


Guideline for the Inspection of Wastewater Treatment Works

LA Boyd & AM Mbelu

TT 375/08

Water Research Commission

Guideline for the Inspection of Wastewater Treatment Works

Report to the

Water Research Commission

by

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Golder Associates Africa

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The financing of the project by the Water Research Commission and the contribution of the members of the Reference Group are gratefully acknowledged.

ABBREVIATIONS

ASP	Activated Sludge Process
CH_4	Methane
CO_2	Carbon Dioxide
COD	Chemical Oxygen Demand
DO	Dissolved oxygen
DWAF	Department of Water Affairs and Forestry
ELU	Existing Lawful Use
GA	General Authorisation
kℓ	Kilolitre (1 kℓ of water = 1 000 litres of water)
M	Metres
m/s	Metres/second
m^3	Cubic metres (1 m^3 of water = 1000 litres of water)
Mℓ	Megalitre (1 Mℓ water = 1 000 000 litres of water)
MLSS	Mixed Liquor Suspended Solids
NH_3	Ammonia
NWA	National Water Act
OHSA	Occupational Health and Safety Act
PPE	Personal protective equipment
PST	Primary Sedimentation/settling Tank
RAS	Return Activated Sludge
s	Seconds
SCBA	Self Contained Breathing Apparatus

SRT	Solids Retention Time (sludge age)
SS	Suspended Solids
TDS	Total Dissolved Solids
TS	Total Solids
VS	Volatile Solids
WAS	Waste Activated Sludge
WSA	Water Services Act
WUL	Water Use Licence
WWTW	Wastewater Treatment Works

SOME DEFINITIONS

Experienced Person

In the context of this document an experienced person is someone who has at least 10 years experience in the field of wastewater treatment and is knowledgeable in wastewater operations or is registered as at least a Class V Process Controller.

Inspection

In the context of this document the word 'inspection' refers to a basic evaluation of a WWTW by an experienced person; an assessment of the WWTW by a Process Controller or a detailed assessment to assess compliance, by a regulator.

Inspector

In the context of this document, and based on the above definition of inspection, an Inspector may be an experienced person, a Process Controller or Process Manager or an official from the regulator.

Pond System

A pond system can be described as a series of relatively shallow bodies (usually earthen basins) of wastewater. While this document can be used for assessment of pond systems, the document entitled: *Status quo assessment of wastewater ponding systems*, WRC Report 1657/1/09 (to be published in 2009) is also available and is very detailed.

Process Controller

In the context of this document a Process Controller is the person who executes those functions that include both the elements of control and operations and may in certain cases also be the Process Manager, as mentioned above.

Process Manager

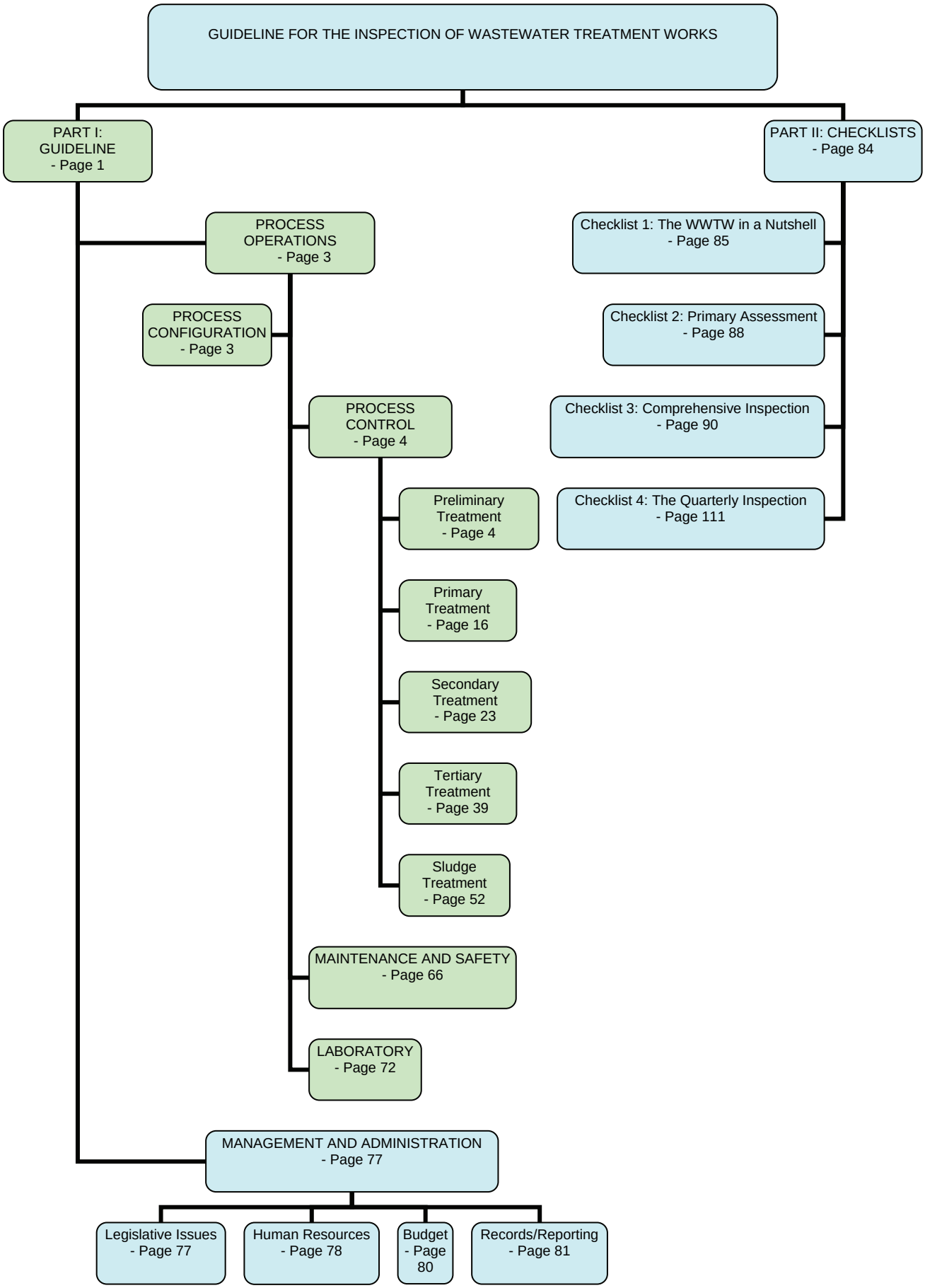
In the context of this document a Process Manager is the person who is on site and is expected to make decisions and give instructions on the day-to-day operations of the WWTW process and in cases may also be the person who executes the day-to-day operations.

Quarterly Inspection

In the context of this document a quarterly inspection means an inspection that is undertaken at a WWTW on a quarterly basis to ensure that good practice is

	ongoing. Should any concerns arise, then the comprehensive inspection should be undertaken.
Regulator	In the context of this document the regulator is a person from that body (currently the DWAF) which at the time is mandated to protect the water resources of South Africa and must undertake inspections in terms of the relevant Acts.
Responsible Person	In the context of this document a responsible person is someone who has been appointed in terms of the OHSA and will be held accountable for an incident that may occur on the WWTW.
Wastewater Treatment Works	In the context of this document a WWTW includes the other terms that are used to describe a WWTW such as: sewage farm, sewage works, sewage plant, water care works and waterworks.

ROADMAP OF THE GUIDELINE



INTRODUCTION TO THE DOCUMENT

MOTIVATION FOR DEVELOPING THE GUIDELINE

The National Water Act, 1998 (Act 36 of 1998)(NWA) states that as the public trustee of the nation's water resources the National Government, acting through the Minister, must ensure that water is protected, used, developed, conserved, managed and controlled in a sustainable and equitable manner, for the benefit of all persons and in accordance with its constitutional mandate. Wastewater treatment works (WWTW) are just one of the many water users of these resources. To control the water uses within the legal requirements of the NWA, the Department of Water Affairs and Forestry (DWAF) must monitor WWTWs.

In order to undertake an inspection and give guidance on how to solve a problem it is important that the person undertaking the inspection fully understands the complex nature of various unit processes involved in the treatment of wastewater.

There are currently several handbooks with relevant technical information for the various processes. However, the Process Controllers or Inspectors (DWAF, Local Authority, contractors, consultants) are not always adequately skilled to correctly interpret this technical information, and do not always know what to look for at the various unit processes when undertaking an inspection.

PURPOSE OF THE GUIDELINE

This guideline document deals with the requirements for undertaking an inspection at a WWTW.

The purpose of the guideline document is to:

- Assist the Process Controller to:
  - prepare for an inspection at the WWTW
  - take corrective action where a problem is identified.
- Assist the Inspector to:
  - undertake an inspection at a WWTW
  - give guidance where a problem is identified.

The guideline describes checklists for those unit processes that are most frequently encountered at South African WWTWs. A list of proposed additional reading material that every WWTW should have on site is set out in Appendix A of the guideline.

The list of questions provided should be adequate to aid the Inspector in drawing up a list of questions for a process that may not be fully described in this guideline.

WHO SHOULD USE THIS GUIDELINE

This guideline has been developed to ensure that the person undertaking an inspection at a WWTW asks the correct questions, understands a problem if noted and is able to give advice where problems are noted. The guideline document has been developed for:

- Regulatory authorities who undertake inspections
- Consultants and contractors who undertake inspections
- WWTW Process Managers
- WWTW Process Controllers.

OVERVIEW OF THE GUIDELINE

Part I: Guidelines

Part I of the document sets out a guideline for undertaking an inspection at a WWTW to support the checklists set out in Part II. The guideline sets out the why, what and how of undertaking an inspection for various performance areas and lists performance indicators to guide the Inspector.

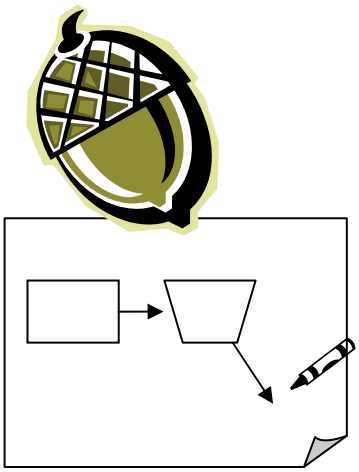
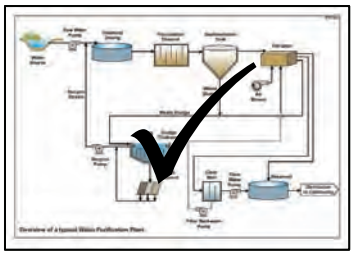
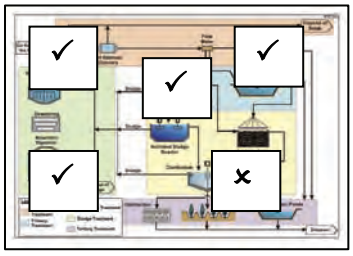
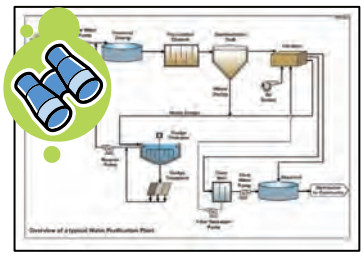
This section gives the Inspector, the Process Manager and the Process Controller a better understanding of the importance of the inspection, whether it be a daily visual inspection or a more comprehensive external or internal inspection. It is important to note that this section should be read in conjunction with a reputable handbook, such as those set out in Appendix A, for the operation of a WWTW.

Part II: Checklists

Part II of this document sets out checklists that should be completed at various times throughout the year, depending on the operational status of the WWTW.

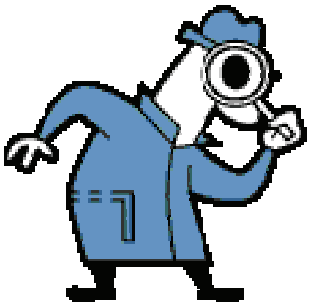
Table 1 below sets out the various checklists and when they should be used.

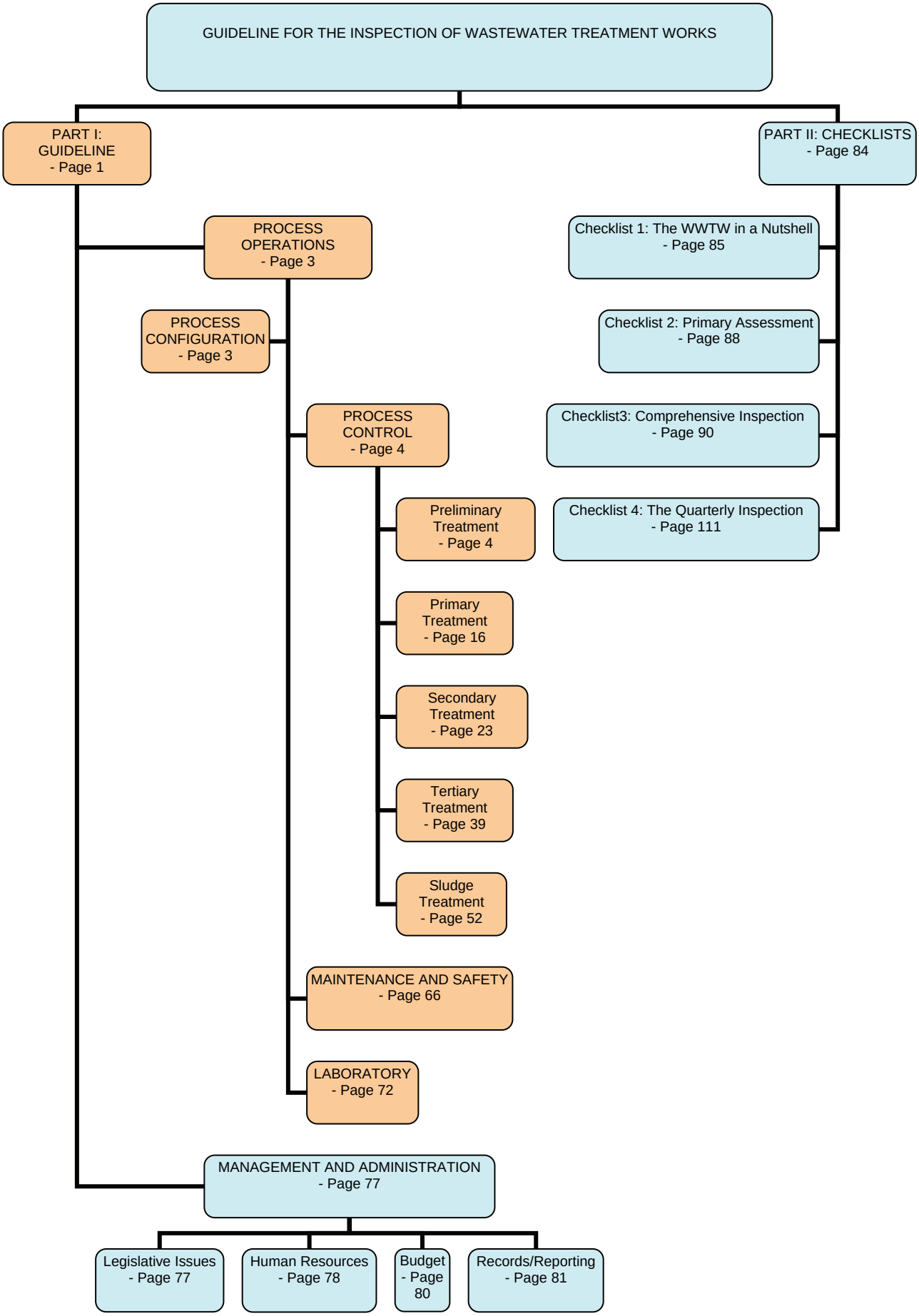
Table 1: Description of the Checklists

Checklist		When should the checklist be used?
1	*The WWTW in a nutshell* 	This checklist will help the person undertaking the inspection to get an understanding of the unit processes making up the WWTW and should be undertaken with the Process Manager. • All Process Managers and Process Controllers should complete this checklist when commencing employment at the WWTW and again if any upgrades are done to the works. External Inspectors should complete this checklist prior to undertaking an inspection. Examples of flow diagrams of various configurations are set out in Appendix B and C.
2	*Primary Assessment* 	This checklist gives an overall evaluation of the WWTW. • The inspection should be undertaken by an experienced person, preferably external to the WWTW, who will make a decision on whether the comprehensive inspection needs to be undertaken or not.
3	*Comprehensive Inspection* 	This checklist includes individual checklists for each unit process. It should be used by the regulators and other Inspectors (both external and internal) when a WWTW has failed the primary assessment, i.e. all aspects have failed or certain parts of the WWTW have serious failures. This checklist will aid in the identification of the problems and will help to make improvements.
4	*Quarterly Inspection* 	This inspection should be undertaken quarterly once the WWTW has been subjected to a comprehensive inspection and/or primary assessment, and has been deemed to be running optimally. Ideally the regulator should undertake this inspection; however, the Process Manager or Process Controller could also undertake this inspection.

PART I

GUIDELINES FOR UNDERTAKING AN INSPECTION AT A WWTW

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PROCESS OPERATIONS

Process Configuration

1

Notes (the what, why and how)	Look for :
Flow diagram	
To understand how the WWTW has been structured and should be operated, it is important that a flow diagram is on hand at the works. Examples of flow diagrams are set out in Appendices A and B. The Process Manager should draw this diagram and explain it to the other Process Controllers.	• a flow diagram of the WWTW
Capacity	
In order to plan for future developments and know how much wastewater can be accommodated at the WWTW, it is essential to know the design capacity of the works. Copies of the design drawings and manuals should therefore be on hand at the WWTW. If these are not available then the Process Manager should get an estimate by measuring the various tanks. This could even be done by pacing out the length (l) and width (w) of the tanks or measuring with a tape measure and using a long stick of known length to get an estimate of the depth (d). The capacity of a unit is then: Capacity of a unit = **(l) x (w) x (d)**	• confirmation of the design capacity or at least that an estimation has been carried out

PROCESS OPERATIONS: PROCESS CONTROL
PRELIMINARY TREATMENT

Notes (the what, why and how)	Look for:
Screens  2 Materials such as rags, plastic and foreign materials can significantly interfere with the treatment processes or damage the plant equipment if not removed. These solids are removed by means of screening. The screened materials are hazardous and must be safely disposed of to prevent human health concerns, fly breeding and odours.	
Manual screens	
The screens may need to be cleaned regularly to prevent the build-up of debris. A significant head loss (in other words, a flow that is much lower than normal) through the screens is an indication that debris is clogging the screens. Overflow at the head of works or a point further upstream may also indicate clogged screens. A hand rake and wheelbarrow should always be available. If the hand rake is missing teeth it will not adequately clean the screens. The wheelbarrow should not have holes at the bottom. The Process Controller must request the Process Manager to purchase a new hand rake and wheelbarrow as required.	• screens that are free of debris • a hand rake and wheelbarrow that are easily accessible and in working order
Automated screens	
A significant head loss (a flow rate that is much lower than normal) through the screens indicates that debris is clogging the screens and the screens may need to be cleaned more often - do not allow debris to build up. Use of the manual control will allow immediate observation of the operation of the manually cleaned bar screens or other equipment even though these may be inactive when the inspection begins.	• screening components that are free of obstructions • unusual sounds or vibrations

PROCESS OPERATIONS: PROCESS CONTROL PRELIMINARY TREATMENT	
Notes (the what, why and how)	**Look for:**
Screeching could indicate scraping of the screen or lack of lubrication of the chain or drive mechanism while thumps could indicate broken or loose components. The Process Controller should report any unusual vibrations and/or sounds to the Process Manager or maintenance personnel. To ensure that the mechanical screens operate optimally, a maintenance schedule should be drawn up. It may be that the suppliers of the screen recommend a maintenance schedule.	• a maintenance schedule that is implemented for the screens • screenings that are washed to remove organics and wash water that is returned to the WWTW • screenings that are pressed before disposal

SCREENS: GOOD

Good housekeeping at the inlet works

Well contained screenings

Enclosed head of works showing bin used for storage of screenings/grit

SCREENS: BAD

Blocked screen causing overflow of wastewater

Badly maintained screen

Badly disposed of screenings – they should go into the trench and be covered once disposed

PROCESS OPERATIONS: PROCESS CONTROL PRELIMINARY TREATMENT	
Notes (the what, why and how)	**Look for:**
Grit removal  **3** Grit material can include sand, silt, glass, small stones as well as other large-sized organic and inorganic substances (detritus). Excess grit can cause operational problems such as pump blockages and high organic concentrations in the digesters and/or reactors. Grit removal is therefore essential to protect moving mechanical equipment and pumps from abrasion and to reduce blockages.	
Manually cleaned channels	
Hand cleaned channel systems are generally only used for WWTWs <4 Ml/d. The channels have control devices, e.g. venturi flumes or weirs to regulate the velocity of flow. If the velocity is too low then there may be contamination of grit with organics that settle out. If the velocity is too high, then grit is carried to downstream processes. A spade is used to manually remove the accumulated grit from the channel that has been closed and drained. Grit should be placed into a container such as a wheelbarrow or large bin for easy removal. The Process Controller must therefore ensure that both channels are in working order by maintaining the channels regularly and request the Process Manager to purchase a new spade and disposal container as required.	• channels that are clear of grit • channels that are in working order, i.e. one can be used while the other is closed for manual removal of grit • a spade and container that are easily accessible for grit storage
Mechanical/ automated cleaned channels	
A noisy, uneven movement of the channel cleaning scraper may indicate a problem with the grit removal system.	• in-line mechanism that is moving smoothly

PROCESS OPERATIONS: PROCESS CONTROL PRELIMINARY TREATMENT	
Notes (the what, why and how)	**Look for:**
A low recovery of grit may mean that the grit scraper system is operating at low speeds or there is another problem with the scraper system.	• channels that are clear of grit • channels that are in working order, i.e. one can be used while the other is closed for manual removal of grit
Automated de-gritters	
Automated de-gritters use centrifugal force in a cone-shaped unit to separate grit from the wastewater by creating a vortex. A pump is required to remove a slurry of grit near the upper perimeter of the de-gritter onto a conveyor which then discharges to a container such as a large bin.	• a pump in working order
Screenings and grit disposal	
Screenings and grit left lying around will cause nuisance conditions such as odours and will encourage fly breeding. It should therefore be disposed of into a suitable container such as a large dustbin that can be closed. It is important to ensure that no screenings are left lying around on the ground. At small WWTWs screenings and grit can be buried in trenches. These trenches must immediately be covered with soil once screenings and grit have been disposed of. Where larger volumes of screenings and grit are collected, the screenings must be disposed of to a permitted waste site.	• non nuisance conditions (odours and fies) • grit or screenings lying around • covered bins that are used for storage of grit • proof that grit and screenings buried on site are covered daily

GRIT REMOVAL: GOOD

Typical grit

Well contained grit before disposal

Vortex de-gritters

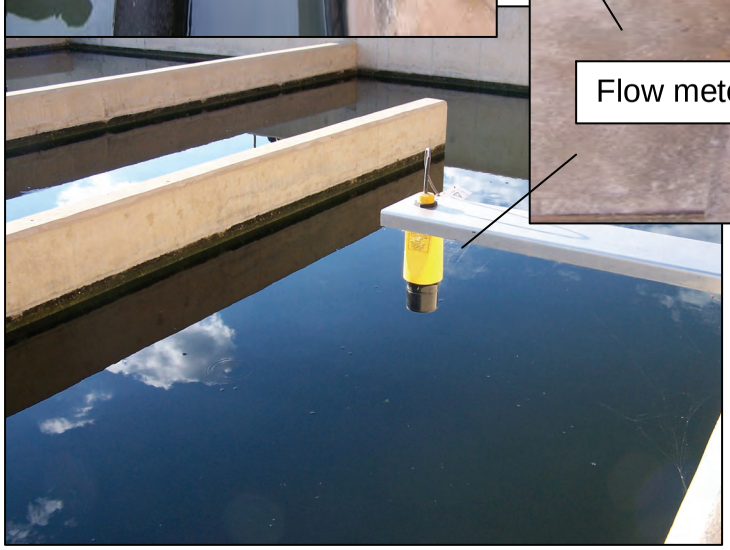
GRIT REMOVAL: BAD

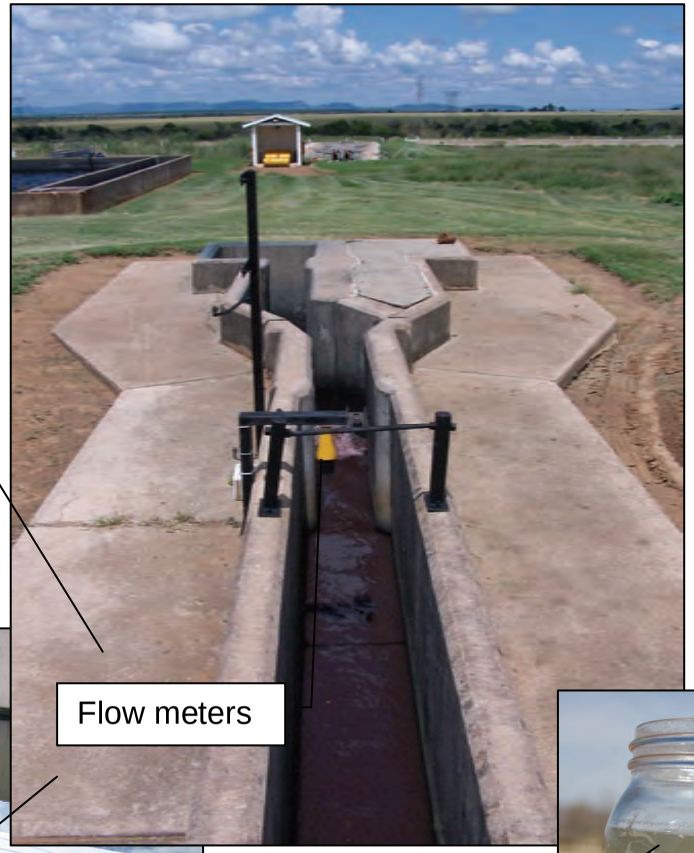
Vortex de-gritter in which sand has accumulated

PROCESS OPERATIONS: PROCESS CONTROL PRELIMINARY TREATMENT	
Notes (the what, why and how)	**Look for:**
Flow  **4** As a WWTW is designed to treat a specific volume of wastewater per day, it is important to know how much wastewater is entering so as not to overload the plant.	
Flow metering	
Changes in the volumes entering the plant will alert the Process Controller to possible problems upstream of the works, e.g. at a pump station. It is also important to know when the peak flow arrives at the WWTW. Flow is typically measured just after the screens and grit removal processes and it is important to note that one of the conditions of an authorisation will be that the flow is measured. In other words ***flow measurement is a legal requirement***. Appendix D sets out a simple method by which flow can be estimated should a flow meter not be in place or in working order. Also, in order to better understand the flows entering in relation to the design capacity, it is important to know what litres per second (ℓ /s) means. 'Normal' raw wastewater is a light grey colour. If the wastewater entering the WWTW is of a darker or different colour or appearance (e.g. oily), it could be an indication of industrial discharges to sewer which may be illegal and may contain a substance/s that could be harmful to the biological organisms of the WWTW.	• flow measurement • knowledge of flow in relation to design capacity • the flow mechanism and determine whether it is in working order and is calibrated

PROCESS OPERATIONS: PROCESS CONTROL PRELIMINARY TREATMENT	
Notes (the what, why and how)	**Look for:**
Flow balancing	
Flow balancing, also called flow equalisation, is used to overcome the operational problems caused by flow rate variations and to improve the performance of the downstream unit processes. In other words, flow balancing is simply the damping of flow rate variations so that a constant or nearly constant flow rate can be achieved. Balancing tanks can be located before or after primary sedimentation. If placed after primary sedimentation, fewer problems with sludge and scum occur. If placed before primary sedimentation, mixing must be in place to prevent solids deposition and aeration may be needed to prevent odours.	• mixers – are they working? • aerators – are they working, if in place? • pumps – are they working? • odours – are odours controlled?

