically requires the adaptation of the duration and the intensity of the aeration cycle by means of the ***OUR*** process control. During the fill-aeration cycle return sludge from the aeration zone is recirculated into the biological ***Selector***.

Fill / Aerate

13.4.2 SETTLEMENT Cycle

The settling cycle starts after the fill / aeration cycle to separate the sludge from the liquid. The inflow, aeration and RAS pumps are stopped to prevent turbulence in the basin which would be detrimental to the effective settlement of solids. The sludge mass forms a sludge blanket, in which the activated sludge ***macrofloc*** particles adhere and the mass settles within the confines of the blanket leaving a top layer of clear supernatant. The settled sludge layer has a mean biomass concentration of around 10 g/l in typical municipal wastewater applications.

Settle

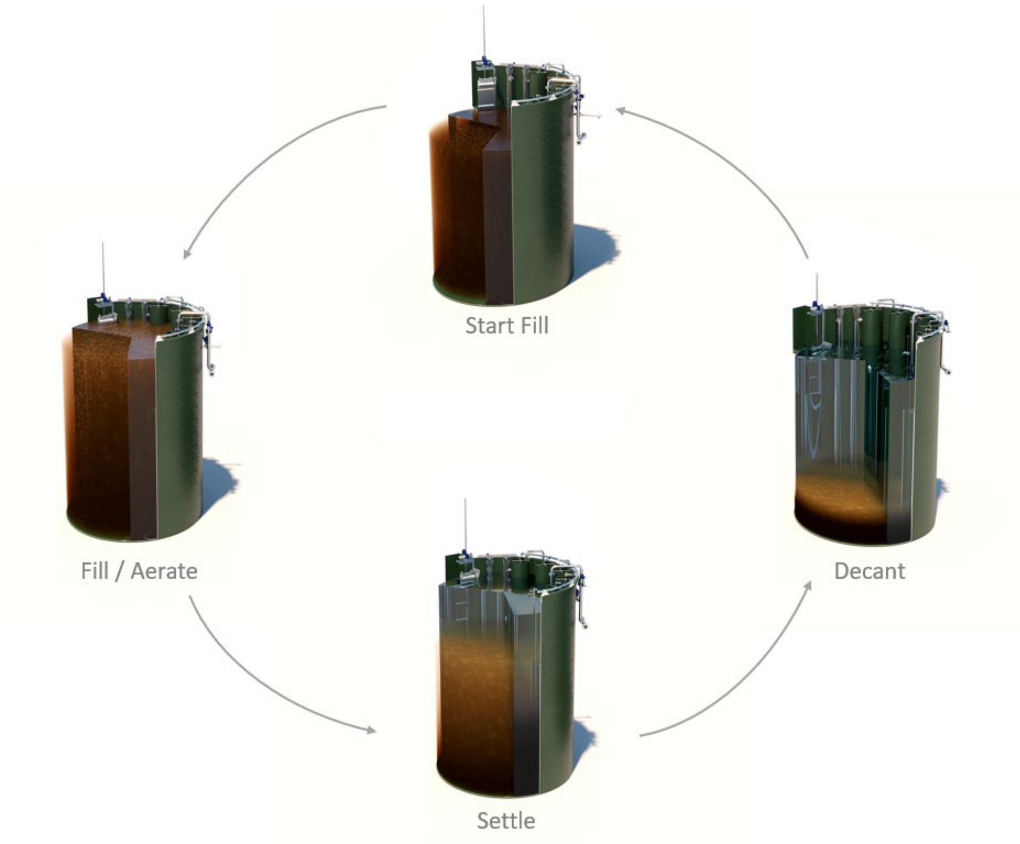
13.4.3 DECANTING Cycle

During decanting there is no inflow to the basin. Just before the end of the settling cycle the ***Decanter*** travels slowly from its parking position to the top water level and rests there until the decanting cycle starts. In the pre-set cycle time, the ***Decanter*** withdraws the supernatant from top water level to bottom water level, then it returns to its parking position by reversal of the drive. Surplus sludge is discharged from the **te-cyc™** basin towards the end of the decanting phase.

Decant

All the phases detailed above in sequence constitute one overall cycle, which is then repeated. A timetable for a typical 4-basin design is illustrated below, demonstrating a continuous influent and effluent flow.