FLOW: GOOD





Flow meters

Typical raw sludge colour

Unusual colour of raw sewage due to a beetroot factory

FLOW: BAD

Non functioning flow metering device

PROCESS OPERATIONS: PROCESS CONTROL

PRIMARY TREATMENT

Notes (the what, why and how)	Look for :
Primary sedimentation  **5** The main purpose of primary sedimentation is to allow separation of the solid and liquid phase fractions in the wastewater. It removes the readily settleable solids which are mainly organics as well as the floating material such as fats, oils and grease. The settled solids are known as primary sludge. The process therefore reduces the suspended solids content of the influent wastewater. Even though the volume of primary sludge is only about 2% of the total influent wastewater volume, it makes up approximately 30 to 40% of the organic load received (expressed as COD) and some 40 to 60% of the suspended solids loading.	
Primary sedimentation tanks (PST)	
Look and listen to all moving parts to determine if the equipment is functioning properly. Odd vibrations or noises could be an indication that a piece of equipment needs maintenance or replacement. If there is more than one (1) PST, it is good practice to ensure that the flow to the PSTs is equally distributed. This can easily be checked by observing the overflow at the weirs – it should be similar. Weirs should be level to ensure uniform overflow of settled wastewater along the PST weirs. Check that the surface scum layer is being properly skimmed off and that there is no sign of belching. If the scum is not being skimmed off adequately, it could mean that: 1. Scrapers are worn or damaged 2. Sludge may be decomposing in the PST 3. There is return of well-nitrified waste activated sludge.	• inflow that should be light grey in colour • overflow at the weirs that is similar where more than one (1) PST is present • weirs in good condition • scum or floating sludge layer • layer of fats/grease/oil • a schedule for desludging and check that it is implemented • records of process sampling

It is important to adhere to the schedule of desludging. Septic sludge (black in colour with a very 'gassy' odour) may indicate that there is:

- inadequate rate of sludge scraper system so that the run time of scraper system should be increased;
- an insufficient rate of sludge pumping so that the frequency and duration of sludge pumping should be increased.

Pre-fermentation may however mean that the sludge would be darker than normal.

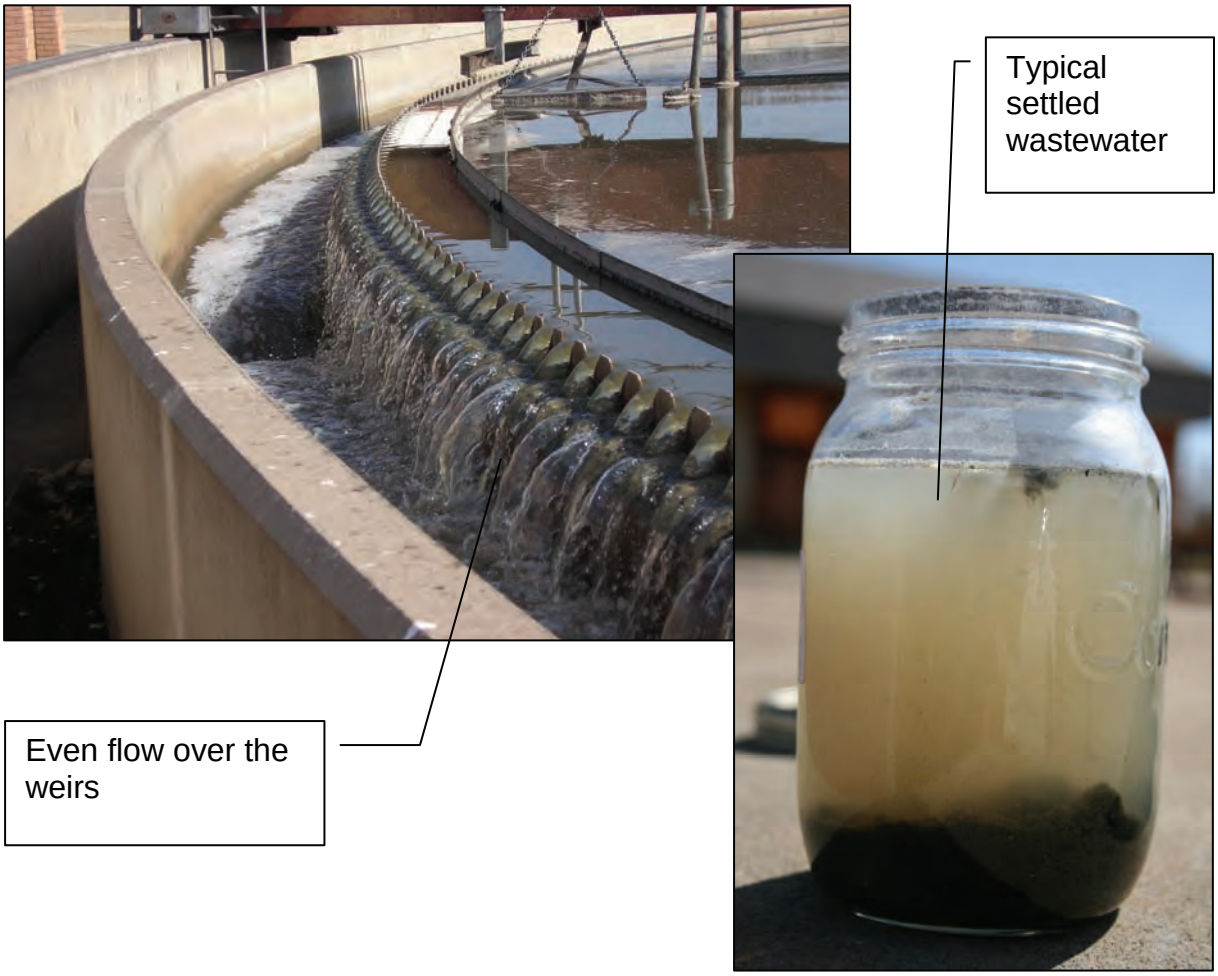
Process sampling should be undertaken on samples from the PSTs - daily if the capacity of the works is >20 Ml/day or twice a week if smaller.

- Suspended Solids (SS)
- Total and Volatile Solids (TS and VS)
- Chemical Oxygen Demand (COD)
- Imhoff cone tests on settleable solids in influent and effluent
- % dry solids in sludge underflow

Records should be kept of preventative maintenance procedures including:

- Lubrication schedules
- Spare parts (required and available)
- Stoppages and malfunctions

PRIMARY SETTLERS: GOOD



PRIMARY SETTLERS: BAD

Scum on the primary settler

Scum collected in the stilling baffle of the primary settler

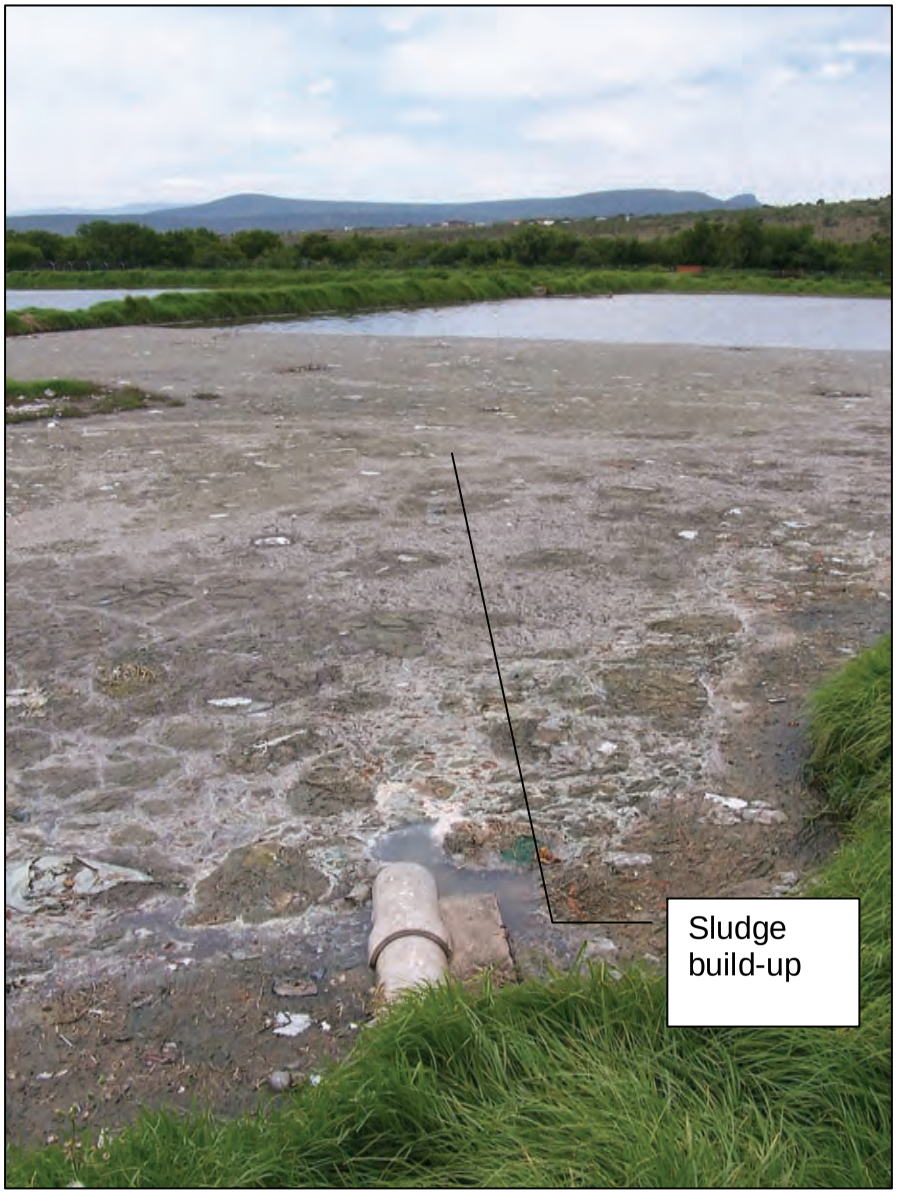
PROCESS OPERATIONS: PROCESS CONTROL PRIMARY TREATMENT	
Notes (the what, why and how)	**Look for:**
Pond systems  **6** Pond systems are relatively shallow bodies of wastewater in which the self-purification of processes of water are used under controlled conditions to purify raw or settled wastewater. The document entitled: ***Status quo assessment of wastewater ponding systems*****, WRC 1657/1/09,** is also available and gives detail on the assessment of pond systems.	
0xidation ponds	
Pond systems may be aerobic and anaerobic and at least four ponds should be linked in series. Short-circuiting means that the wastewater is following a course through the ponds that would mean that the detention time of the wastewater in the pond is inadequate to allow any biological purification to occur, so that the final effluent will be of very poor quality. Often, floating mechanical aerators are used to add air (oxygen) to one or more ponds to assist with the biological processes. The advantage of a floating aerator is that it is portable and can be easily removed or moved from place to place. Sludge buildup occurs in the first pond so that it will need to be desludged from time to time. The pond will need to be emptied and the sludge will need to be removed. It is therefore important that there is a parallel pond to which the influent can be diverted while desludging occurs. All sludge must be disposed of responsibly in accordance with the relevant authorisation in place. The area around the ponds must be kept clean and tidy. Any solids that have passed through the inlet must be removed from the surface of the ponds and disposed of with the grit and screenings if these are removed prior to the ponds. No solids should be allowed to accumulate on the side of the ponds.	• ponds operated in series • the presence of short-circuiting • aerators - are they working if present? • evidence of desludging - is it done periodically to a schedule and is sludge correctly disposed of? • area around the ponds – is it well maintained? • visible erosion around the ponds

OXIDATION PONDS: GOOD

Aerated pond with floating aerator in working condition

Well maintained pond

OXIDATION PONDS: BAD



PROCESS OPERATIONS: PROCESS CONTROL
SECONDARY TREATMENT

Notes (the what, why and how)	Look for:
Attached growth processes  7 Aerobic attached-growth treatment processes are those processes that utilise microorganisms that grow on a medium, such as stones and discs, to remove organic matter found in wastewater. They can also be used to achieve nitrification – the conversion of ammonia to nitrate/nitrite.	
Trickling filters (also known as biofiters)	
It is important to be able to access the top of the trickling filter to observe the rotating arm and distribution of the wastewater. A slow or stopped arm may be due to: insufficient flow clogged arms or orifices (small holes in the distributor arms) clogged distributor arm vent pipe bad main bearing the distributor arms not being level the distributor rods hitting the media. Uneven distribution may be due to clogged orifices on the distributor arms. Uneven distribution may cause the problems described above. It is therefore important to know the flows entering the works so that the flows can be evenly distributed, or filters taken off-line if necessary.	• access to the top of the filter • movement of the rotating distributor arm – is it smooth? • distribution of wastewater to the filter media through the rotating distributor arm – is it even? • filter media – is it free of ponding? • underdrains - are they clear of any obstructions?

PROCESS OPERATIONS: PROCESS CONTROL SECONDARY TREATMENT	
Notes (the what, why and how)	**Look for:**
Ponding may be due to: excessive biological growth thus not allowing the wastewater to flow through adequately poor media poor housekeeping. The underdrains need to be kept clean to allow free flow of the effluent from the filter. Material that has fallen off the filter material and collected in the underdrains of the filter must be cleared often and disposed of with the screenings and grit. Inorganic material should be removed from the filter media. Unpleasant odours could indicate that excessive organic load is causing anaerobic decomposition in the filter or that there is insufficient ventilation.	
Rotating biological contactors (RBC)	
These aerobic attached-growth treatment processes are also known as disk systems as they consist primarily of a set of disks, made of some man-made material mounted on a shaft that is mounted over the wastewater that is being treated. The shaft needs to rotate slowly so that the disks are immersed in the wastewater for a short period of time before returning to the air. This ensures that a biological slime develops on the disks in a manner similar to that of the biological filter. In time, this slime falls off and falls into the wastewater where it has to be settled out and removed/recycled. In this respect in order for the RBC to work adequately, all the instrumentation needs to be in working order. • The shaft must turn at a steady rate of rotation and not move unevenly	• the motor - is it working? • the disk system – does it rotate freely at a steady rate? • the sludge return pump - is it working? • the ammeter - does it fluctuate as the disk turns? • floating sludge in the final settling tank?

PROCESS OPERATIONS: PROCESS CONTROL SECONDARY TREATMENT	
Notes (the what, why and how)	**Look for:**
• The ammeter should not fluctuate (the needle move backwards and forwards) as the disk turns. Clumps of floating sludge may indicate that the sludge return pump is not working or that the sludge is sticking to the sides of the settling tank and not reaching the pump inlet.	

TRICKLING FILTERS: GOOD

Even distribution of wastewater

Well maintained trickling filter

Well maintained rotating distributor arms

TRICKLING FILTERS: BAD

Poorly maintained trickling filter. Arms have collapsed and no longer move around so that wastewater is only distributed onto one point of the filter. This will lead to short circuiting and the wastewater will not be treated.

Clogged orifices leading to uneven distribution of wastewater. This will cause the stone media to dry out and lose functionality.

ROTATING BIOLOGICAL CONTACTORS (RBC): GOOD

ROTATING BIOLOGICAL CONTACTORS (RBC): BAD

PROCESS OPERATIONS: PROCESS CONTROL
SECONDARY TREATMENT

Notes (the what, why and how)	Look for:
Activated Sludge Processes (ASP)  **8** The activated sludge process (ASP) is a biological process of developing an activated mass of microorganisms capable of stabilizing waste aerobically. Organic waste is introduced into a reactor where a bacterial culture (biomass) is maintained in suspension. The reactor content is referred to as the 'mixed liquor' or activated sludge.	
Activated sludge	
Visual observation of the ASP is very important. The colour, smell and appearance of the biomass give a good indication of whether the ASP is working well. The control of the solids retention time (SRT) (sludge age) is one of the most important controls in the activated sludge process. The mass of organisms in terms of actual sludge in the aeration basin can be expressed as the concentration of the sludge (kg.m^{-3} or g.ℓ^{-1}) multiplied by the volume of the basin in m^3. The product is the mass of sludge in kg. The mass of surplus sludge wasted per day can be expressed in kg per day (kg/d). Under stable operating conditions the mass of surplus sludge produced per day must equal the mass of sludge wasted per day. Typical sludge age is 15 days. Controlling the SRT at 15 days means regulating the amount of sludge wasted per day such that the average retention time of the sludge in the system is 15 days. The sludge wasted per day must then be 1/15 of the mass of sludge in the aeration basin.	• records of the sludge age • scum on the surface • records of he MLSS (mg/l) • records of the DO • dark brown biomass (colour) • an earthy smell • clean bunded chemical dosing area • records of daily process

The mixed liquor suspended solids (MLSS) concentration is one of the most important routine control tests for an ASP. Knowledge of the MLSS is necessary to know whether the solids loading on the clarifier are within suitable limits. In other words, will the mixed liquor settle adequately in the clarifier? The typical range for MLSS is 2 500 – 4 500 mg/ℓ.

Chemical dosing for ASP

Chemical dosing may be required at certain plants to assist with phosphate removal. The coagulating characteristics of the chemicals lead to the production of a clear effluent. A number of chemicals are effective for the removal of phosphates including: alum, ferric chloride, ferric sulphate and ferrous sulphates.

It may take some experimentation to determine the best point of application for the particular chemical and the Process Controller should get guidance from the chemical distributor. In this respect it is important to purchase chemicals from a reputable company. Based on the experimentation the Process Controller will then know :

- Where to dose the particular chemical
- How much chemical to dose
- When to dose (i.e. the frequency per day).

In all cases where chemicals are used, storage will be needed. Due to the nature of the chemicals used in the ASP, the chemicals must be stored in a bunded area so that if spillage does occur the chemical will be contained and can be cleaned up more easily.

The ASP, being a biological system, is extremely sensitive to change (e.g. pH, temperature). Daily process monitoring is therefore essential to ensure that the processes are working adequately and also to optimize the process to achieve a good quality final effluent.

Parameters to measure include:

- Chemical Oxygen Demand	- Nitrate	- Ammonia
- Dissolved oxygen	- Suspended solids	- pH
- Total dissolved solids	- Ortho-phosphate	

monitoring as appropriate to the ASP

- on-line equipment - is it in working order and calibrated; are calibration certificates available?
- aerators - are they in working order?
- recycling - is it taking place and is a record of the correct ratio of inflow to sludge recycle maintained?

If field or on-line equipment is used, it must be correctly and accurately calibrated as per the specifications from the supplier. An example of this is a dissolved oxygen (DO) meter. The control of dissolved oxygen (DO) in the aeration basin is important for: • Saving energy by avoiding excessive input of oxygen • Removal of nitrogen and phosphates from wastewaters where over-aeration of the activated sludge can decrease the removal rate of these nutrients • Sludge with good settling characteristics • Improvement in effluent quality. The ammonia should be monitored in the final effluent. If ammonia concentration is undetectable then cut back on aeration until the ammonia rises, but not exceeding 1 $mg\ell^{-1}$. The ideal range of DO concentration varies with the SRT, temperature and the need for nitrification. An indication of correct aeration is the concentration of the ammonia in the effluent. Over-aeration will result in an effluent with ammonia concentration that is virtually non-detectable. Aeration in the activated sludge process serves to: introduce oxygen into solution for the bacteria mix the incoming raw or suspended wastewater with the contents of the basin keep the bacterial mass in suspension. For adequate operation of the activated sludge process, it is important that the incoming raw wastewater is in contact with the bacterial mass while the dissolved oxygen is distributed throughout the basin. Elimination of dead spots is therefore important. Recycle in the activated sludge process is very important in maintaining the MLSS in the system and to avoid loss from the clarifier. In certain instances where biological nutrient removal is practiced, recycle is essential for both phosphate and nitrogen removal. It is important to ensure that the ratio of inflow to sludge recycle (s-recycle) is maintained at 1:0.8 to 1.	