Time (h)		2	3	4
Time (mins)		120	180	240
Basin 1	Fill/Aerate		Settle	Decant
Basin 2	Settle	Decant	Fill/Aerate	
Basin 3	Decant	Fill/Aerate		Settle
Basin 4	Fill/Aerate	Settle	Decant	Fill/Aerate



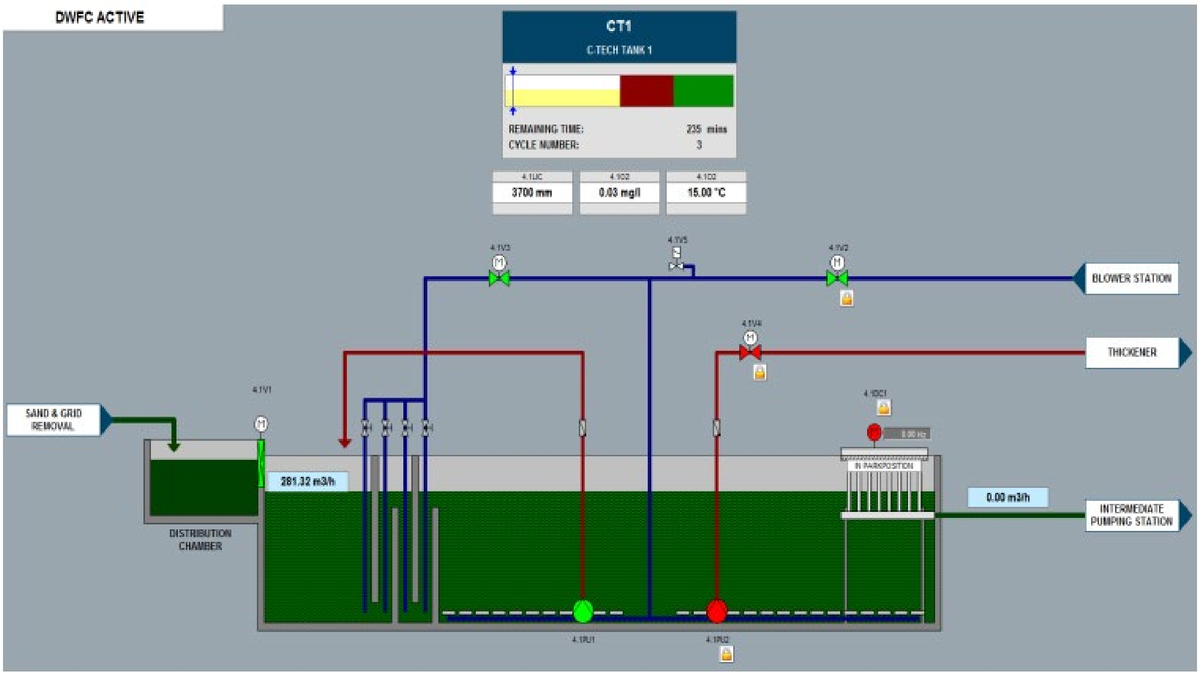
13.5 Operational Simplicity of the te-cyc™ Process

Plant control is fully automated, the entire equipment of the **te-cyc™** basins like decanters, pumps, valves, blowers etc. as well as the cycles are controlled by the PLC.

The cycle time functions of each basin are displayed on a monitor in the control room. Duration and intensity of the aeration are regulated by the ***OUR*** process control system via the same PLC. This means that optimum operation and performance are synonymous.

Varying loads and flows within a day can be handled via the PLC and therefore the system always works in an economic mode.

There are only a limited number of components and variables to be controlled by the PLC, the SCADA image below illustrates the simplicity of the **te-cyc™** control system.



13.6 Advantages of the te-cyc™ Process

13.6.1 Specific design advantages of te-cyc™ over other biological solutions

- **te-cyc™** tanks are simpler to construct than a combination of primary settling tanks, biological tanks and final settling tanks and will typically generate a 50% saving on footprint and civil construction costs.
- The **te-cyc™** operation itself favours the suppression of filamentous bacteria. In addition, the biological selector is particularly effective for suppressing any kind of filamentous microorganisms.
- **te-cyc™** provides simultaneous nitrification and denitrification, providing enhanced performance and resilience against future tightening discharge consents.
- The mechanical equipment in the system is reduced to a minimum.

- There are no exposed sludge collection and pumping stations, no separated re-cycle stations, no complicated collection and distribution channels and networks nor any mixers

13.6.2 Advantages over conventional SBR systems

In comparison to other conventional SBR (sequencing batch reactor) processes, the use of the **te-cyc**™ process offers significant economies in capital cost, operation and maintenance costs and land area requirements. Its main advantages include:

- Effective oxygen demand/supply operational control delivered by the ***OUR*** process control system, in combination with the ***Selector*** design, achieves simultaneous nitrification and denitrification without the need for dedicated mixing tanks or equipment.
- The ***OUR*** process control reduces the aeration time during night-time automatically to accommodate reductions in flow and load during the night. This increases the lifetime of blowers and diffusers and reduces the energy demand.
- A clear water withdrawal system for high-rate decanting allows drawing off up to 2.5 m of solids free effluent without complex valving arrangements.
- "Dry Weather Flow" and "Wet Weather Flow" operating protocols are standard features, whereas conventional SBR systems typically have only one cycle with confusing adjustment possibilities for the operator.
- The SCADA makes provision for maintenance cycle settings.
- The **te-cyc**™ does not require buffering capacity or equalization tanks.
- The incorporation of the selector in the **te-cyc**™ design promotes enhanced biological P removal.
- Conventional SBR systems do not have an anaerobic selector. Hence, filamentous sludge bulking in conventional SBR systems can be a problem, which can typically only be avoided with additional equipment like equalization tanks and pumps.
- There are extensive **te-cyc**™ reference plants ranging in capacity from small package plants and rural plants to large scale plants for major towns and cities.

13.6.3 Advantages over Conventional Activated Sludge Systems

In addition to the specific advantages detailed in 6.6.1, compared to conventional activated sludge systems **te-cyc**™ has the following advantages:

- **te-cyc**™ has variable volumes for biological treatment and sedimentation. It provides flexibility and resilience to accommodate variations in design flows or loadings and avoids sludge bulking.
- **te-cyc**™ operates utilising the ***OUR*** process control, the design incorporates the measurement of the actual biological activity of the microorganisms. This results in reduced operation costs, increased treatment efficiency, and precise aeration of the activated sludge.

- **te-cyc™** is not sensitive to peak flows and loadings because the cycle times of **te-cyc™** can be adapted to flows and loads. Hence, peak flows have no influence on the performance of the **te-cyc™** system.
- Each **te-cyc™** basin has its own recirculation pump, which pumps the sludge back into the ***Selector***. Therefore, high initial F/M loadings are achieved, and sludge bulking can be avoided.
- **te-cyc™** needs only little electro-mechanical equipment due to the ***Selector*** and simultaneous nitrification and denitrification. Hence, the whole **te-cyc™** process is simpler and therefore has low maintenance, repair, and replacement costs.
- **te-cyc™** detects toxicity at the beginning of the cycle and in such case does not allow other basins to be filled.
- There is no requirement for sedimentation tanks, hence no risk of sludge wash out or carry over.
- There is no requirement for a separate anoxic zone with mixers.

13.7 Operation & Maintenance

The **te-cyc™** process is a straightforward to operate, robust, and resilient process requiring only routine visual inspection and minimal operator training, intervention, and maintenance. The **te-cyc™** process is controlled by timers with standard DO and level instruments for aeration and decanter control only. The control system is managed and operated by your own plant operatives and does not require any external remote monitoring or licence agreement. The **te-cyc™** control system does however contain an optimisation feature, the Oxygen Uptake Rate (OUR) control mode to optimise blower control and reduce operational cost, initiated as a standard control feature by your own operator.

Routine operation activities are very similar to standard or conventional Activated Sludge processes typically including general process checks such as visual checks on aeration distribution, selector flow and checking for scum build up. Routine checks and maintenance such as cleaning of the level and DO probes, air blower checks, calibration and greasing activities can be carried out during and without interruption to normal operation.

Long term planned maintenance activities every 5 years include general servicing of air blowers, servicing of RAS and SAS pumps and decanter motors which again can generally be performed without interruption to normal operation. Significant planned maintenance such as replacement of fine bubble diffusers every 7 to 10 years would require access to the basins (unless retrievable diffuser assemblies are installed) but this would be done on individual basins whilst maintaining operation through the remaining basins.

13.8 Carbon Reduction

The **te-cyc™** process provides a positive contribution towards net zero and carbon reduction commitments in the following key areas.

13.8.1 Biological Wastewater Treatment

te-cyc™ is an enhanced biological nutrient removal process with the associated benefits of significantly reduced or zero demand for chemicals and associated carbon footprint for the supply, transportation, and storage.

13.8.2 Process Control

As previously described the ***OUR*** (Oxygen Uptake Rate) process control automatically regulates the duration of the aeration cycle and the rate of aeration.

This ***OUR*** process control provides a true in-basin method for the efficient use of energy providing significant carbon and energy cost savings.

13.8.3 DfMA

The modular and package **te-cyc**TM arrangements minimise the embodied carbon of the treatment assets and reduce on site construction activities and durations.

13.8.4 N_2O Emissions

Nitrous oxide N_2O is approximately 300 times more potent than Carbon Dioxide at heating the atmosphere and has an atmospheric lifetime of typically 110 years.

The process that removes nitrous oxide from the atmosphere also depletes ozone. So nitrous oxide is not only a greenhouse gas, but also an ozone destroyer.

Whilst agriculture may be the most significant contributor to N_2O emissions, unfortuantely there are also always N_2O emissions in biological wastewater treatment. The level of emissions do however vary between different treatment technologies and can therefore be mitigated.