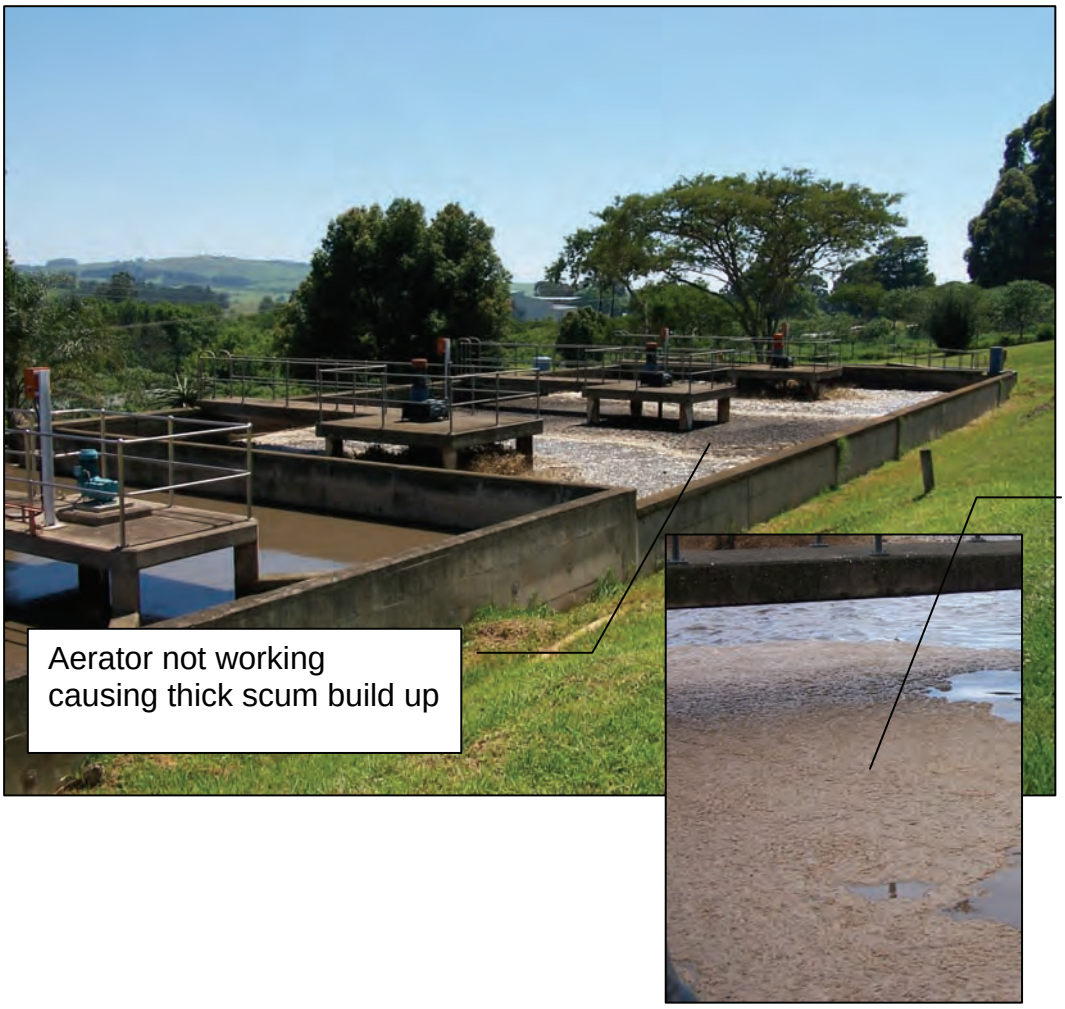
ACTIVATED SLUDGE (ASP): GOOD

Typical activated sludge colour and consistency

Well maintained activated sludge process

ASP showing distinct anoxic and aerobic zones

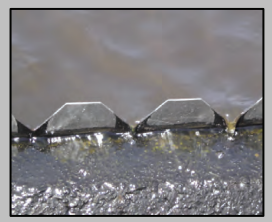
ACTIVATED SLUDGE (ASP): BAD



Aerator not working causing thick scum build up

Scum caused by filamentous bacteria

Aerators not working - it appears that biomass has settled

PROCESS OPERATIONS: PROCESS CONTROL SECONDARY TREATMENT	
Notes (the what, why and how)	**Look for:**
Clarification/ secondary settling  9 Clarification, also known as secondary sedimentation/settling, is required after the aerobic oxidation processes encountered with trickling filters and activated sludge plants. In both cases the purpose is to clarify the effluent and prevent solids carry-over to the water resource (e.g. river).	
Humus tanks	
Humus tanks are used for clarification following trickling filters. The amount of settleable humus solids is relatively small (ranging from 3-4% of the primary sludge). The clear overflow from the humus tank is the treated effluent that will undergo disinfection prior to disposal and the underflow, which contains the settled sludge solids, is the sludge return or recycle stream. The functioning of the humus tank can affect that of the biofilter. In order to avoid gasification or denitrification of the sludge, the sludge must be removed quickly. Solids in the overflow would indicate that settling is not occurring properly.	• clean scum troughs • clean effluent weirs and baffles • working sludge withdrawal equipment • clear overflow
Clarifier/ secondary settler	
Clarifiers, also known as secondary settlers, are used after the ASP. Sludge from the ASP is in suspension and must be settled out in the clarifier to produce two streams, i.e. the sludge and the clear effluent.	• trends of the SVI test • clean effluent weirs/channel

The Sludge Volume Index (SVI) is an indicates the settleability of activated sludge, i.e. the test gives an indication of the ease with which the sludge will settle and could be used by the Process Controller as a tool in the operation of the plant. **SVI test:** Consists of pouring mixed liquor into a 1 000 ml cylinder and allowing it to settle for 30 minutes. The level of the sludge is then measured (a). The MLSS (b) of the sludge is measured at the same time. The SVI is expressed as the density of sludge after settlement ($m\ell.g^{-1}$). This is obtained by dividing the volume determined in (a) by the mass (b) and is expressed in $m\ell.g^{-1}$, i.e. the better the sludge compacts, the lower the SVI. The weirs/launders of the clarifiers need to be kept clean to ensure uniform overflow rates. For the clarifier to operate optimally, the mechanical equipment must be in working order and therefore must be maintained. Scum on the surface of a clarifier could indicate: • Worn scraper blades • Blocked scum hoppers • An inadequate scum removal frequency. Desludging must take place in a manner that will optimize the clarifier operation and produce a clear effluent. Solids in the effluent may be due to : • Hydraulic overload; • a low sludge recycle; or • excessive solids loading. If the scum draw-off system is not in working order scum will accumulate on the surface and overflow with the final effluent.	• clean launders • operational desludging equipment • limited scum on the surface of the clarifier • an operational scum draw-off system • clear overflow

CLARIFIER/SECONDARY SETTLER: GOOD

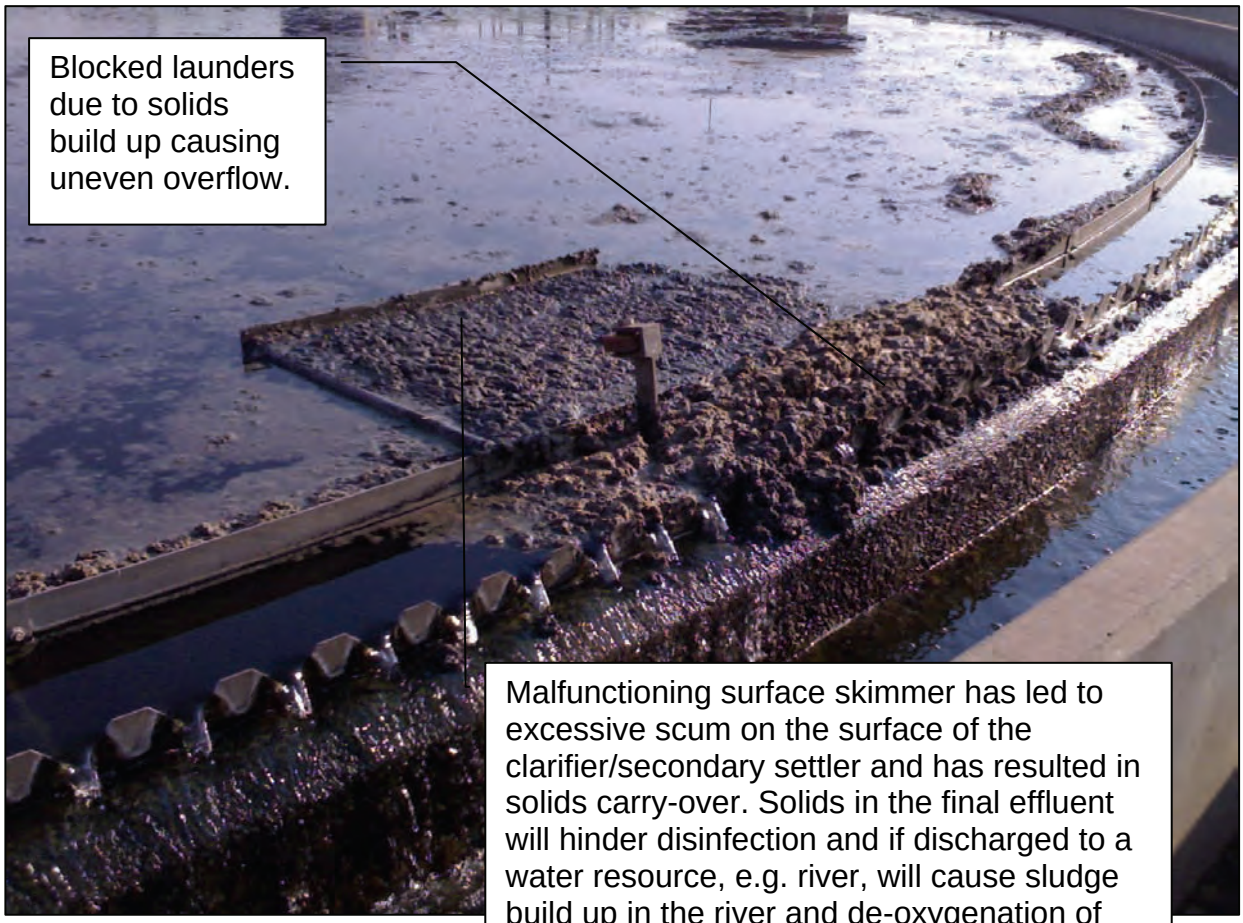
Clear, even effluent overflow

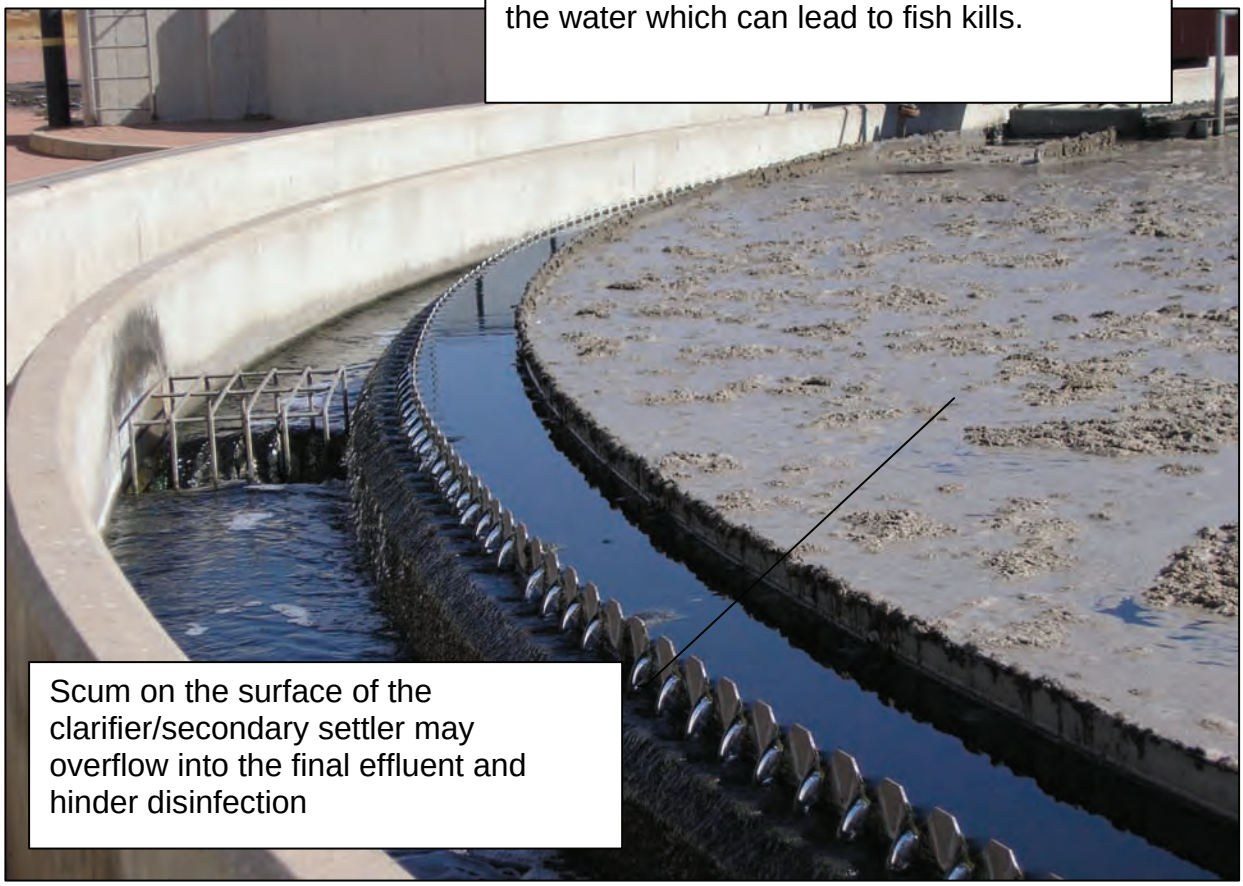
Well maintained launders with minimal algal growth

Good settling

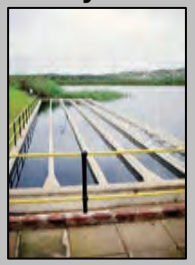
Well maintained bridge

CLARIFIER/SECONDARY SETTLER: BAD





PROCESS OPERATIONS: PROCESS CONTROL
TERTIARY TREATMENT

Notes (the what, why and how)	Look for:
Tertiary treatment  **10** Raw wastewater is a hazardous waste containing human pathogens and while each unit process reduces the number of microorganisms, high numbers of pathogenic organisms will still remain even after the best possible biological treatment. The goal of disinfection therefore is to remove or inactivate pathogenic microorganisms. However, disinfection is not synonymous with sterilisation, in which all organisms are killed. The primary pathogenic micro-organisms targeted for inactivation include bacteria, viruses and protozoan cysts. It is therefore very important to have disinfection process/equipment in place and in working order. The possible methods of wastewater effluent disinfection are many and include natural processes (predation and normal death), environmental factors (salinity and solar radiation) and methods having certain industrial applications (ultrasonics and heat). The systems for disinfection are also therefore numerous. This guideline however deals only with the most commonly used systems in South Africa.	
Chemical disinfection	
While the chemical disinfection systems are numerous, the use of chlorine is currently still the dominant disinfectant used at WWTWs either in the form of gas or solids such as sodium or calcium hypochlorite (HTH). Depending on the type of chemical being dosed, the equipment may differ. For example: ⇒ Gas chlorinators basically consist of a vacuum regulator with adjustable gas flow measurement via a float tube and an ejector on a pressure water line. The water passes through the ejector creating a vacuum so that the chlorine gas is sucked into water at the ejector and into solution. This solution is then added to the final effluent at a suitable point. The amount of gas drawn into the water at the ejector is regulated by a valve and measured on the float tube.	• the dosing equipment is in working order, e.g. the little ball in the rotameter is moving • no chlorine can be smelled • relevant training has been given to the Process Controller/s

PROCESS OPERATIONS: PROCESS CONTROL
TERTIARY TREATMENT

Notes (the what, why and how)	Look for:
⇒ Hypochlorite solutions may be drip fed or dosed via a metering pump ⇒ On very small WWTW tablet dispensers (HTH) can be used Apart from being corrosive, chlorine is also very poisonous. All personnel working with chorine must undergo relevant training on the use and handling of chlorine often on offer from the supplier. Should other chemicals such as bromine be used, the same should apply. Aquatic life is very sensitive to chlorine so there are standards set for discharges to a water resource. The common test undertaken for chlorine determination is known as the DPD method* and will give an indication of whether the chlorine concentration in the final effluent is too high. Each water use authorisation has a condition that specifies standards that have to be met in terms of the quality of the final effluent. These would include, but not be limited to, the following parameters: - Chemical Oxygen Demand - Nitrates - pH - Residual chlorine - Ammonia - Faecal coli - Ortho-phosphate - Suspended solids The frequency of monitoring for compliance will also be stipulated in the water use authorisation, however for performance monitoring of the WWTW, it may be necessary to monitor these parameters more frequently. The contact tank is where the chemicals do the job of disinfecting the final effluent. Solids in the effluent can interfere with this process. Sludge build-up also occurs due to settlement of solids because of the reaction with the chemical. It is therefore very important that the contact chamber is desludged at least every two weeks to ensure that adequate kill of pathogens occurs.	• residual chlorine level is being measured in the final effluent using the DPD method* • the contact tank is clean (i.e. not sludged up) and free of algae • final effluent samples are taken in accordance with water use authorisation

PROCESS OPERATIONS: PROCESS CONTROL TERTIARY TREATMENT	
Notes (the what, why and how)	**Look for:**
*DPD Method: this method test kits use a powder or tablet chemical DPD (N,N diethyl-p-phenylene diamine) that causes a color change to pink in the presence of chlorine. The field worker uses a color wheel/chart to visually match the color to a numerical free or total chlorine reading. The test kit can be used to measure free chlorine and/or total chlorine, with a range of 0-3.5 mg/L, equivalent to 0-3.5 ppm (parts per million).	
Constructed wetlands	
Artificial or constructed wetlands consist of a bed of granular material through which the effluent can flow without too much hydraulic resistance. The flow may be through the media in sub-surface flow or over the top of the bed. The surface of the bed is planted with reeds. These may be of a variety of types, the most common being *Phragmites australis*, which grows wild in many parts of South Africa. Control of reeds can involve: • Harvesting, by cutting or dredging to control species development diversity, positioning and dominance. Nutrients assimilated are also removed from the system by harvesting though the effect of this on total nutrient removal is limited • Burning provides the same control as harvesting, though nutrients may be released back into the water body, and the conservation and ecological aspects of the natural wetland are seriously affected. Harvesting and burning remove carbon from the system. Carbon provides the energy source for important reactions such as denitrification and sulphate reduction. The removal of the surface layer also influences evapo-transpiration, and the composting process, which assists in controlling temperature below surface. Periodic seeding and planting of candidate species will influence the natural development of the wetland and provide more controlled sites for wastewater treatment within the ecosystem.	• reeds are planted • reed growth is controlled using a schedule • selective seeding and planting is undertaken periodically • samples are taken according to relevant authorisation • herbicidal and insecticidal treatment is practiced

PROCESS OPERATIONS: PROCESS CONTROL TERTIARY TREATMENT	
Notes (the what, why and how)	**Look for:**
Herbicidal and insecticidal treatment to control the development of undesirable weed species, algae and aphids may be done. It is, however, important to know what effect these may have on the quality of water that is leaving the wetland. Each water use authorisation has a condition that specifies standards that have to be met in terms of the quality of the final effluent. These would include, but not be limited to: - Chemical Oxygen Demand - Nitrates - pH - Residual chlorine - Ammonia - Faecal coli - Ortho- phosphate - Suspended solids The frequency of monitoring for compliance will also be stipulated in the water use authorisation, however for performance monitoring of the WWTW, it may be necessary to monitor these parameters more frequently.	
Maturation ponds	
Maturation ponds give a final 'polish' to effluents before discharge. They are used to improve the bacteriological quality of the final effluent and can also act as a buffer in the event of a breakdown at the works. If used after a process such as the activated sludge process, a series of maturation ponds can reduce the bacteriological count considerably. The water use authorisation will give specific conditions with respect to the quality of the final effluent and the frequency at which sampling must take place. The ponds and surrounds should be kept neat and tidy to minimize nuisance conditions which include rats, snakes and insect infestations. Due to the fact that the ponds are shallow, plant growth is common and needs to be controlled.	• overflow is clear • no erosion is observed • the banks of the ponds are protected against erosion

CHEMICAL DISINFECTION: GOOD

Well maintained gas cylinder room and well housed gas cylinders on scales

Well maintained dosing equipment placed externally to the gas cylinders

Effective mixing

Effective aeration after disinfection and before discharge to the resource

CHEMICAL DISINFECTION: BAD

Inadequate chlorination dosing technique

Scum on the chlorine contact tank that will interfere with disinfection and enter the resource

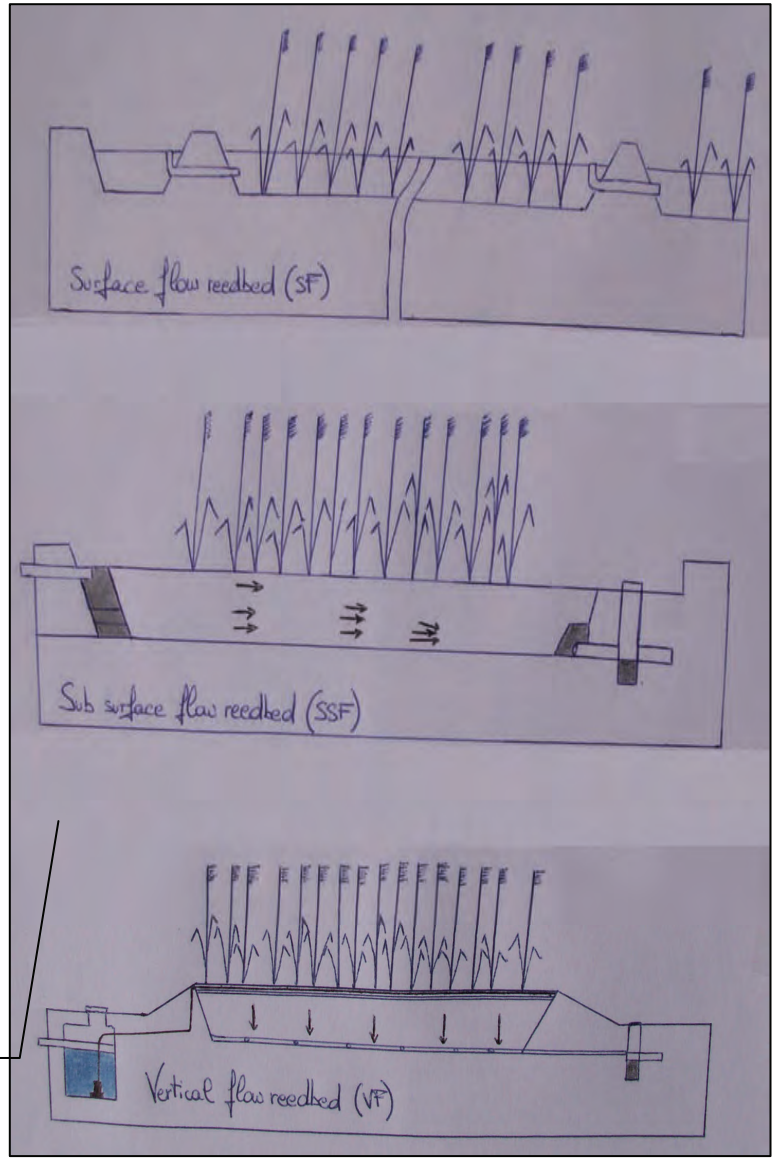
Dysfunctional dosing unit

CONSTRUCTED WETLANDS

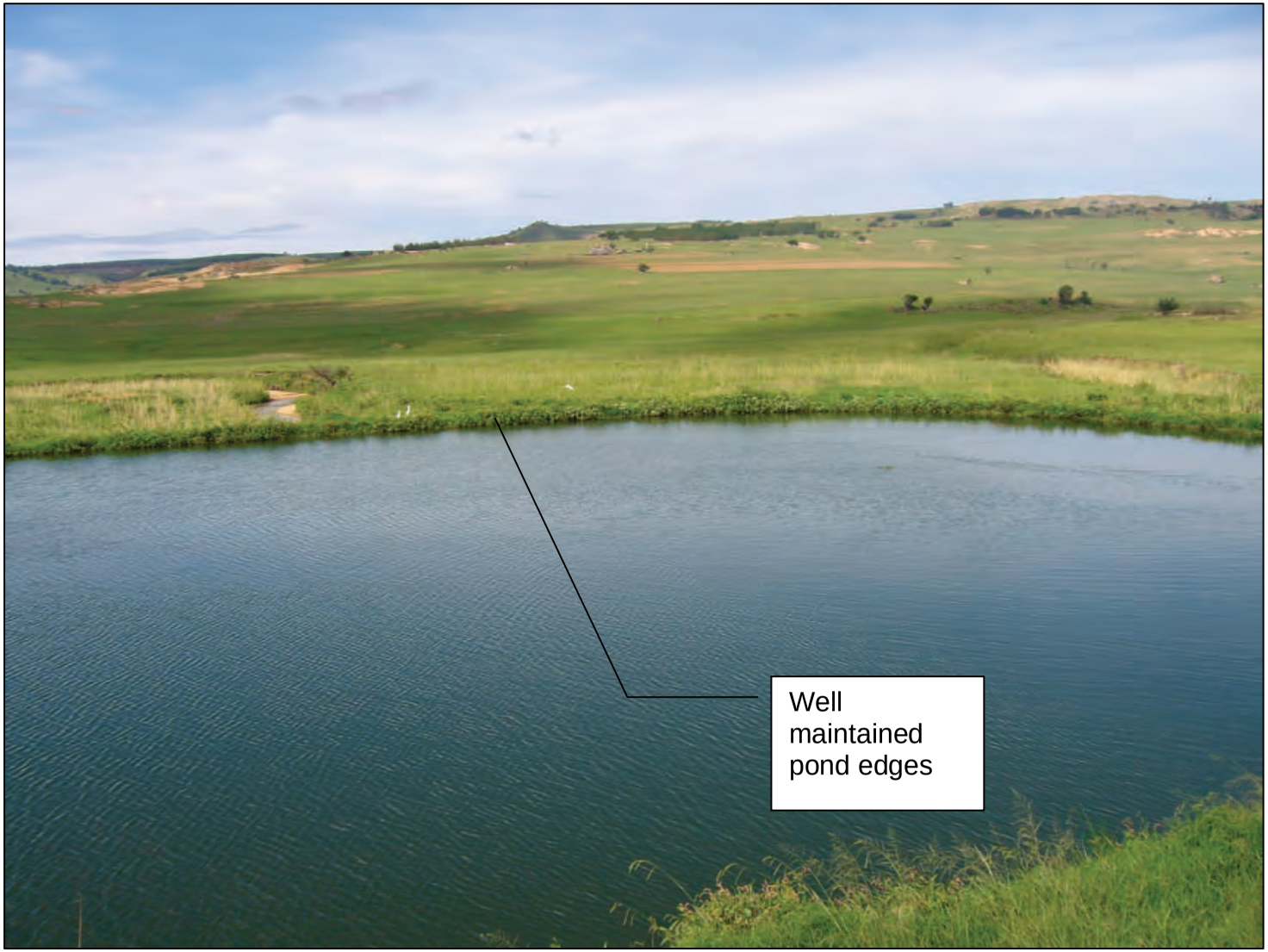
Good growth of reeds

Planting of reeds

Types of constructed reed beds



MATURATION PONDS: GOOD



Good safety signage around maturation ponds

MATURATION PONDS: BAD

PROCESS OPERATIONS: PROCESS CONTROL TERTIARY TREATMENT	
	Look for:
FINAL EFFLUENT  Environmental and human health is dependant on good quality effluent being discharged to a water resource or disposed of to the environment as for example, irrigation water.	
Sampling frequency	
In order to get an understanding of the effluent quality, it is important to take final effluent samples daily and to record the results to get a trend. Sampling on a frequency less than this would render the overall interpretation of the results meaningless. All authorisations contain conditions which stipulate the frequency of monitoring and the parameters to be measured. At least pH, COD, phosphate, nitrate, ammonia, suspended solids and faecal coliforms and electrical conductivity should be monitored. A consistently good effluent indicates that the wastewater works is running well.	Sampling frequency: • daily • weekly • bi-weekly • monthly
Sampling location	
Regardless of whether a WWTW discharges effluent or disposes of it in another manner such as irrigation, the final effluent quality must be known. Where effluent is discharged, the sampling locations are very important and there should be at least three sampling locations.	Sampling location: • upstream of WWTW • point of discharge • downstream of WWTW

PROCESS OPERATIONS: PROCESS CONTROL TERTIARY TREATMENT	
• Upstream of the WWTW to indicate the quality of the water in the river before the WWTW • At the point of discharge to understand the quality of effluent being discharged to the water resource in comparison to the river water quality • Downstream of the WWTW to understand the impact that the discharge is having on the water resource.	
Final effluent quality	
At least pH, COD, phosphate, nitrate, ammonia and faecal coliforms, electrical conductivity and suspended solids should be monitored. A consistently good effluent indicates that the wastewater works is running well. While in terms of any authorisation, the final effluent quality compliance should be 100%, it is expected that non-compliance will occur at some stage for various reasons. In this respect it is reasonable that the final effluent from a wastewater works should comply at least 80% of the time for all parameters measured. The results need to be interpreted against the authorisation conditions. The Process Manager must understand how to calculate the % compliance and keep a graphical record of the monthly compliance per parameter. How to calculate compliance per parameter: (Sum of monthly results that comply per parameter) x 100 = % compliance (Number of samples taken)	• records of final effluent quality • compliance figure • a graphical record of final effluent quality

FINAL EFFLUENT: GOOD

Clear final effluent being discharged to a water resource. Limited algae and sludge are visible.

Continuous sampler for final effluent sampling after chemical disinfection

FINAL EFFLUENT: BAD

Poor discharge of final effluent – discharge point should not be submerged. Final effluent should preferably cascade to allow final aeration before entering water resource.

PROCESS OPERATIONS: PROCESS CONTROL
SLUDGE TREATMENT

Notes (the what, why and how)	Look for:
Thickening  **11** The main reasons for thickening sludge prior to digestion are: • To maximize the use of the available digester capacity in the digestion of the solids (i.e. water takes up space) • To prevent the dilution of the feed material which could cause difficulty in the utilization of the food by the bacteria • To reduce the amount of heat required in a heated digester • To prevent the washout of solids and micro-organisms from hydraulically overloaded digester • To prevent the dilution of the generated alkaline buffer in the digester as this could cause pH instability. Regardless of the type of sludge, the concentration of the thickened solids should be high enough to promote effective digestion, but not too thick to adversely affect pumping and mixing of the sludge in the digester. In smaller plants, thickening is achieved in the primary settling/sedimentation tank or in the sludge digestion unit. In larger plants there may be a separate thickener, e.g. gravity and dissolved air flotation thickeners. Thickening is also important in the dewatering process.	
Gravity thickening	
It is important for the operating staff to familiarise themselves with the manufacturer's instructions for operating the gravity thickener. For the thickener to operate optimally, the mechanical equipment must be in working order and therefore must be maintained. Scum problems are often encountered when the sludge is kept too long in the gravity thickener. It is therefore important to draw off sludge at regular intervals. In case of scum problems, it may be necessary to fit a high-pressure spray that covers a portion	• mechanical equipment - working order • a schedule for sludge draw -off

PROCESS OPERATIONS: PROCESS CONTROL SLUDGE TREATMENT	
Notes (the what, why and how)	**Look for:**
of the tank. Grease build-up in underflow lines is also a potential problem especially in works where no grease and fat removal is practised in the PST. Grease and fat particles cling to the sludge particles and settle out. High-pressure water hoses can be used to flush out the sludge lines. A plant Imhoff cone test of the settleable solids in the supernatant liquor from the thickener and a total solids analysis of the sludge underflow rapidly indicate the efficiency of the thickening process. In order to optimize the frequency and duration of desludging, a total solids test should be carried out on the underflow. The feed to the gravity thickener should be as near to continuous as possible. This promotes a stable sludge blanket and also tends to reduce gasification and the resultant floating sludges. Chemicals such as polymers (usually powder that must be mixed), lime (powder that must be mixed) or ferric chloride (liquid in a tank) may be added to the sludge beforehand to aid in the thickening process. These should be kept within a bunded area to contain spills. It is important that excessive solids are not carried into the overflow.	• adequate skimming of scum • records of settleable solids (overflow) and total solids (sludge underflow) • feed to the thickener - should be continuous • chemicals used for conditioning - are they adequately stored in a bunded area? • overflow - excessive solids are not being carried over
Dissolved air flotation	
Establish the required inflow rate of sludge and adjust if necessary. The DAF system consists of three main unit processes: ⇒ The pressurisation system ⇒ The flotation tank ⇒ The recycle system. Should there be a malfunction in any one of these units, then the system will not function.	• air compressors - are in working order • valves and pressure gauges - are in working order • leaks in the pipes and pumps

PROCESS OPERATIONS: PROCESS CONTROL SLUDGE TREATMENT	
Notes (the what, why and how)	**Look for:**
The rising sludge is guided upwards and outwards by the tiny bubbles to form a floating scum, which is removed from the surface by skimmers. The surface skimmers are set at a level above the water level to allow float to form above the water surface. This allows drainage of the upper float layer, and thickening. Solids in the clarified liquor may be an indication that desludging is not being done often enough. Results of total and volatile solids from tests done on composited samples from the feed to the thickener and the underflow from the thickener provide information on the solids loading rate to the thickener and the anaerobic digester respectively and also on the degree of thickening achieved. Suspended solids on composited samples of the overflow liquor from the thickener provide information on the success of the thickening operation. Chemicals such as polymers (usually powder that must be mixed), lime (powder that must be mixed) or ferric chloride (liquid in a tank) may be added to the sludge beforehand to aid in the thickening process. These should be kept within a bunded area to contain spills. The underflow should not contain a large concentration of solids and if present, this is an indication that there is a problem somewhere in the process.	• surface skimmers on the flotation tanks - are working adequately • clarified liquor - free of solids • records of settleable solids (overflow) and total solids (sludge underflow) • chemicals used for conditioning – are they safely stored in a bunded area? • underflow - few solids are carried over

DISSOLVED AIR FLOTATION

Well maintained dissolved air flotation unit showing clear, even overflow

Well maintained dissolved air flotation unit showing good housekeeping around the tanks

PROCESS OPERATIONS: PROCESS CONTROL
SLUDGE TREATMENT

Notes (the what, why and how)	Look for:

DEWATERING

12

Sludge is a mixture of solid matter, both organic and inorganic, and water. The amount of solids in this mixture, or suspension, is usually defined as the ratio of the mass of dry solids to the total mass of the sludge and is expressed as a percentage.

Dewatering is therefore important in reducing the volume of sludge to be disposed.

Example: 1 ton of wet sludge with 4% solids content will contain only 40 kg of solids when completely dried out.

Filter press/belt press

Flocculent is added to the thickened sludge to aid in the dewatering process. It is usually supplied as a powder and needs to be mixed. In this respect it must be correctly stored in an area where the chemical can be contained, should there be any spills from the bags. If belt presses are being used for dewatering sludge, they must be kept in working order to avoid the problem of sludge building up. The visual quality of the filtrate and washwater will give an indication of how well the presses are working. A poor visual quality filtrate will indicate that there is a problem with the feed or the presses themselves.	• flocculent - stored safely and within a bunded area • belt presses - in working order • records of feed to the presses - measured • records of the quality of the filtrate and washwater

PROCESS OPERATIONS: PROCESS CONTROL SLUDGE TREATMENT	
Notes (the what, why and how)	**Look for:**
Drying beds	
If debris is allowed to collect in the sludge lines, blockages will occur and the sludge will not reach the drying beds causing problems upstream of the drying beds. An important aspect of bed maintenance is the raking and leveling of the bed. Water that drains from the sludge will cement the sand particles and lead to increased resistance to filtration in the sand and eventually, complete blockage. The walls and floors of the drying beds need to be inspected regularly and maintained. Cracks that form due to settlement or for any other reason, lead to the leakage of sludge or drainage water. The drying beds should be weeded on a regular basis as weeds slow down the drying process. Each time sludge is removed after drying, a few millimetres of sand is lost. The sand therefore needs to be replaced at regular intervals to compensate for this loss. An excessive dewatering time could indicate that the draining and piping system is blocked or broken. Samples for analysis of total solids of composite samples of feed sludge and dried sludge must be taken per bed. Maintain records of: • drying time per bed • thickness of sludge layer added and date of application • malfunctions • climatological records (e.g. rainfall).	• sludge lines - are they free of debris? • sludge on the beds - is it raked to keep it level? • walls of the drying beds – are they intact? • beds – a they free of weeds? • a schedule for replacement of sand as dried sludge is removed • the draining system and piping - is it working? • records of total solids determination

FILTER/BELT PRESS: GOOD

Well maintained belt press area showing belt press cake falling onto the convevor

Even distribution of sludge onto the filter belt presses

FILTER/BELT PRESS: BAD

DRYING BEDS: GOOD

Well maintained drying beds and valves with even distribution of sludge

DRYING BEDS: BAD

PROCESS OPERATIONS: PROCESS CONTROL
SLUDGE TREATMENT

Notes (the what, why and how)	Look for:

Stabilisation

13

The wastewater solids are treated in the anaerobic digesters after primary sedimentation and thickening. This process of digestion converts the raw sludge from a smelly putrescible nature to a substance that is relatively odour-free, readily dewaterable and sufficiently stabilised to be disposed of without causing nuisance conditions.

Anaerobic digestion

The 2-stage biological process utilizes acid forming bacteria which convert the organic matter to organic acids which are then converted to methane (CH_4) and carbon dioxide (CO_2) by methane forming bacteria.

It is important that the organic acids formed in the first stage are converted to methane at the same rate at which they are formed. If not, instability will occur and ultimately digester failure.

Parameters to measure:

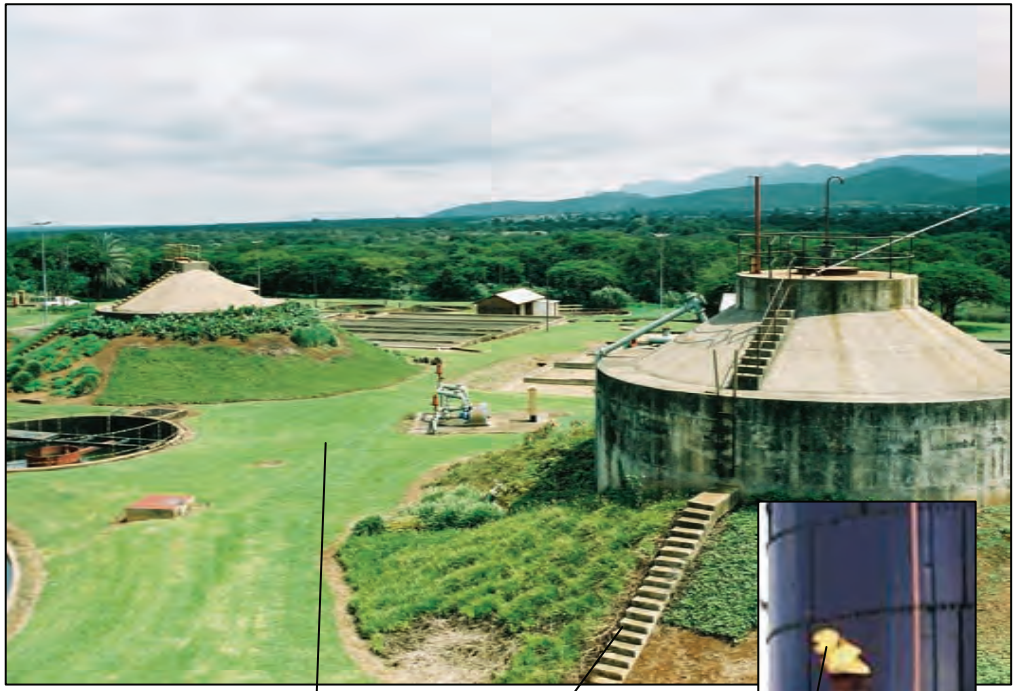
- Feed rate
- Alkalinity
- pH value
- Volatile solids reduction
- Volatile solids loading rate
- Carbon dioxide content of the biogas
- Volatile acids
- Volatile Acids/Alkalinity ratio
- Biogas production rate
- Temperature
- Hydraulic retention time

- level of the grit and sand in the digester
- records of alkalinity measurement
- bottom draw-off – working
- records of sludge retention time
- schedule for filling and wasting
- unusual noises

PROCESS OPERATIONS: PROCESS CONTROL
SLUDGE TREATMENT

Notes (the what, why and how)	Look for:
<u>Biogas management:</u> The main constituents of gas produced in a digester are methane (60-75%) and carbon dioxide (25-40%) with small amounts of nitrogen (1-5%), hydrogen sulphide and hydrogen. A typical gas handling system comprises: - digester cover pressure and vacuum relief devices - flame trap - gas meter - pressure gauges - water trap - pressure regulator - check valve - waste gas burner - gas holder (this may be as a floating roof on the digester or it my be a separate gas holder) If mixing of the digester is done by means of gas recirculation, then a compressor will be required. **!** It is important to note that biogas and air can form an explosive mixture For this reason it is very important to do monthly checks on: • pressure and vacuum relief devices • valves and gauges and to keep records of: • the maintenance of the above • the gas flow rate between the digester and the gas holder. If the volume of the gas in the gas holder seems lower than expected, then it is important to check for leaks immediately.	• schedule for supernatant and sludge withdrawal • pressure gauges - in working order • pressure relief device- in working order • colour of the flame - yellow with blue at the base • records of relevant parameters monitored • records of compliance to current sludge guidelines • records of maintenance of pressure and vacuum relief devices • records of maintenance of valves and gauges • records of gas flow rate from the digester to the gas holder

ANAEROBIC DIGESTION: GOOD



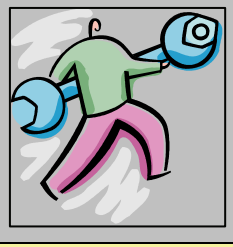
Well maintained areas around the digesters

Good access to top of digester

Biogas flare

ANAEROBIC DIGESTION: BAD

Badly maintained digester showing cracks in the structure where plants are growing

PROCESS OPERATIONS: SAFETY AND MAINTENANCE	
Notes (the what, why and how)	**Look for:**
Maintenance Operations 	**14**
Maintenance schedule	
A planned maintenance schedule is essential to ensure that mechanical equipment is always in working order. A schedule needs to be drawn up and implemented by the Process Manager.	• maintenance schedule • records that it is implemented
Housekeeping	
The area around all the unit processes must be kept clean and tidy. No solids that may be removed from the processes, and in particular the grit and screenings area, should be allowed to accumulate on the side. *Sludge disposal areas* It is imperative that good housekeeping is practiced around the areas where sludge is being dewatered and/or stored prior to disposal to ensure that no odours and pests such as flies and rats occur.	• paved areas - free of weeds • grass - kept short • evidence of rodents • flies • areas around each unit process - neat and tidy

PROCESS OPERATIONS: SAFETY AND MAINTENANCE	
Notes (the what, why and how)	**Look for:**
Standby equipment	
Standby equipment such as pumps and motors should be kept on site so that when a pump/motor needs maintenance, the standby can be put in place and the operation of the works will not be disrupted. It is imperative to ensure that standby equipment is available and in working order.	• standby equipment – in working order • record of who does the maintenance
Malfunctions	
It is important to keep a record of all malfunctions or mechanical equipment that is broken, the date when they were reported and when the repair was done. In this respect it is important to ensure that the necessary spare parts are kept on site.	• record of malfunctions – is it reported and is date of repair on hand?
Maintenance Personnel	
Suitably qualified fitters and electricians should always be available – they do not have to be on site but should be available to report to the WWTW within a reasonable timeframe.	• evidence of suitably qualified fitters and electricians

MAINTENANCE: GOOD

Well maintained pumps and valves

Well maintained chemical dosing system

MAINTENANCE: BAD

Poor maintenance

Badly maintained mixer

PROCESS OPERATIONS: SAFETY AND MAINTENANCE	
Notes (the what, why and how)	**Look for:**
Safety  **15**	
Personal Protective Equipment	
To comply with the OHSA PPE, overall, safety shoes, hard hat, gloves should be worn as required. In the case of an activated sludge plant where blowers are used, ear muffs would be essential. Masks should be available if there is excessive spray.	• PPE – is it adequate?
Safety signage	
In terms of the Occupational Health and Safety Act, it is important to have visible safety signs, e.g. where tap water is not to be used for drinking purposes, the dangers of chlorine and safety equipment to be worn when entering, etc.	• safety signage - is it adequate?
Safety equipment/ mechanisms	
In terms of the Occupational Health and Safety Act, safety equipment/mechanisms such as safety railings and life saving equipment, etc. must be in place where necessary, e.g. around large tanks that are partially sunk and other areas where there is a possibility of falling in.	• hand rails – adequate? • life saving equipment – is it easily accessible? • Ladders – are they present

PROCESS OPERATIONS: SAFETY AND MAINTENANCE	
Notes (the what, why and how)	**Look for:**
Activated sludge The activated sludge process operates 24 hours a day providing an almost continuous health and physical hazard. The following safety issues are important: Adequate accessibility must be provided to all parts of the plant that need maintenance, e.g. surface aerators, DO probes, recycle pumps and other units of modern activated sludge plant. Bridges, complete with handrails and other safety features, should be provided to these points. The bridge should be low enough or have a rail just above the water level as a safety device. Proper access should also be provided for sampling. Other safety devices that should be available include: • Handrails • Buoys with a long enough rope tied to a fixed object so that it would be possible to retrieve a person from the basin should they fall in • Hanging a few nylon ropes with loops just above the liquid level as a safety feature. Where chemicals such as chlorine are being dosed self contained breathing apparatus (SCBA) must be available and the expiry date is relevant. This apparatus must be kept out of the chlorine room. Fire extinguishers must be serviced annually.	where needed? • SCBA gear - is it easily accessible?
Emergency preparedness	
Relevant emergency contact numbers (including the fire brigade, ambulance, police) must be well displayed at various points around the works, e.g. – • On a notice board at the entrance to the WWTW • On a notice board in a change room • On a notice board in a dining area, if present.	• emergency contact numbers are clearly posted in several areas.

PROCESS OPERATIONS: PROCESSCONTROL	
Notes (the what, why and how)	**Look for:**
Laboratory  **16**	
In-house	
Certain WWTWs have a laboratory on site. To ensure quality, it is important that the laboratory takes part in inter-laboratory quality assurance. It is also important that the laboratory uses recognised standard methods of analysis. The Process Manager must ensure that he/she receives the results of the analyses within as short a time as possible to be able to interpret the results and make operational adjustments as required.	• records on inter-laboratory quality assurance • evidence that results are received within 24 hours
Out-sourced	
If the samples are sent to an external laboratory, the ideal situation would be that the laboratory is accredited. The laboratory should therefore provide evidence of participation in an inter-laboratory quality assurance programme. It is also important that the laboratory uses recognised standard methods of analysis. The Process Manager must ensure that he/she receives the results of the analyses within as short a time as possible to be able to interpret the results and make operational adjustments as required. (Note: for less capacitated municipalities that may not receive results within 24hours there needs to be some agreement with the lab that results can be given telephonically to say whether there is a problem or not).	• records of quality assurance between laboratories • evidence that results are received within 24 hours

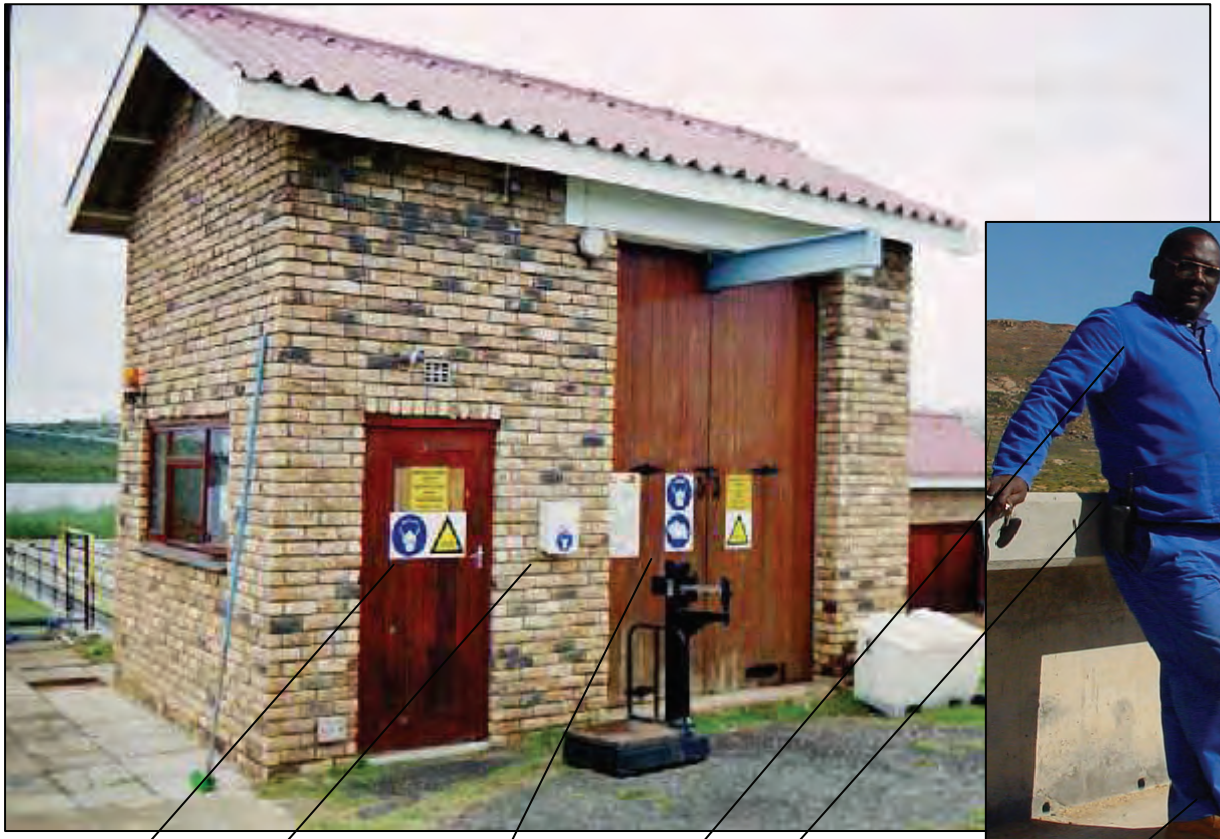
SAFETY AROUND THE WWTW

High-quality fencing

Well sign-posted entrance

Relevant safety signs on the fence of the WWTW

SAFETY: GOOD



Good safety signage and SCBA

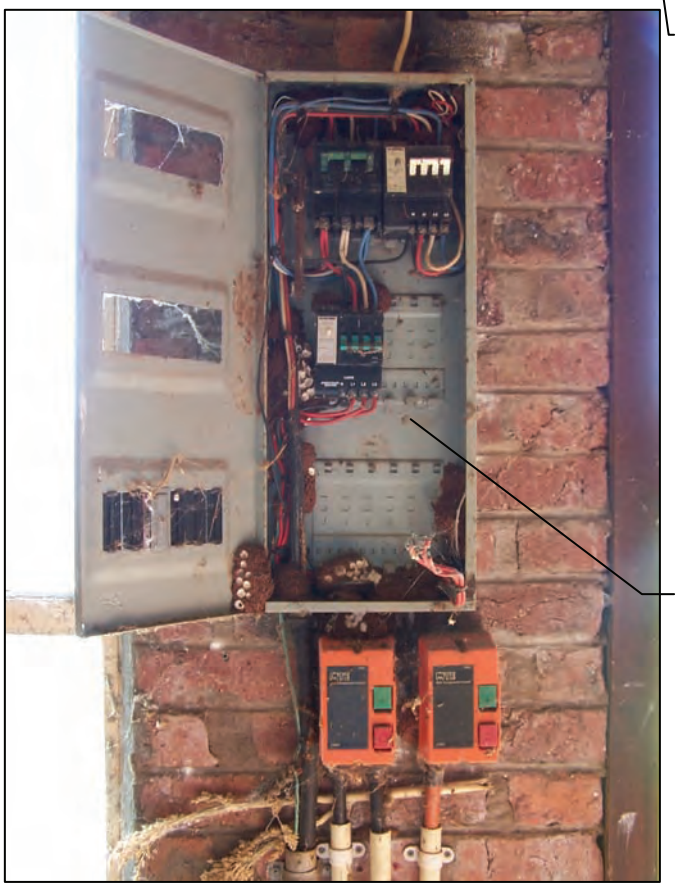
PPE: safety shoes; overall; radio. (Note: different PPE is required for different jobs on the WWTW.)