The **te-cyc**TM process generates much lower N_2O emissions through the following design features:

- Long anaerobic retention time in the **te-cyc**TM selector of over one hour help ensure that the remaining N_2O and nitrate in the return sludge is consumed to ensure that less N_2O is released to atmosphere in the main aeration zone.
- In the **te-cyc**TM process the denitrification is almost complete, consequently most of N_2O produced in the main aeration zone is also consumed within the main aeration zone.
- Over and under aeration will promote N_2O, the ***OUR*** process control however ensures that this risk is mitigated.
- Shock loads of NH_4 may also have a detrimental impact on N_2O generation, however the **te-cyc**TM process eliminates this risk.

Appendices

PROCESS SOLUTIONS®

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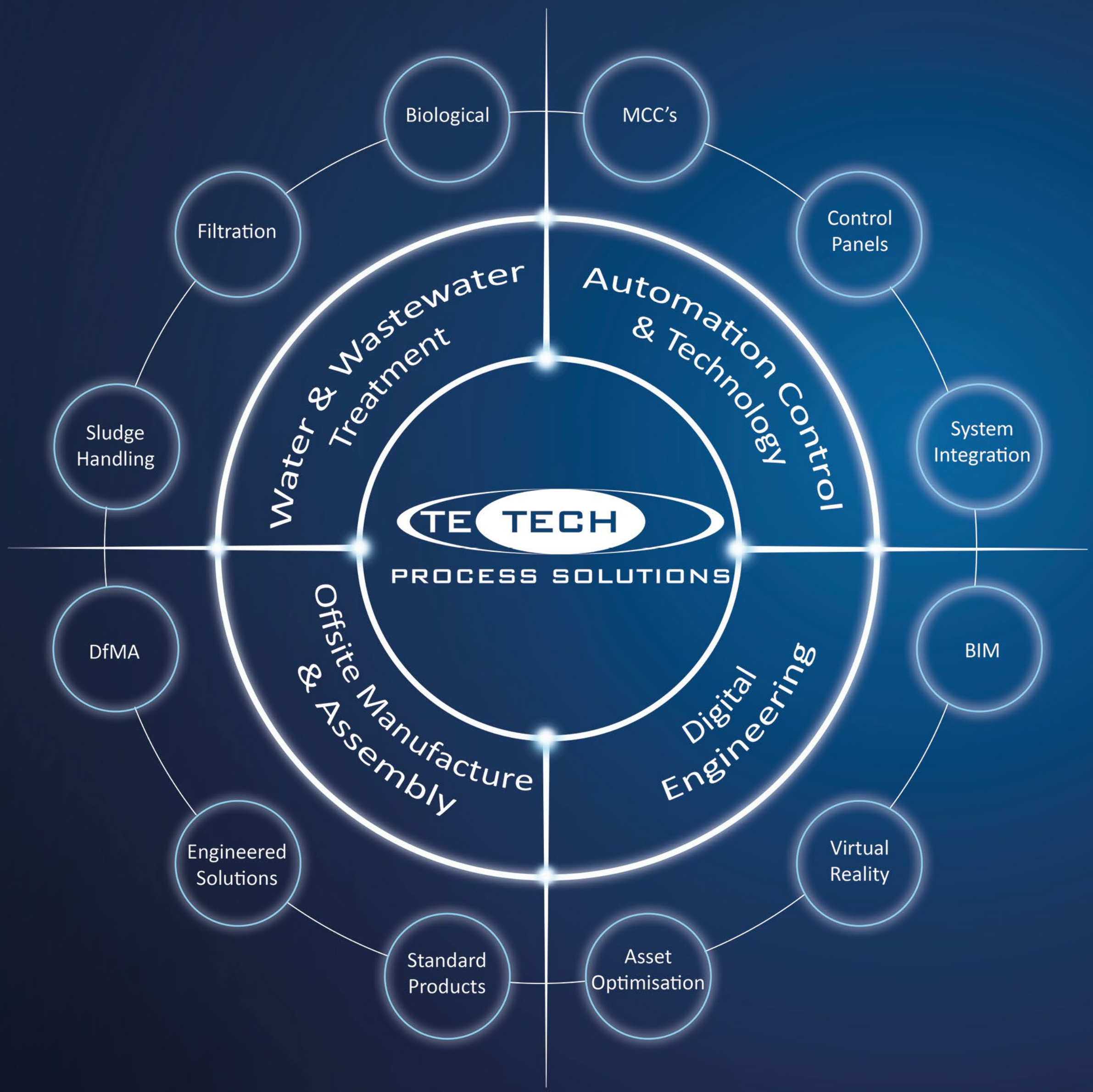
APPENDIX A – N/A



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