Well maintained safety railings

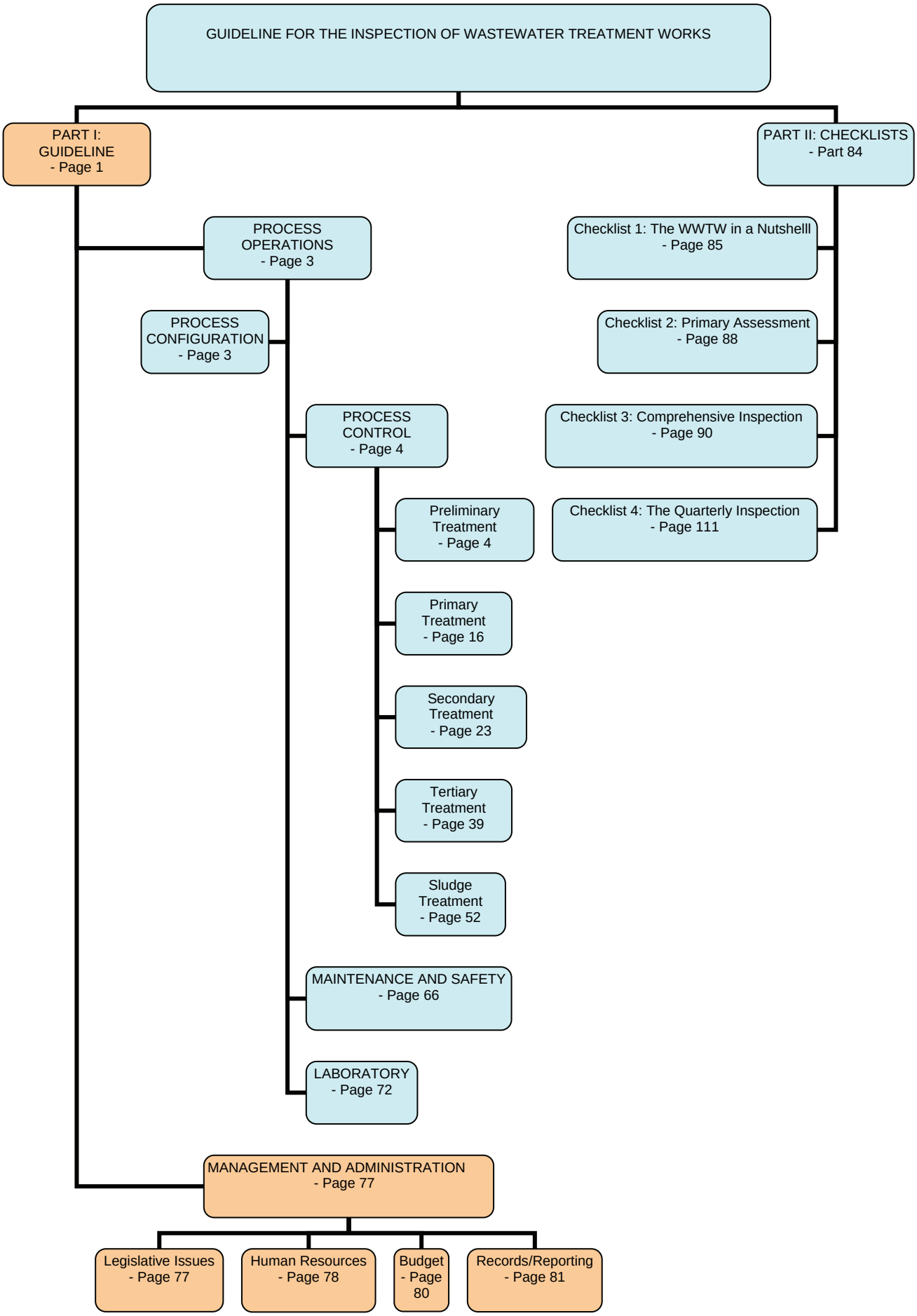
SAFETY: BAD

Cables should be buried and not lying open on the ground

Bad housekeeping in the chlorine room



Poor maintenance of electrical equipment leads to safety hazards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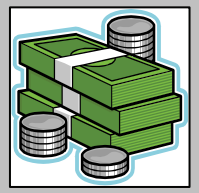
MANAGEMENT AND ADMINISTRATION	
Notes (the why, what and how)	**Look for:**
Legislative issues 	**17**
Classification	
In terms of NWA and WSA regulations, all waterworks, the definition of which includes WWTW, must be classified based on various criteria. The Process Controller in charge of the WWTW must discuss this issue with the relevant administrative personnel who must request the relevant forms from DWAF. Once received, copies of the certificates should be kept at the WWTW.	• classification certificate for the WWTW (or at least a copy thereof)
Water Use Authorisation	
Section 21 of the National Water Act of 1998 defines all water uses that must be authorised, i.e. discharge of treated effluent, disposal to ponds and irrigation of treated effluent. All WWTWs will fall within some sort of authorisation including: • General Authorisations (GA) • Existing Lawful Use (ELU) • Water Use Licence (WUL). All of the authorisations are legal instruments that will have certain conditions, such quantity and quality issues that must be met. The authorisations may also refer to other relevant regulations or guidelines that must be met.	• a copy of relevant authorisation at the WWTW

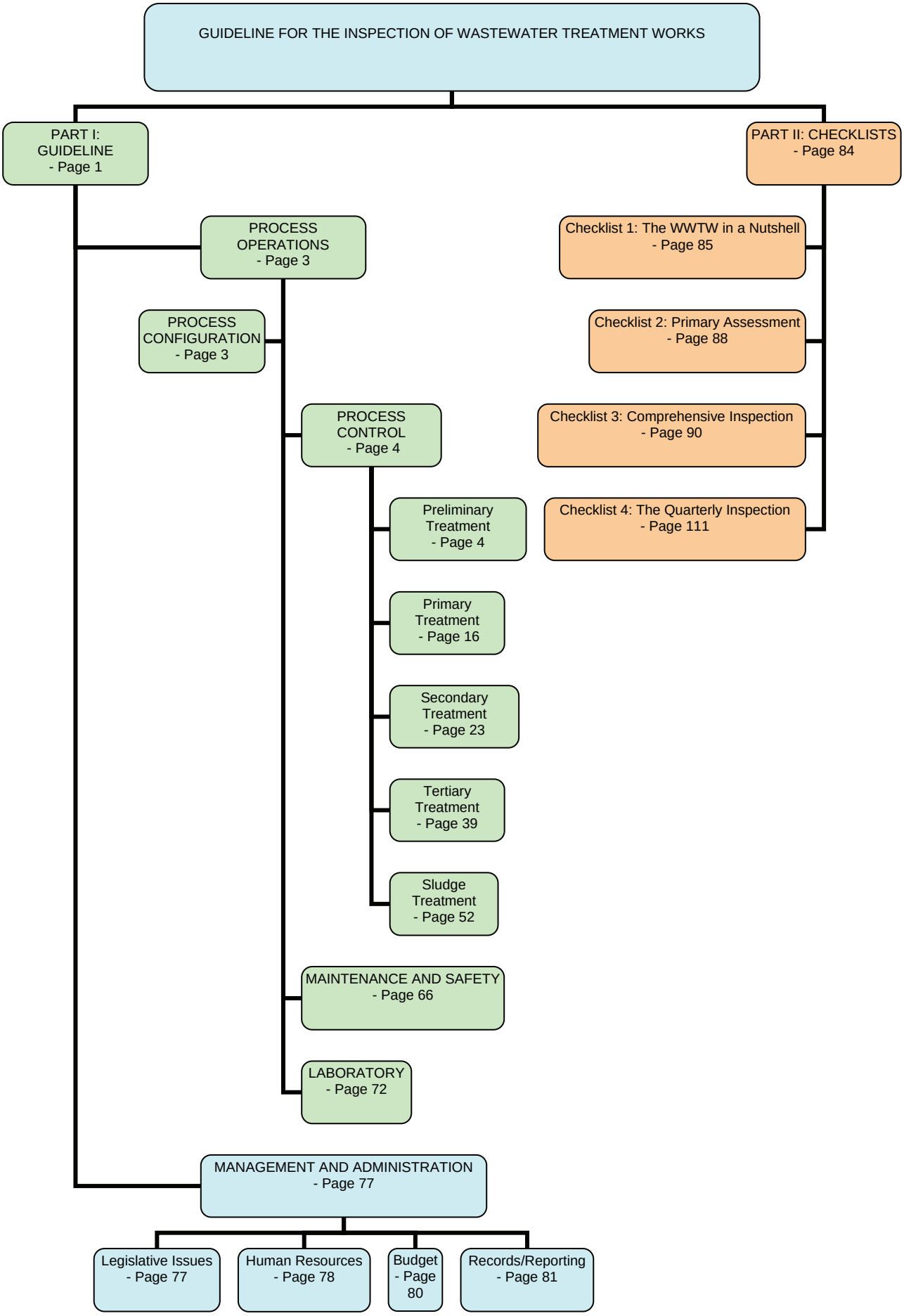
MANAGEMENT AND ADMINISTRATION	
Notes (the why, what and how)	**Look for:**
Human Resources 	**18**
Operational staff (Process Controllers)	
The Process Controllers (operational personnel) need to be registered in terms of DWAF regulations (regulation 2834 or any update thereto) as this is a legal requirement in terms of the NWAct and/or the WSAct regulations. Depending on the classification of the WWTW, the Process Controllers need to be correctly placed. The Process Controller in charge of the WWTW must discuss this issue with the relevant administrative personnel who must request the relevant forms DWAF. Once received copies of the certificates should be kept at the WWTW.	• registration certificates of operational personnel
Maintenance personnel	
Maintenance personnel (including electricians and fitters) need to be available at all times. The maintenance function may be done in-house or contracted out. However, the Process Controller in charge needs to be in close contact with any in-house or external maintenance contractors who are not always on site. The maintenance personnel need to be able to respond within a reasonable timeframe (the time taken to respond must be such that the breakdown does not severely affect the final effluent quality). The Process Manager must discuss any concerns with management who must resolve the problem with the relevant in-house maintenance section or external contractor.	• evidence (such as a contract) that maintenance personnel are available within a reasonable timeframe

MANAGEMENT AND ADMINISTRATION	
Notes (the why, what and how)	**Look for:**
Safety representative	
In terms of the Occupational Health and Safety Act (OHSA), all WWTWs must have a safety representative and all personnel on the site must know who the safety representative is. The Process Manager must ensure that a safety representative is elected.	• evidence that a safety representative is available (e.g. ask to meet with the safety rep.)
Technical expertise	
At the smaller and more rural WWTWs it is expected that technical expertise will be limited. In this respect it is important that a technical expert is available to be contacted for advice on troubleshooting as necessary. The Process Manager needs to ensure that all Process Controllers know the technical expert and relevant contact details.	• evidence that a technical expert is available to advise (e.g. ask for the name and contact number of the person)
Training/ capacity building	
A schedule of training for each Process Controller should be available at the WWTW indicating the type of training that will be undertaken and when. This may range from in-house mentoring to external certificate courses. The Process Manager must understand what training requirements are needed for each Process Controller. These must be submitted to management who need to source the relevant type of training, draw up a training schedule and support the implementation of the schedule.	• a training schedule • evidence that the training schedule is implemented (e.g. ask the staff if a particular course in the schedule has been attended)

MANAGEMENT AND ADMINISTRATION	
Notes (the why, what and how)	**Look for:**
BUDGET 	**19**
Operational	
Financial provisions must be made to ensure adequate stock and human resources requirements so that the WWTW can operate optimally. Chemicals, safety equipment and issues such as training of personnel are essential to the optimum working of a WWTW and finances must be available. The person ultimately responsible for municipal services such as wastewater treatment (e.g. the Town Engineer, Municipal Manager, etc) or his/her representative in that department, needs to understand the consequences if adequate funding for chemicals, training and safety equipment is not available. The Process Controller in charge of the WWTW needs to highlight these issues to his/her line manager who must then take it further.	• proof that an operational budget is known • proof that the operational budget is available
Maintenance	
Financial provisions must be made to ensure that maintenance can take place when breakdowns occur and to undertake scheduled maintenance before breakdowns happen. The person ultimately responsible for municipal services such as wastewater treatment (e.g. the Town Engineer, Municipal Manager, etc) or his/her representative in that department, needs to understand the consequences of inadequate funding. The Process Controller in charge of the WWTW needs to highlight these issues to his/her line manager who must make provision.	• proof that the maintenance budget is known • proof that the maintenance budget is available

MANAGEMENT AND ADMINISTRATION	
Notes (the why, what and how)	**Look for:**
Records/reporting 	**20**
Safety meetings	
In terms of the Occupational Health and Safety Act, safety meetings should take place regularly. The Process Manager needs to ensure that safety meetings are held, minutes are taken and actions are addressed and that all Process Controllers understand the OHSA. It is important that all employees understand the contents of the OHSA and are involved in it's implementation on WWTW.	• copies of minutes of meetings • an action plan that has been developed to address the actions
Final effluent records	
The following documents should be available to show that the Process Controller in charge understands the results of the final effluent: • Water use authorisation documentation (old permit/licence/general authorisation) • Compliance graphs of final effluent. The Process Manager must understand the contents of the authorisation relevant to the WWTW. If an authorisation is not in place, the person ultimately responsible for municipal services such as wastewater treatment (e.g. the Town Engineer, Municipal Manager, etc.) or his/her representative in that department, must liaise with the relevant authorities to get it in place and ensure that the Process Manager understands the legal requirement and the need to comply.	• graphical presentation of the latest final effluent results • historical records of the final effluent results (5 years) • a database of the results • reports interpreting the results and recommending actions to be taken

MANAGEMENT AND ADMINISTRATION		
Notes (the why, what and how)		**Look for:**
See Appendix E for an example of how to keep a graphical record of all water quality results.		
Reports to management/ authorities		
	The following reports must be maintained and copies should be available at the WWTW or submitted to the line manager as required: • Safety meetings • Maintenance requests • Compliance reports • Operational/process monitoring • Malfunctions. The Process Manager must ensure that these records are kept at the WWTW.	• up to date records at the WWTW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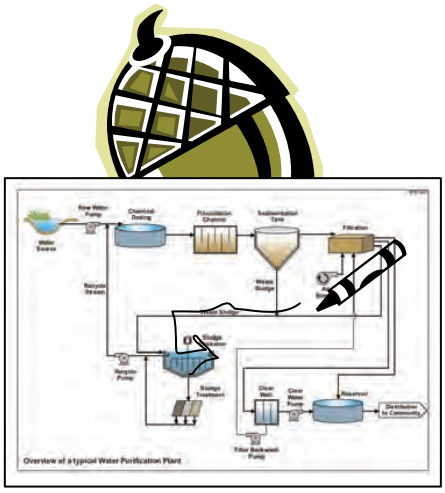
PART II

CHECKLISTS FOR UNDERTAKING AN INSPECTION AT A WWTW

- Checklist 1: The WWTWs in a nutshell
- Checklist 2: Primary Assessment
- Checklist 3: Comprehensive Inspection
- Checklist 4: Quarterly Inspection

CHECKLIST 1

THE WWTW IN A NUTSHELL



In order to understand the flow through at the WWTWs to be inspected, all Inspectors should complete this checklist at the start of an inspection or in the office in preparation for the inspection. The flow diagram could then be completed while walking through the WWTW.

All Process Managers and Process Controllers should complete this checklist when first being employed at the WWTW and again if any upgrades are done to the WWTW.

Examples of flow diagrams of various configurations are set out in Appendix A and B.

CHECKLIST 1: THE WWTW IN A NUTSHELL

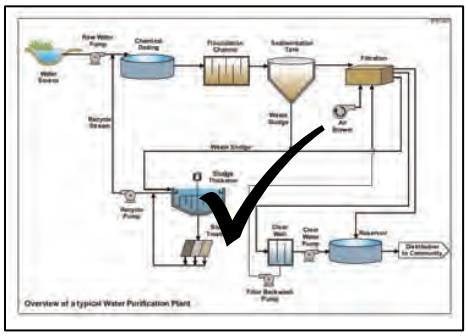
Tick next to the unit processes that you have on your WWTW and write out how many of each unit process are on the site. Draw a flow diagram of your WWTW on the blank page provided.

	UNIT PROCESS		✓	Number
PRELIMINARY TREATMENT PROCESSES	Screens	manual		
		mechanical		
	Grit removal	manually cleaned channels		
		mechanically cleaned channels		
		automated de-gritters		
	Flow measuring device			
	Flow balancing/equalization basin/tank			
PRIMARY TREATMENT PROCESSES	Primary settling			
	Oxidation pond system			
	Flow balancing/equalization basin/tank			
SECONDARY TREATMENT PROCESSES	Trickling filters			
	Activated sludge			
	Rotating biological contactors			
	Secondary settler	humus tank		
		clarifier		
TERTIARY TREATMENT PROCESSES	Disinfection (e.g. chemical, UV)			
	Constructed wetlands			
	Maturation pond/s			
SLUDGE TREATMENT PROCESSES	Dewatering	filter/belt press		
		drying beds		
	Thickening	gravity		
		dissolved air flotation		
	Digestion			

Draw your flow diagram showing the unit processes of the WWTW

CHECKLIST 2

THE PRIMARY ASSESSMENT



The primary assessment should be undertaken by an Inspector who has at least 5 years experience in the overall management of a WWTW or is registered at least as a Class IV Process Controller

or

an Inspector from a regulatory authority who has been undertaking regular WWTW inspections for a period of at least 5 years.

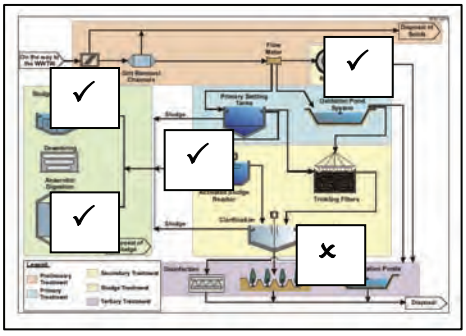
Time required:

typically an Inspector would require at least an hour in the office to prepare for the inspection and at least an hour would be needed to undertake the assessment on site.

Performance Area		Aspects to consider	**Notes** (use a separate page if necessary)
1	**Mechanical assessment**	• Mechanical equipment • Maintenance schedule and implementation	
2	**Final effluent**	• Looks and smells good • Results are displayed graphically *Note:* take a final effluent sample at this time and send to an independent laboratory for analysis; do field tests as appropriate (e.g. residual chlorine using DPD tablets) and interpret the results once received	
3	**Biological treatment process**	• Attached growth media (e.g. stones, disks) is in good condition and does not have a bad smell • Activated sludge - mixed liquor looks good and smells earthy	
4	**Good house-keeping**	• Areas around unit processes are kept clean and tidy • Chemical storage areas are bunded	
5	**Disposal of solids**	• Screenings, detritus and sludge are correctly disposed of in accordance with relevant authorisations	
6	**Paper work**	• Water use authorisation is in place and conditions stipulated are implemented • Contracts for sludge disposal are in place	
7	**Safety issues**	• Obvious safety hazards	

CHECKLIST 3

THE COMPREHENSIVE ASSESSMENT



The comprehensive assessment can be undertaken by an Inspector from a regulatory authority who has a good understanding of a WWTW or a WWTW Process Manager.

Time required:

typically an Inspector would require at least an hour in the office to prepare for the inspection and at least two hours would be needed to undertake the assessment on site.

Rating

Rating	**Description**	
	Observation of a physical item (e.g. a pump, unit process)	**Note/comment on an issue (e.g. documentation)**
3	Major failure	No/false
2	Problematic	Yes, but inadequate/not applicable (n/a)
1	Ideal performance	Yes/true

Entering the wastewater treatment works					
Performance indicator		**Comments**	**3**	**2**	**1**
1	No complaint/(s) of wastewater leaks				
2	No noticeable odours from areas outside of the WWTW				
3	Adequate fencing is provided around the WWTW				
4	The entrance is signposted				
5	There are relevant safety signs around the WWTW				
6	There is adequate security on entering the WWTW and a sign-in/out register for entering or leaving the site is present				
		Total			

Preliminary treatment: Screens (2)					
Performance indicator		**Comment**	**3**	**2**	**1**
MANUAL SCREENS					
1	Screens are free of debris				
2	The hand rake and wheelbarrow are easily accessible and in working order				
MECHANICAL SCREENS					
3	Screening components are free of obstructions				
4	There are no unusual vibrations				
5	There are no unusual sounds				
MAINTENANCE					
6	Suitably qualified fitters and electricians are available when maintenance is required				
7	A maintenance schedule for the screens is being implemented				
8	Mechanical equipment is in working order				
9	Malfunctions are recorded and reported timeously				
10	Downtime of equipment is recorded				
ENVIRONMENTAL and SAFETY ISSUES					
11	Personnel have correct PPE				
12	There are no nuisance conditions				
13	Screenings are properly stored prior to disposal				
14	Screenings are disposed of in accordance with legislation				
		Total			

Preliminary treatment: Grit removal (3)					
Performance indicator		**Comments**	**3**	**2**	**1**
HAND CLEANED CHANNELS					
1	The channels are in working order, i.e. one can be used while the other is closed for manual removal of grit				
2	A spade and wheelbarrow are easily accessible				
MECHANICAL DE-GRITTERS					
3	The mechanism is moving smoothly				
4	Channels/tanks are clear of grit				
MAINTENANCE (14)					
5	Suitably qualified fitters and electricians are available to undertake maintenance				
6	Mechanical equipment is in working order				
7	Malfunctions are recorded and reported as required				
8	Downtime of equipment is recorded				
ENVIRONMENTAL and SAFETY ISSUES (15)					
9	Personnel have correct PPE				
10	There are no nuisance conditions				
11	Grit is adequately stored prior to disposal				
12	Grit is correctly disposed of				
		Total			

Preliminary treatment: Flow (4)					
Performance indicator		**Comments**	**3**	**2**	**1**
1	Process sampling is being undertaken from time to time to get an understanding of the nature of the wastewater entering the WWTW				
2	The expected flow is reaching the plant				
3	The wastewater flow is light grey in colour				
4	A flow meter is in place				
5	The flow meter is working. If not, how long has it been out of order?				
6	The flow rate/volume is recorded daily				
7	The flow rate is converted and interpreted				
FLOW BALANCING					
8	Flow balancing/equalisation is in place				
9	Mixers are working				
10	Aerators, if present, are working				
		Total			

Primary treatment: Primary settling (5)					
Performance indicator		**Comments**	**3**	**2**	**1**
1	The mechanical equipment is moving correctly				
2	There are no abnormal sounds or vibrations				
3	The flow is adequate for the PST				
4	Sluice gates are properly adjusted so as to equalise the flow to multiple PSTs				
5	Weirs are in good condition				
6	There is no scum or floating sludge layer				
7	There is no layer of fats/grease/oil				
8	The scum draw-off system is operational				
9	There is a schedule for de-sludging & it is properly followed				
10	The sludge is not black and odorous (septic)				
11	The sludge is easily removed from the hopper				
MAINTENANCE (14)					
12	Good housekeeping is practiced				
13	There is a maintenance schedule				
14	Suitably qualified fitters and electricians are available when maintenance is required				
15	Mechanical equipment is in working order. How long has it been standing if it is not in working order?				
16	Malfunctions are recorded and reported				
ENVIRONMENTAL and SAFETY ISSUES (15)					
17	Safety railings are adequate				
18	Personnel have correct PPE				
		Total			

Primary treatment: Oxidation pond systems (5)					
Performance indicator		**Comments**	**3**	**2**	**1**
1	Ponds are operated in series. If yes, how many?		n/a		
2	Short-circuiting is not taking place				
3	Aerators are working (if present). If not, working, how long have they been standing?				
4	A schedule is available for operating the aerators				
5	The first anaerobic pond is desludged. How often? What is done with the sludge? If not, is there a parallel pond that the influent can be diverted to while desludging occurs?				
MAINTENANCE (14)					
6	Good housekeeping is practiced				
7	Suitably qualified fitters and electricians are available if maintenance is required				
8	The banks are clear of weeds				
9	The banks are protected from erosion				
10	Malfunctions are recorded and reported				
11	Downtime of equipment is recorded				
ENVIRONMENTAL and SAFETY ISSUES (15)					
12	Odours are absent				
13	Personnel have correct PPE				
14	The final effluent is being disposed of in accordance with water use authorisation conditions				
		Total			

Secondary treatment: Trickling filters(7)					
Performance indicator		**Comment**	**3**	**2**	**1**
1	The top of the trickling filter can be safely accessed by a ladder				
2	The flow is being evenly distributed to the trickling filters				
3	The rotating distributor arm is moving				
4	The rotating distributor arm is distributing wastewater evenly across the filter media				
5	There is no ponding on the filter media				
6	The underdrains are free of debris and plant material				
7	The stone bed is turned periodically. How often?				
8	Inorganic material removed from the stone bed. How often?				
MAINTENANCE (14)					
9	There is good housekeeping on and around the filter				
10	The ladder for access to the top of the filter is well maintained				
11	Suitably qualified fitters and electricians are available to undertake maintenance as required				
12	The outer structure is intact (i.e. no major cracks)				
13	Malfunctions are recorded and reported				
14	Downtime of equipment is recorded				
ENVIRONMENTAL and SAFETY ISSUES (15)					
15	Odours are absent				
16	Personnel have correct PPE				
		Total			

Secondary treatment: Rotating biological contactors (RBC) (7)					
Performance indicator		**Comments**	**3**	**2**	**1**
1	The disk system is in working order, i.e. are the shafts turning at a steady rate of rotation?				
2	The ammeter is in working order				
3	The motor is working. Is the motor running hot?				
4	The sludge return pump is in working order				
5	There are no clumps of floating sludge in the final settling tank				
MAINTENANCE (14)					
6	Good housekeeping is practiced around the RBC tanks				
7	Suitably qualified fitters and electricians are available if maintenance is required				
8	Malfunctions are recorded and reported				
9	Downtime of equipment is recorded				
ENVIRONMENTAL and SAFETY ISSUES (15)					
10	Very mild odours are experienced				
11	Personnel have correct PPE				
		Total			

Secondary treatment: Activated sludge (8)					
Performance indicator		**Comments**	**3**	**2**	**1**
1	The sludge age is monitored, i.e. is adequate sludge being wasted?				
2	There is no scum on the surface				
3	There is good floc formation (visual)				
4	There is an earthy smell				
5	The colour of the sludge is a light brown				
6	There is chemical dosing. Which chemicals?				
7	The area housing the chemical dosing unit is bunded				
8	Process monitoring is taking place for:				
	COD				
	Nitrate				
	Ammonia				
	Dissolved oxygen				
	Suspended solids				
	pH				
	Total dissolved solids				
	Ortho-phosphate				
9	Field and on-line equipment is calibrated				
10	Calibration certificates for field and on-line equipment are available				
11	Aerators are working. If not, how long have they being standing for?				
12	There is a schedule for switching aerators on and off				
13	There are no dead spots in the aeration basin				
14	The recycle pumps are working. If not, how long have they been standing for?				
15	Flow to the reactors is measured				
16	There are no strange noises or vibrations related to any of the pumps/motors				

Secondary treatment: Activated sludge (8)					
Performance indicator		**Comments**	**3**	**2**	**1**
MAINTENANCE (14)					
17	There is good housekeeping				
18	Suitably qualified fitters and electricians are available if maintenance is required				
19	Standby pumps are available if one goes in for repairs				
20	Downtime of equipment is recorded				
21	All malfunctions recorded and reported				
22	Essential spare parts are available				
ENVIRONMENTAL and SAFETY ISSUES (15)					
23	The necessary safety signs are clearly visible				
24	Personnel have correct PPE				
25	Correct safety equipment is available. Adequate handrails?				
		Total			

Secondary treatment: clarification/secondary settling (9)					
Performance indicator		**Comments**	**3**	**2**	**1**
HUMUS TANK					
1	Scum troughs and grease wells are clean				
2	Effluent weirs and baffles are clean				
3	Sludge withdrawal equipment is in working order. If not, how long has it been standing?				
4	The overflow is clear				
CLARIFIER					
5	The SVI is tested				
6	The effluent weir/channel is clean				
7	The launders are clean				
8	The desludging equipment is working. If not, how long has it being standing?				
9	There is no scum on the surface				
10	There is a desludging schedule that is adhered to				
11	The overflow is clear				
12	The scum draw-off system is operational				
13	Weirs, scum removal equipment and stilling chambers are kept clean				
MAINTENANCE (14)					
14	Suitably qualified maintenance personnel are available if repairs are necessary				
15	Malfunctions are recorded and reported				
16	Downtime of equipment is recorded				
ENVIRONMENTAL and SAFETY ISSUES (15)					
17	There are limited unusual/unpleasant odours				
18	Personnel have correct PPE				
19	Necessary safety equipment is available				
		Total			

Sludge treatment: Thickening (11)					
Performance indicator		**Comments**	**3**	**2**	**1**
GRAVITY THICKENER					
1	All mechanical equipment is in working order. If not, how long has it been standing?				
2	Sludge draw-off is done according to a schedule				
3	Scum is being adequately skimmed				
4	The following monitoring is being undertaken:				
	Settleable solids (overflow)				
	Total solids (sludge underflow)				
5	The feed to the thickener is continuous				
6	Chemicals are used for conditioning. What chemicals?				
7	The chemicals are adequately stored in a bunded area				
8	Excessive solids are not being carried over into the overflow				
DISSOLVED AIR FLOTATION THICKENER					
9	The inflow rate of sludge is adjusted as needed				
10	The air compressors are in working order				
11	The valves and pressure gauges are in working order. If not, how long have they been standing?				
12	There are no leaks in the pipes and pumps				
13	The surface skimmers on the flotation tanks are working adequately. If not, how long have they been standing?				
14	Clarified liquor is free of solids				
15	The following monitoring is being undertaken:				
	Settleable solids (overflow)				
	Total solids (sludge underflow)				
16	Chemicals are used for conditioning. What chemicals?				
17	The chemicals are adequately stored in a bunded area				
18	Few solids are carried over to the underflow				
MAINTENANCE (14)					
19	Suitably qualified maintenance personnel are available if repairs are necessary				

Sludge treatment: Thickening (11)					
Performance indicator		**Comments**	**3**	**2**	**1**
20	Weirs, scum removal equipment and stilling chambers are kept clean				
21	Malfunctions are recorded and reported				
22	Downtime of equipment is recorded				
ENVIRONMENTAL and SAFETY ISSUES (15)					
23	Personnel have correct PPE				
24	Safety equipment is easily accessible				
25	There are limited odours				
		Total			

Sludge treatment: Dewatering (12)					
Performance indicator		**Comments**	**3**	**2**	**1**
FILTER PRESS/BELT PRESS					
1	Flocculent is stored safely				
2	The belt presses are in working order. If not, how long have they been standing?				
3	The feed to the presses is measured				
DRYING BEDS					
4	Sludge lines are free of debris				
5	Sludge on the beds is raked to keep it level				
6	Walls of the drying beds are intact. Are there any serious cracks?				
7	Beds are free of weeds				
8	Sand is replaced as dried sludge is removed according to a schedule				
9	The draining system and piping is in working order				
10	A sample is taken to determine total solids				
11	Records of:				
	- drying time per bed				
	- thickness of sludge layer added and date of application				
	- climatological records (e.g. rainfall)				
	- malfunctions				
MAINTENANCE (14)					
12	Good housekeeping is maintained				
13	Suitably qualified maintenance personnel are available if repairs are necessary				
14	Downtime of equipment is recorded				
ENVIRONMENTAL and SAFETY ISSUES (15)					
15	Dried sludge is adequately stored prior to re-use or final disposal				
16	Personnel have correct PPE				
		Total			

Sludge Treatment: Anaerobic digestion (13)					
Performance indicator		**Comments**	**3**	**2**	**1**
1	Level of grit and sand in the digester is known				
2	There is a schedule for filling and wasting				
3	There are no unusual noises				
4	Supernatant and sludge are withdrawn according to a schedule				
5	Pressure gauges are in working order. If not, how long have they been out of order?				
6	The pressure relief device is in working order				
7	The colour of the flame is yellow with blue at the base				
8	The following parameters are monitored and recorded weekly:				
	Feed rate				
	Volatile acids				
	Alkalinity				
	Volatile Acids/Alkalinity ratio				
	pH value				
	Biogas production rate				
	Carbon dioxide content of the biogas				
	Volatile solids reduction				
	Temperature				
	Volatile solids loading rate				
	Hydraulic retention time				
9	Records of the gas flow rate from the digest to the gas holder are kept				
MAINTENANCE (14)					
10	Good housekeeping is practiced				
11	Records of digester cleaning are kept				
12	Suitably qualified maintenance personnel are available if repairs are necessary				
13	Malfunctions are recorded and reported				
14	Downtime of equipment is recorded				
ENVIRONMENTAL and SAFETY ISSUES (15)					
15	Personnel have correct PPE				
16	Relevant safety signs are visible				
17	Sludge is disposed of according to the latest Sludge Guidelines				
		Total			

Tertiary treatment: Chemical disinfection (10)					
Performance indicator		**Comments**	**3**	**2**	**1**
1	Chemicals are being dosed. What chemicals?				
2	The dosing equipment is in working order. If not, is disinfection being practiced in a different manner?				
3	The Process Controller handling the gas has been trained in the correct handling procedures. Is the certificate (or a copy thereof) presented available?				
4	Chlorine products are dosed - the residual chlorine level is being measured in the final effluent				
5	The contact tank is clean and free of algae				
6	The water use authorisation is complied with in terms of final effluent quality				
MAINTENANCE (14)					
7	Good housekeeping is practiced				
8	Chemicals are safely stored				
9	Downtime of equipment is recorded				
10	A maintenance contract is in place with the dosing equipment supplier				
ENVIRONMENTAL and SAFETY ISSUES (15)					
11	Safety signs relevant to the particular chemical being dosed, are visible				
12	Personnel have correct PPE				
13	Relevant safety devices are available				
		Total			

Tertiary treatment: Constructed wetlands (10)					
Performance indicator		**Comments**	**3**	**2**	**1**
OPERATION AND MAINTENANCE					
1	Reeds are planted. What type? Do they look healthy?				
2	Reed growth is controlled using a schedule				
3	How is reed growth controlled, e.g. harvesting?		n/a		
4	Selective seeding and planting is undertaken periodically. How often? Is there a schedule?				
5	Herbicidal and insecticidal treatment is practiced. Which herbicide/insecticide is used?				
6	If irrigation of wetland takes place, give a reason		n/a		
7	Relevant samples are taken in accordance with the water use authorisation				
ENVIRONMENTAL and SAFETY ISSUES (14)					
8	Are the relevant safety signs visible?				
9	Personnel have correct PPE				

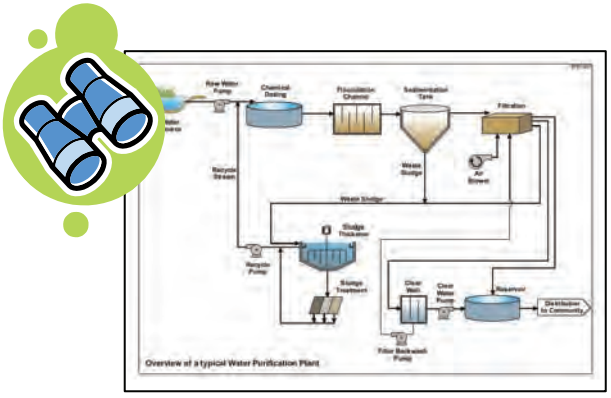
Tertiary treatment: Maturation ponds (10)					
Performance indicator		**Comments**	**3**	**2**	**1**
1	Overflow is clear				
2	Overflow is being monitored according to relevant conditions in the water use authorisation				
3	The banks of the ponds are protected against erosion				
MAINTENANCE (15)					
4	Good housekeeping is practiced around the ponds				
ENVIRONMENTAL and SAFETY ISSUES (14)					
5	Safety signs are up and fencing/security signage around the ponds is adequate				
		Total			

Resources					
Performance indicator		**Comments**	**3**	**2**	**1**
LEGISLATIVE ISSUES (17)					
1	The Classification certificate is clearly displayed or available				
2	The WWTW has a relevant water use authorisation				
HUMAN RESOURCES (18)					
3	Personnel are registered in terms of Regulation 2834 or any update thereto				
4	Staff numbers are in compliance with Regulation 2834 or any update thereto				
5	Personnel are trained according to a schedule and the training schedule takes career development into account				
FINANCIAL RESOURCES (19)					
6	Financial provisions are in place to ensure adequate stores, human resources and maintenance requirements				
DOCUMENTATION (20)					
7	Various documents are available: • Water use authorisation documentation (old permit/licence/general authorisation) • Compliance with sludge guidelines - Results of classification - Contracts as necessary				
8	Records are maintained and copies are available at the works:				
	Malfunctions				
	Flow entering the WWTW				
	Volume of wastewater treated (out)				
	Safety meetings				
	Maintenance requests				
	Compliance reports				
	Operational/process monitoring				
9	Documents are displayed: • Compliance graphs of final effluent				
	• Safety representative - Name and photo - Contact number				
	• Emergency numbers - Fire brigade - Local police station				
	Maintenance contact numbers				

LABORATORY (16)					
10	Records of inter-laboratory quality assurance are kept				
11	Results are received within 24 hours				
		Total			

CHECKLIST B4

THE QUARTERLY ASSESSMENT



This inspection should be undertaken quarterly once the WWTW has been subjected to a comprehensive inspection and/or primary assessment and has been deemed to be running optimally.

Time required:

typically an Inspector would require at least an hour in the office to prepare for the inspection, and at least one hour would be needed to undertake the assessment on site.

Rating	Description	
	Observation of a physical item (e.g. a pump, unit process)	**Notes/comment on an issue (e.g. documents)**
3	Major failure	No/false
2	Problematic	Yes, but inadequate
1	Ideal performance	Yes/true

Tick once next to each performance area. Take note of the rating table below for any comments.

Rating	Overall assessment based on total score
STOP (S)	A comprehensive assessment must be undertaken regardless of the total score
1	✋ means that the specific unit process sheet from the comprehensive assessment must be undertaken for that particular rating parameter; > 5 ticks **(✓)** means that a comprehensive assessment must be undertaken.
2	> 10 ticks **(✓)** means that a comprehensive assessment must be undertaken.
3	Well done! Keep up the good work.

Performance Area		Performance indicator	Any comment?	Reference in Guideline	Rating (✓)		
					3	2	1
1	Final effluent	Sampling of final effluent is undertaken in accordance with relevant authorisation		10	S		
		Final effluent quality is in compliance with conditions of authorisation		10	S		
2	Process Configuration	The Process Controller is aware of the flow to the WWTW		1			
		The Process Controller is aware of the design capacity		1			
3	Operation	Mechanical equipment is in working order (including, e.g. screens, de-		2 - 13	✋		

Performance Area		Performance indicator	Any comment?	Reference in Guideline	Rating (✓)		
					3	2	1
		gritters, aerators, blowers, mixers, conveyors, scrapers, bridges, pumps, rotating arms)					
		Screenings and grit are correctly disposed of					
		Overflow from unit processes is 'typical' as described in guidelines, i.e. primary, secondary and tertiary					
		Sludge is classified according to latest sludge guidelines		Refer to latest Sludge Guidelines			
		Sludge is disposed of according to latest sludge guidelines					
4	Laboratory	Analyses are undertaken ensuring quality control		16			
5	Maintenance	Standby equipment is available, e.g. pumps		14, 18, 19			
		A maintenance plan is in place					
		Maintenance personnel are on standby					
		A maintenance budget is available					

Performance Area		Performance indicator	Any comment?	Reference in Guideline	Rating (✓)		
					3	2	1
6	Supervision and management	The WWTW is correctly classified		17,18, 19, 20			
		The WWTW and Process Controllers are correctly registered					
		Technical experts are on hand to advise					
		Training/capacity building takes place					
		Adequate records are kept					
7	Safety	Correct/adequate PPE is worn		14			
		A safety representative is present on the WWTW					
		Safety meetings are held					
		Safety signage is in place					
		Safety equipment/ mechanisms are in place					
8	Emergency preparedness and response	Response contacts are clearly displayed in various areas		14			

Performance Area		Performance indicator	Any comment?	Reference in Guideline	Rating (✓)		
					3	2	1
9	Legislation/ regulations	Relevant authorisations are in place		17			
Total number of ticks (✓)							

APPENDIX A

REFERENCE DOCUMENTS THAT SHOULD BE ON HAND AT THE WWTW

REFERENCE DOCUMENTS TO KEEP ON SITE

The following documents are guidelines for the operation of WWTW and should be kept on site:

- Department of Water Affairs and Forestry (2002). An Illustrated Guide to Basic Sewage Purification Operations
- WRC 1992, Anaerobic Digestion of wastewater sludges (operating guide) Report No. TT 55/92
- WRC 1999, Guidelines for the design and operation of sludge drying beds, Report No. TT 107/99
- WRC 2002, Guidelines for the application of natural stone trickling filters, Report No. TT178/02
- WISA 2002, Handbook for the operation of wastewater treatment works
- WRC 2009, Status quo assessment of wastewater ponding systems, Report No. 1657/1/09

WRC 2006, Guidelines for the utilisation and disposal of wastewater sludge, Volumes 1 to 5, Report No's TT 261/06-265/06.

Volume 1: Selection of management options

Volume 2: Requirements for the agricultural use of sludge

Volume 3: Requirements for the on-site and off-site disposal of sludge

Volume 4: Requirements for the beneficial use of sludge

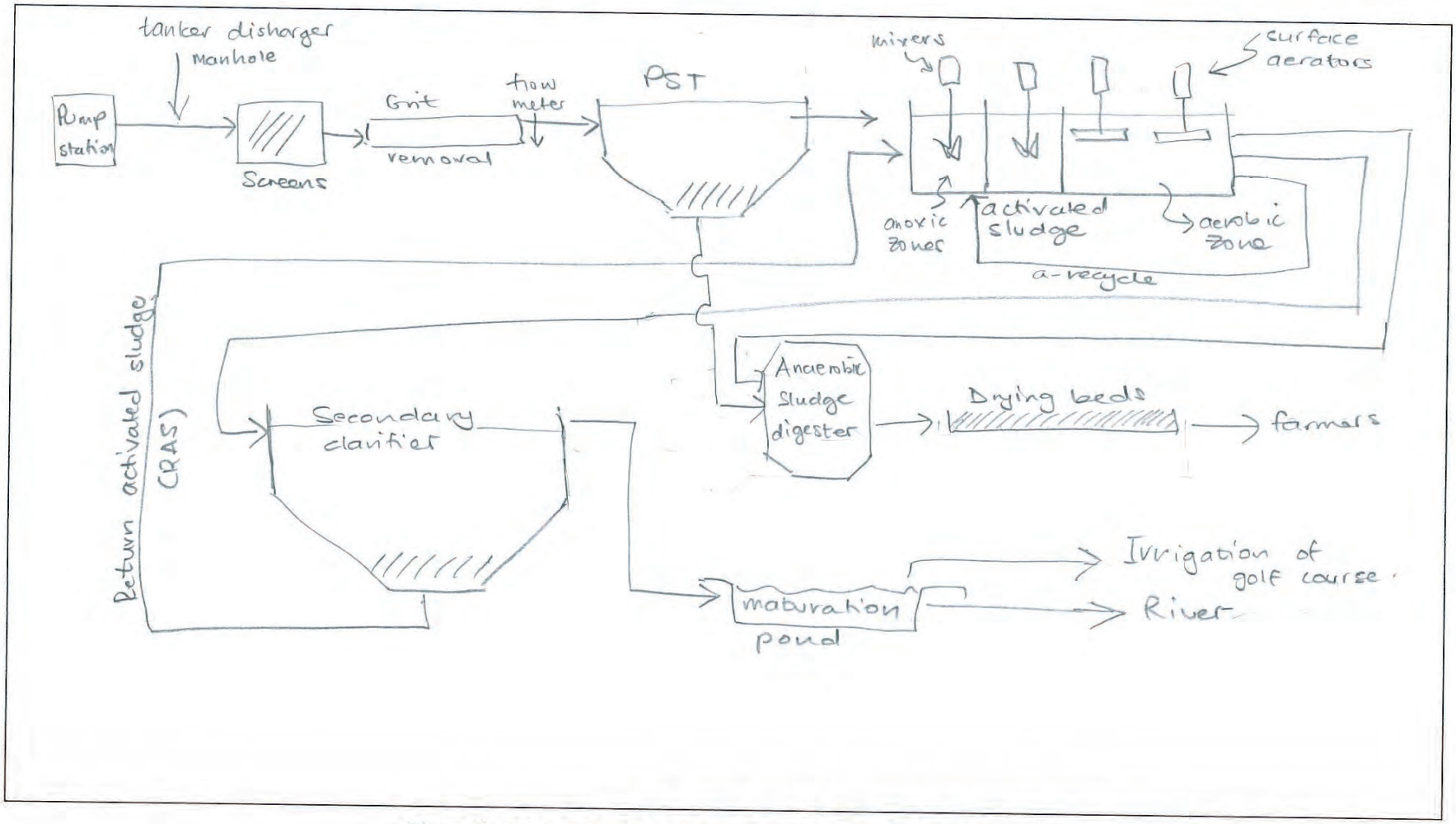
Volume 5: Requirements for thermal sludge management practices and for commercial products containing sludge.

For the more specialised treatment works, such as biological nutrient removal plants or constructed wetlands, the following documents are useful:

- WRC 1984, Theory, design and operation of nutrient removal activated sludge processes, Report No. TT 16/84
- WRC 1997, Operating Manual for biological nutrient removal, Report No. TT 83/97
- WRC 1999, Investigation into the Application and Performance of Constructed Wetland for Wastewater Treatment in South Africa, Report No. 416/1/99

APPENDIX B

HAND-DRAWN FLOW DIAGRAM EXAMPLE



Flow diagram showing the unit processes of the WWTW

APPENDIX C

VARIOUS CONFIGURATIONS OF WWTWs THROUGHOUT SOUTH AFRICA

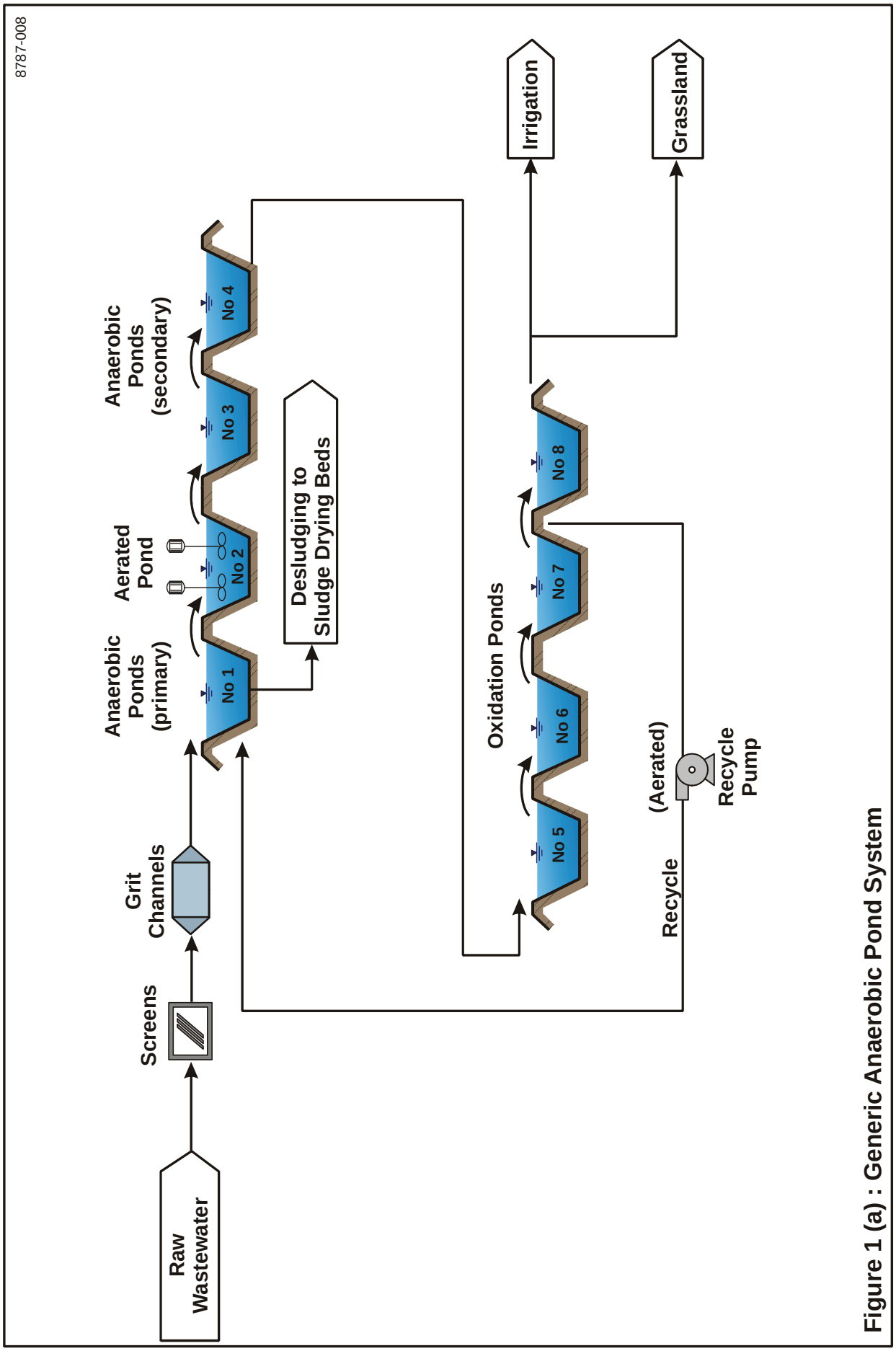


Figure 1 (a) : Generic Anaerobic Pond System

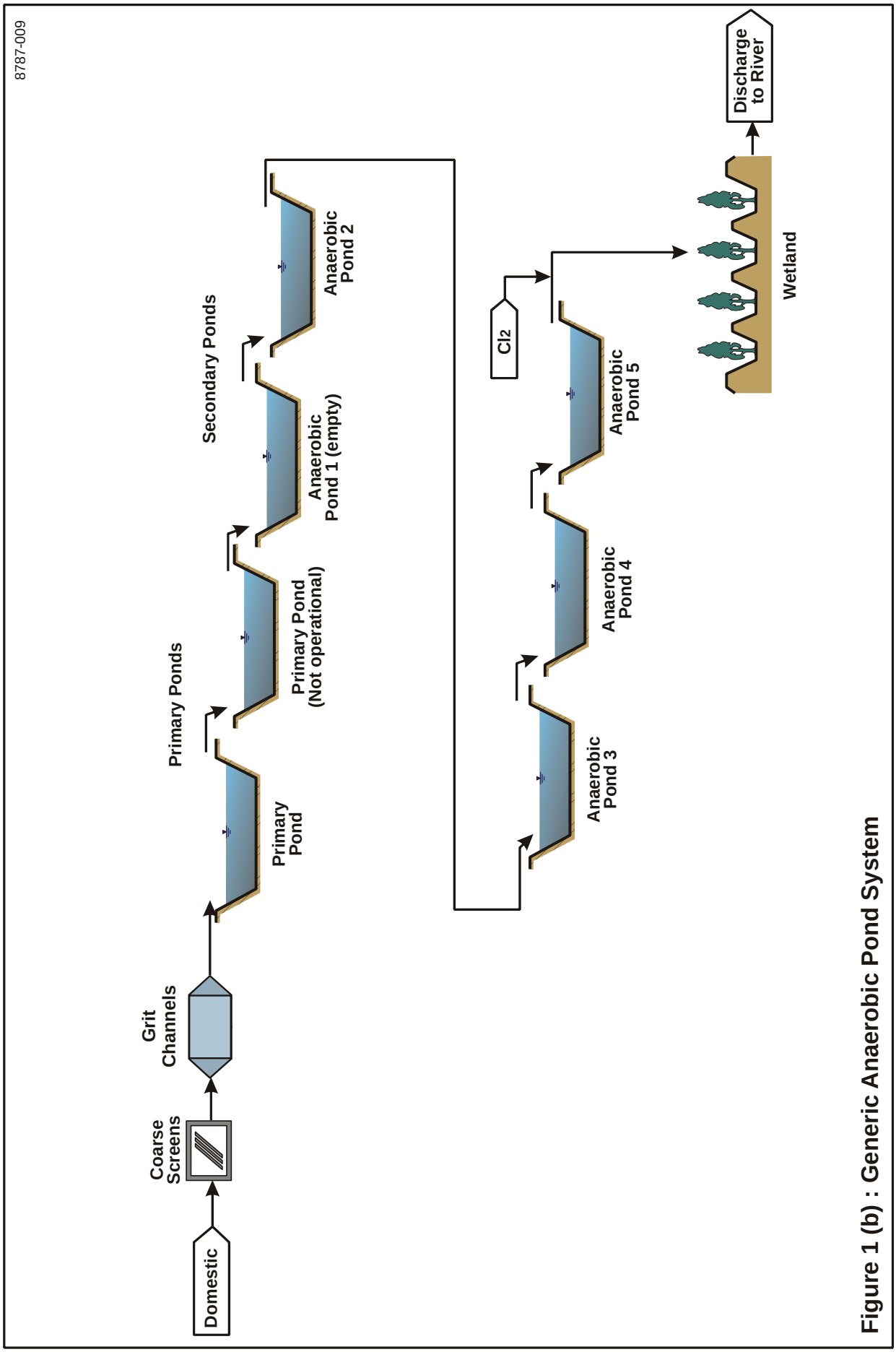


Figure 1 (b) : Generic Anaerobic Pond System

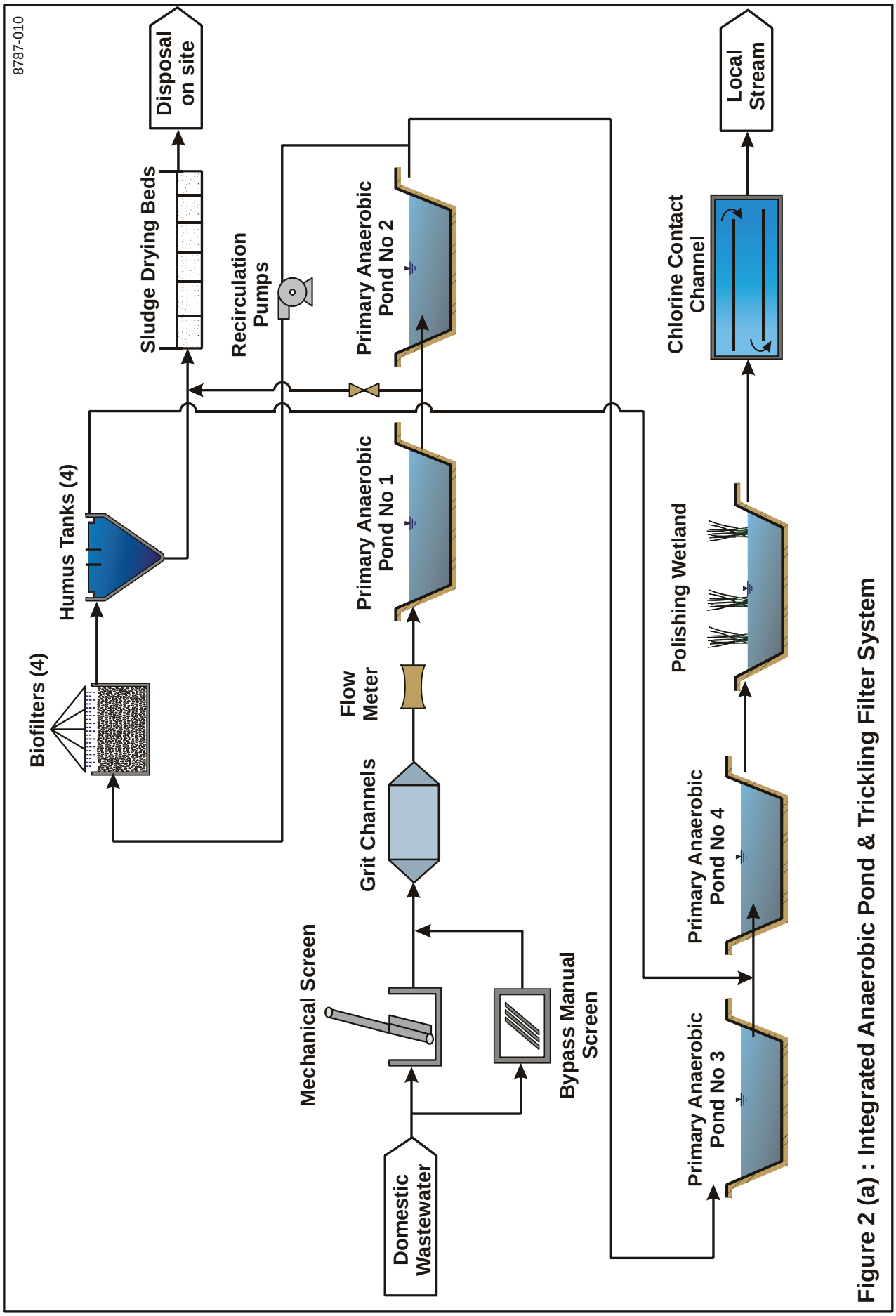


Figure 2 (a) : Integrated Anaerobic Pond & Trickling Filter System

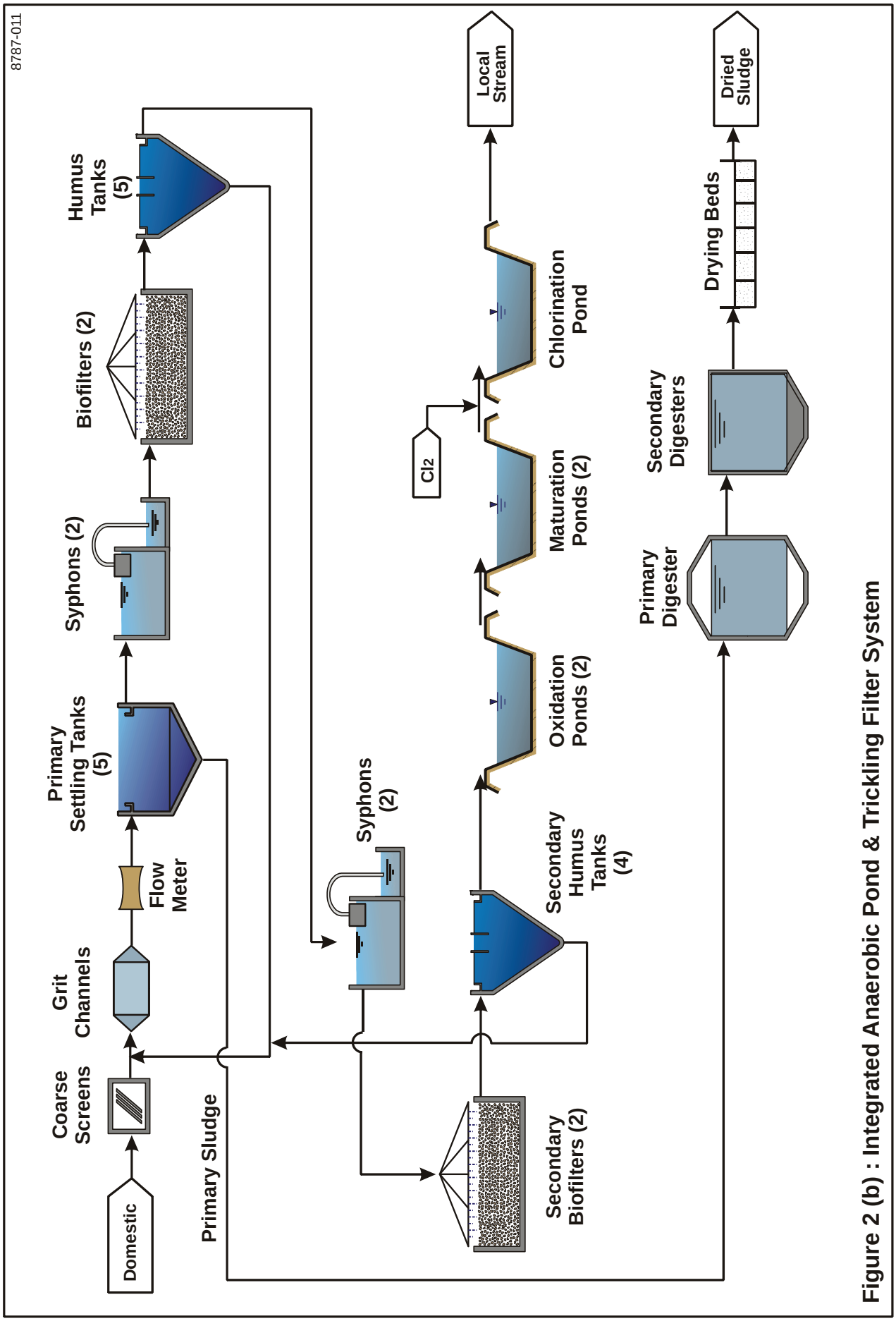


Figure 2 (b) : Integrated Anaerobic Pond & Trickling Filter System

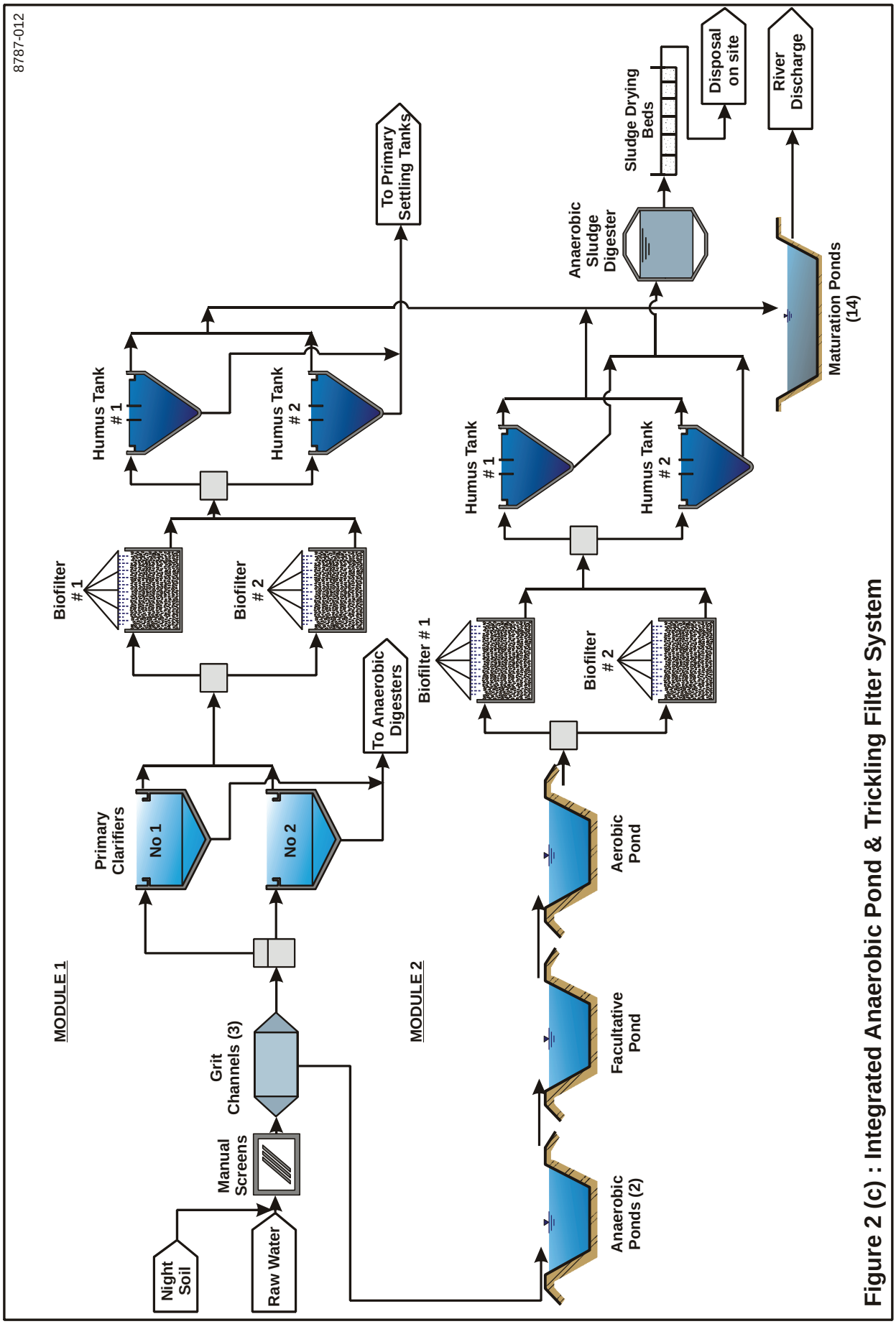


Figure 2 (c) : Integrated Anaerobic Pond & Trickling Filter System

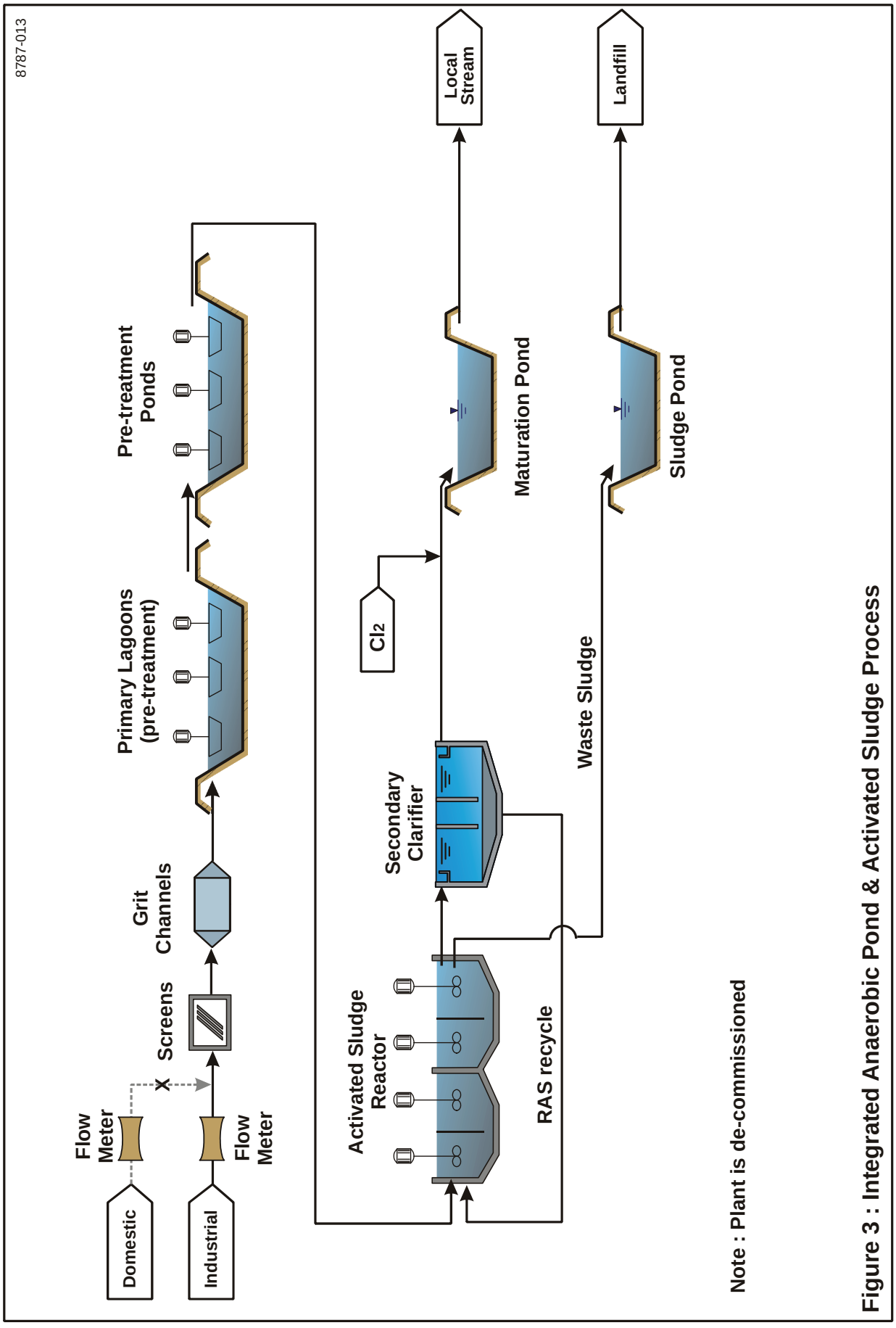


Figure 3 : Integrated Anaerobic Pond & Activated Sludge Process

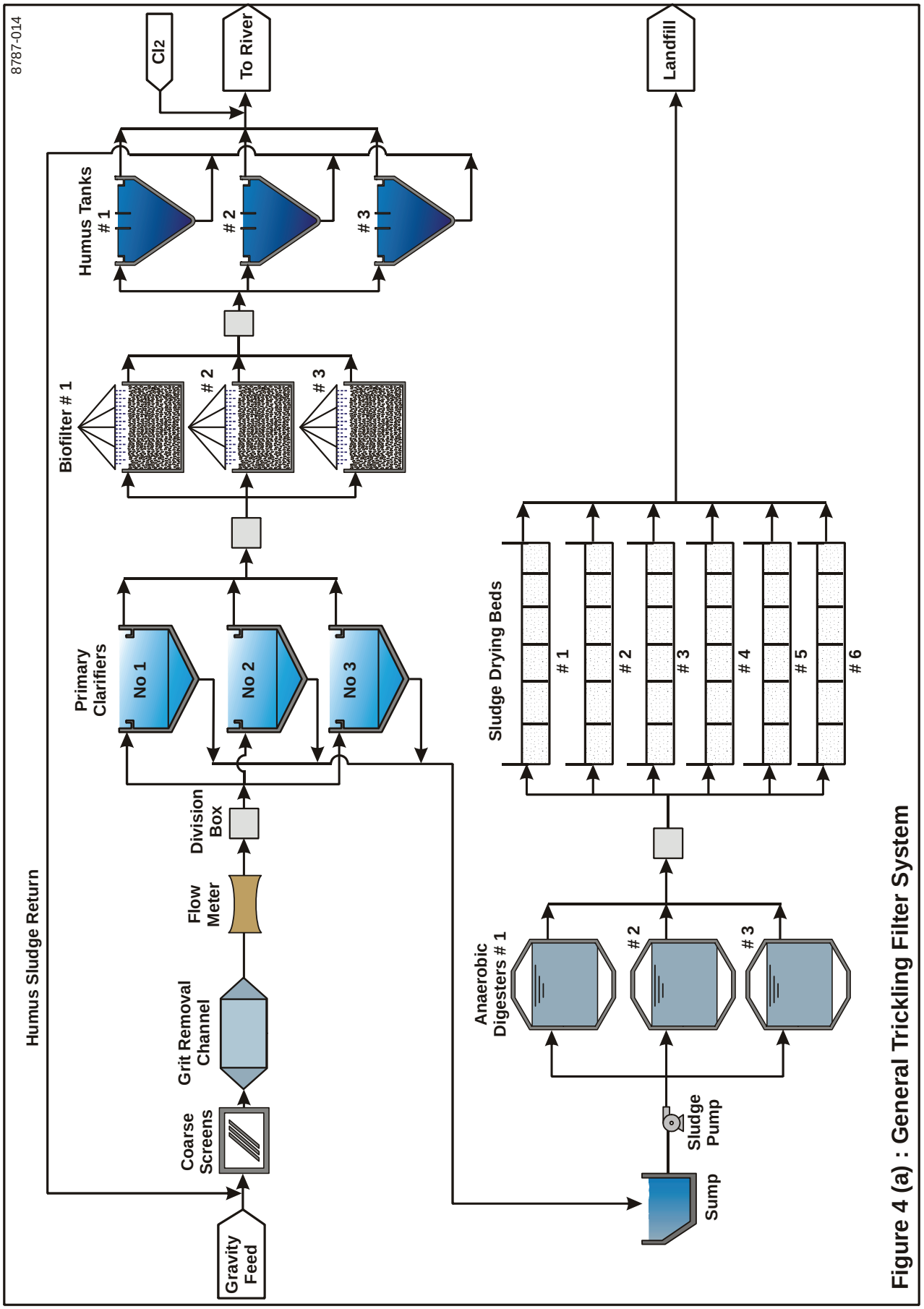


Figure 4 (a) : General Trickling Filter System

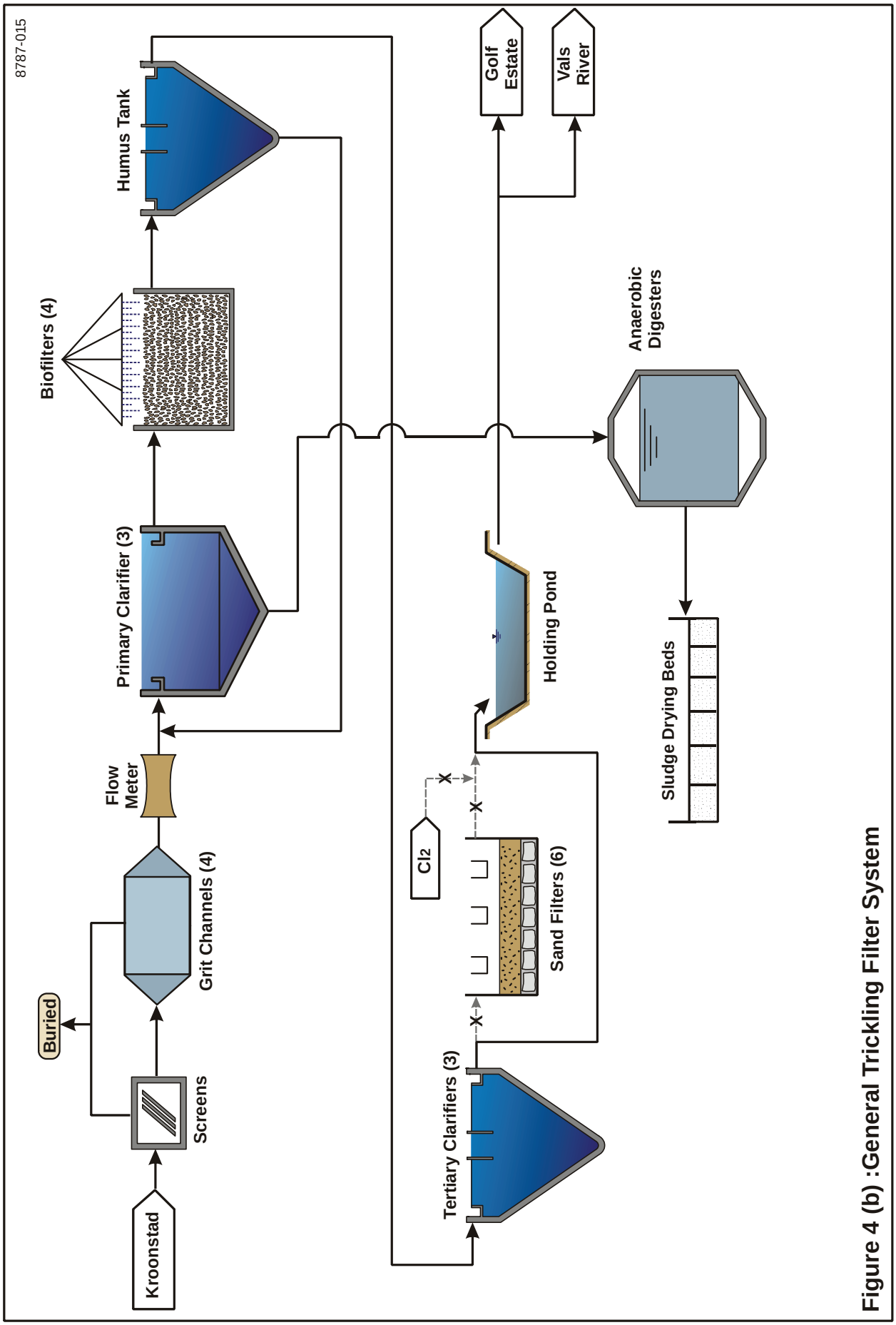


Figure 4 (b) :General Trickling Filter System

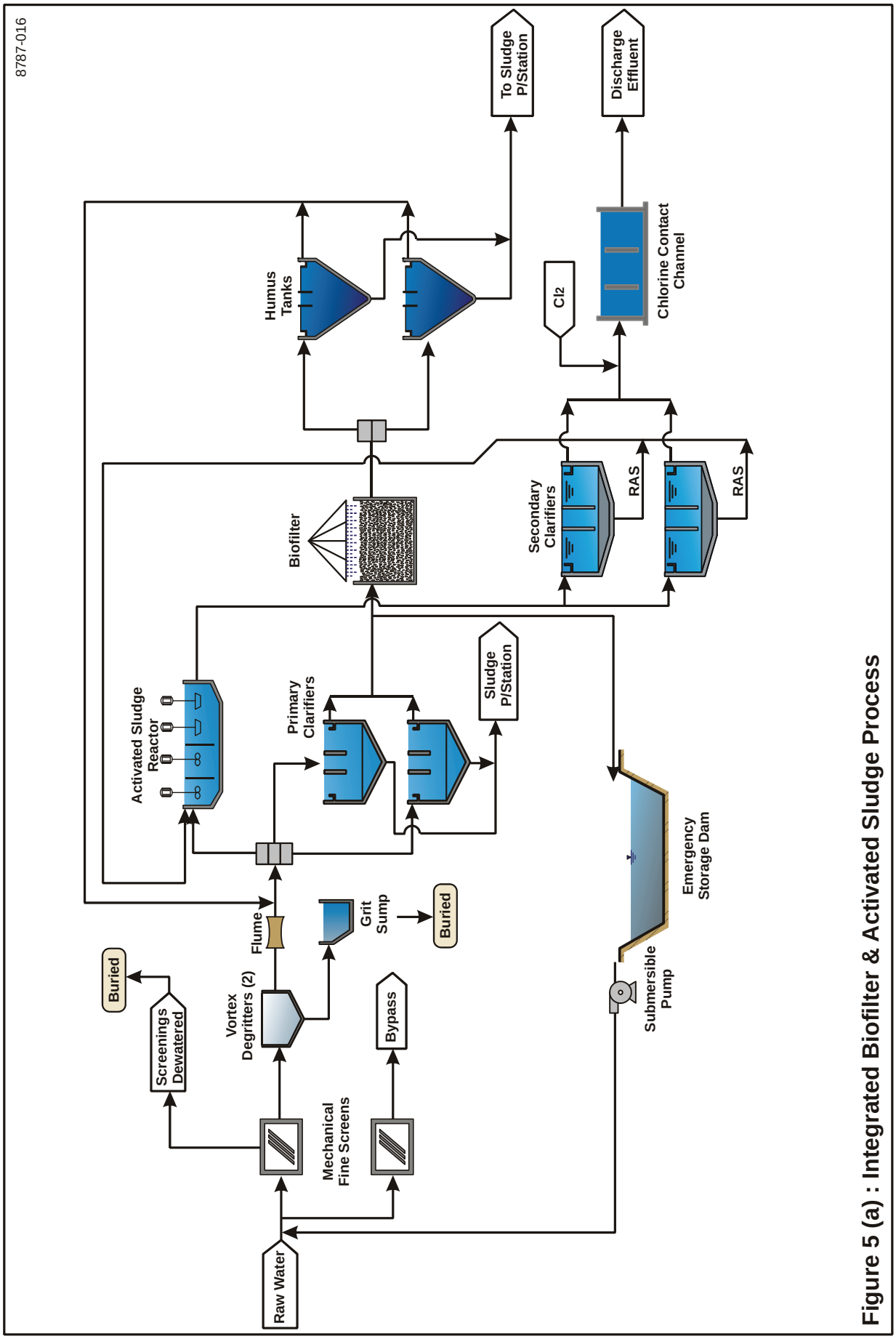


Figure 5 (a) : Integrated Biofilter & Activated Sludge Process

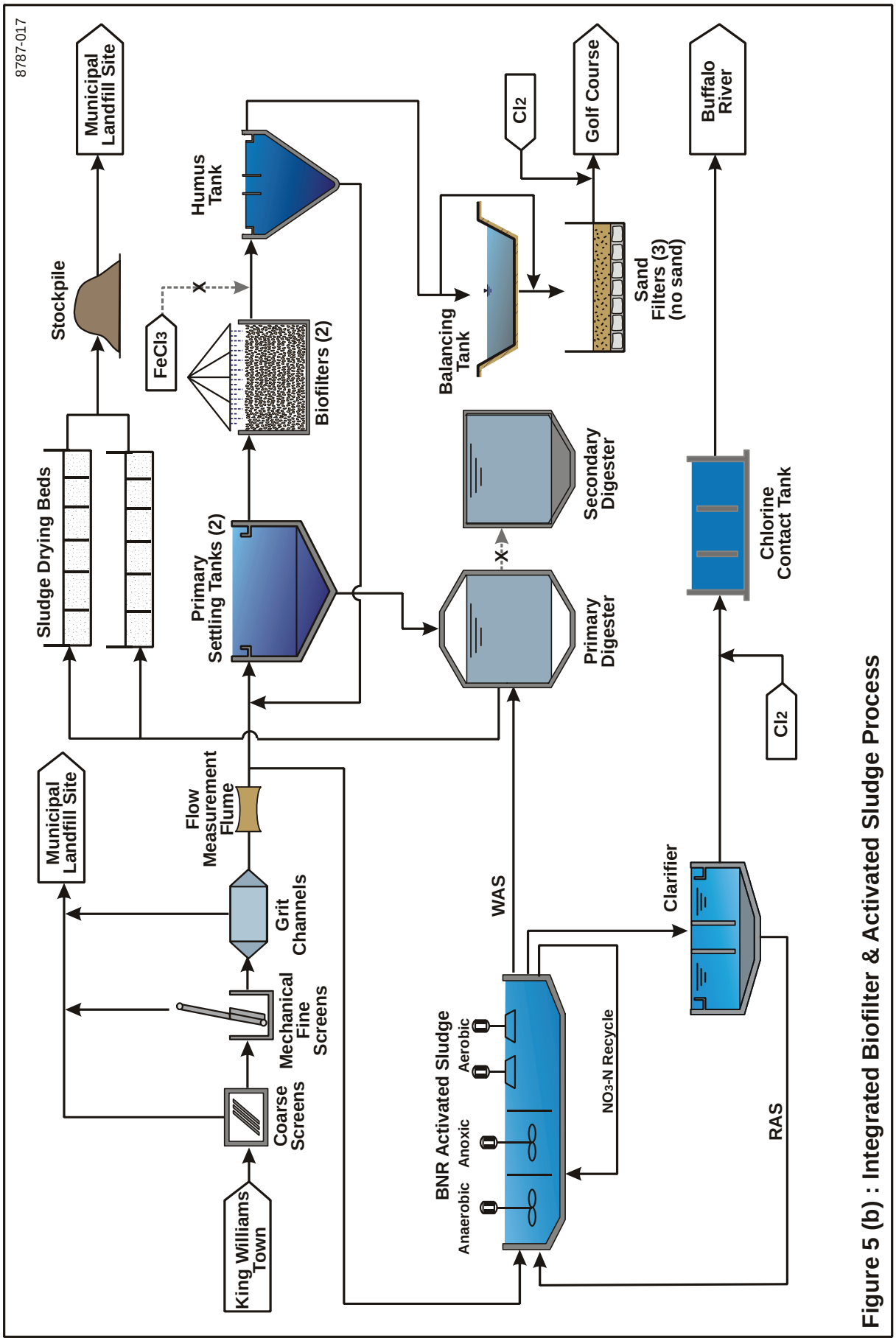


Figure 5 (b) : Integrated Biofilter & Activated Sludge Process

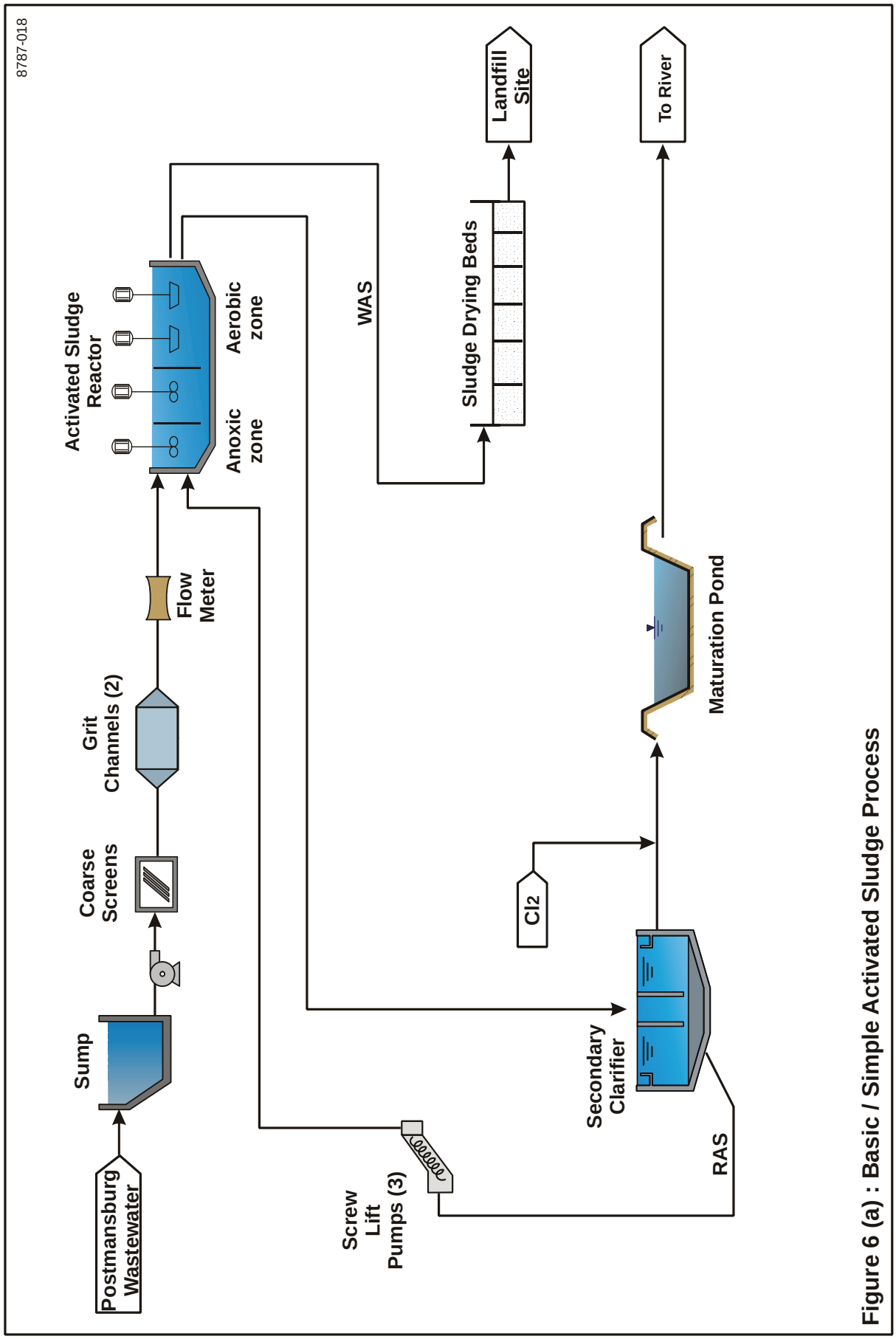


Figure 6 (a) : Basic / Simple Activated Sludge Process

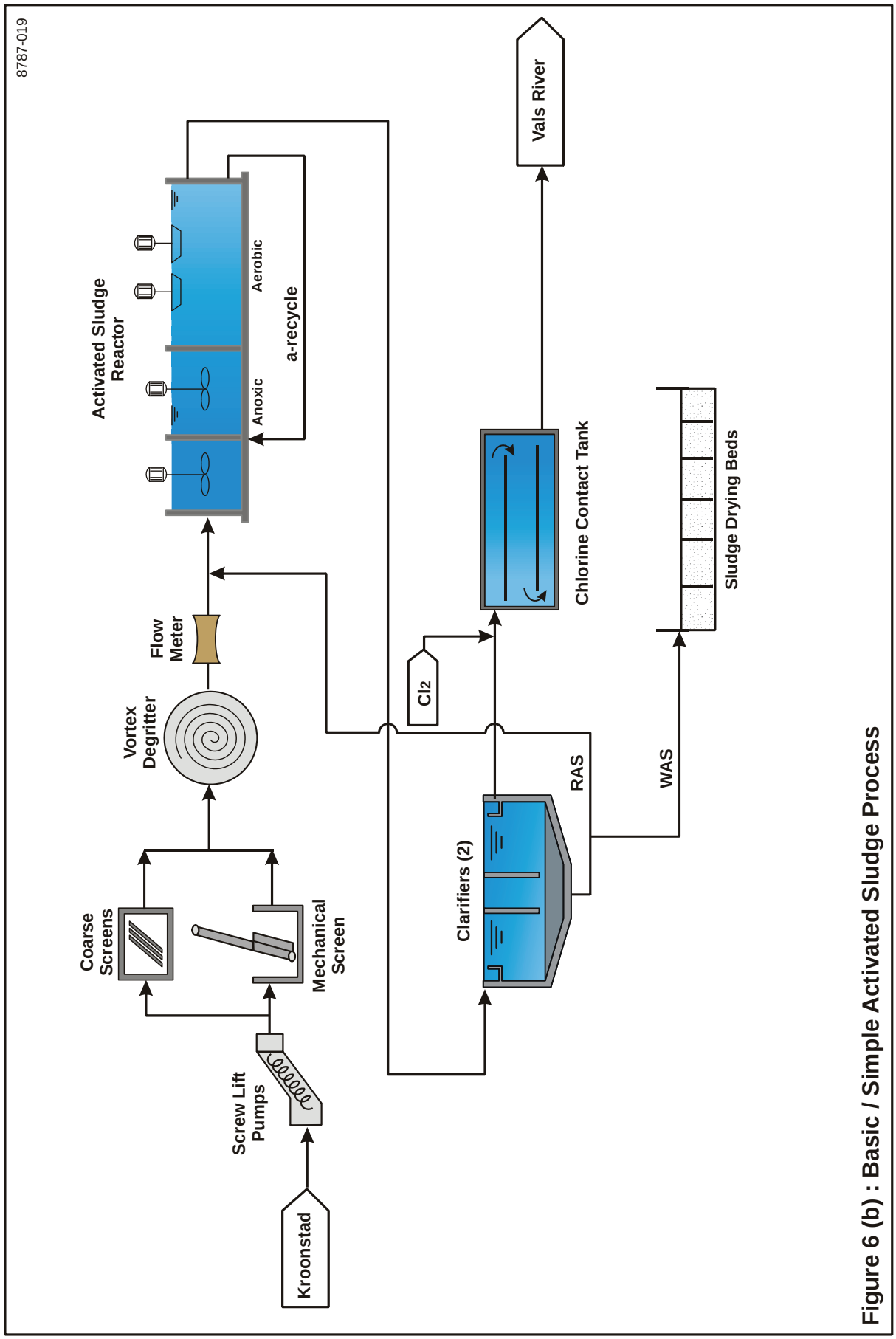


Figure 6 (b) : Basic / Simple Activated Sludge Process

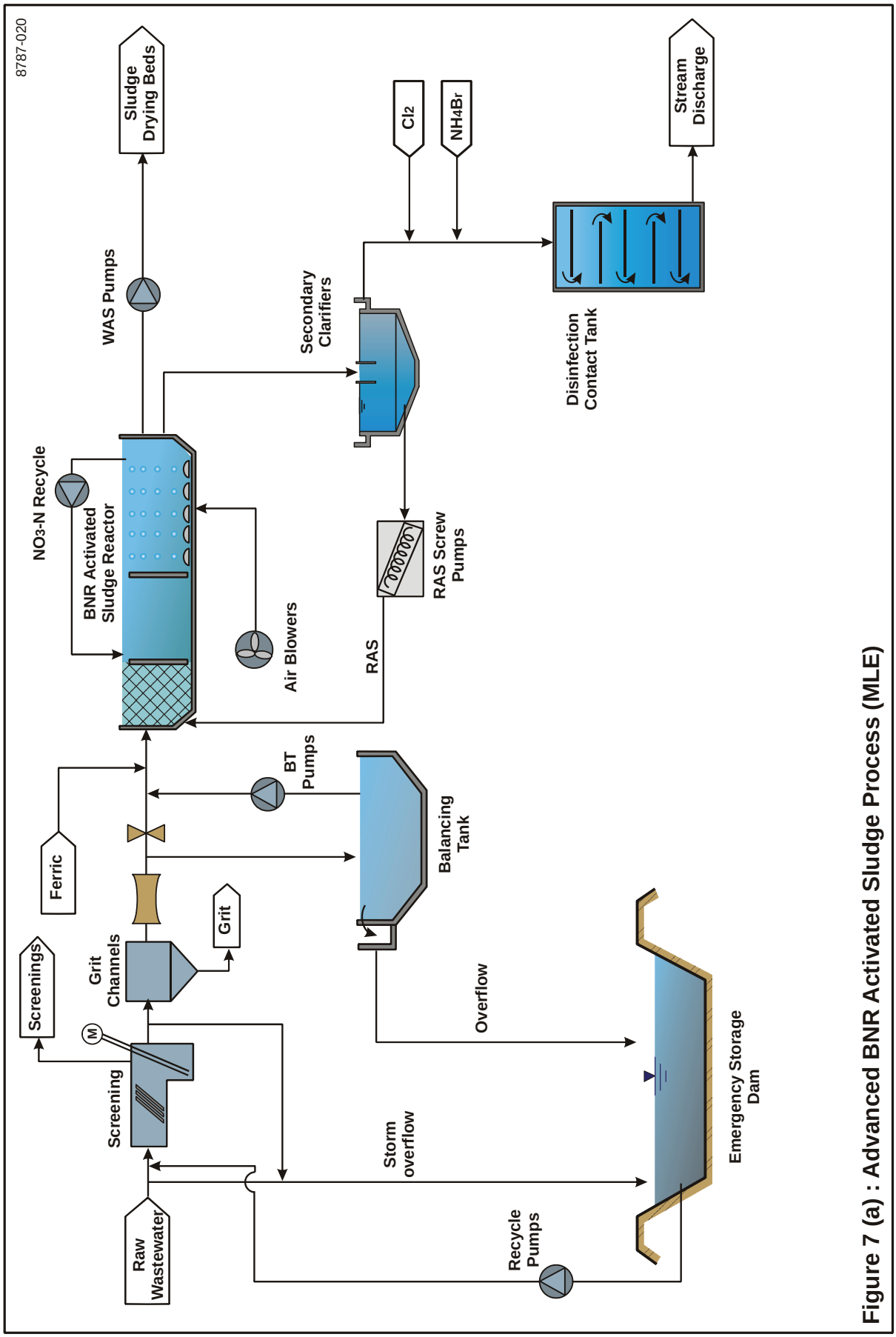


Figure 7 (a) : Advanced BNR Activated Sludge Process (MLE)

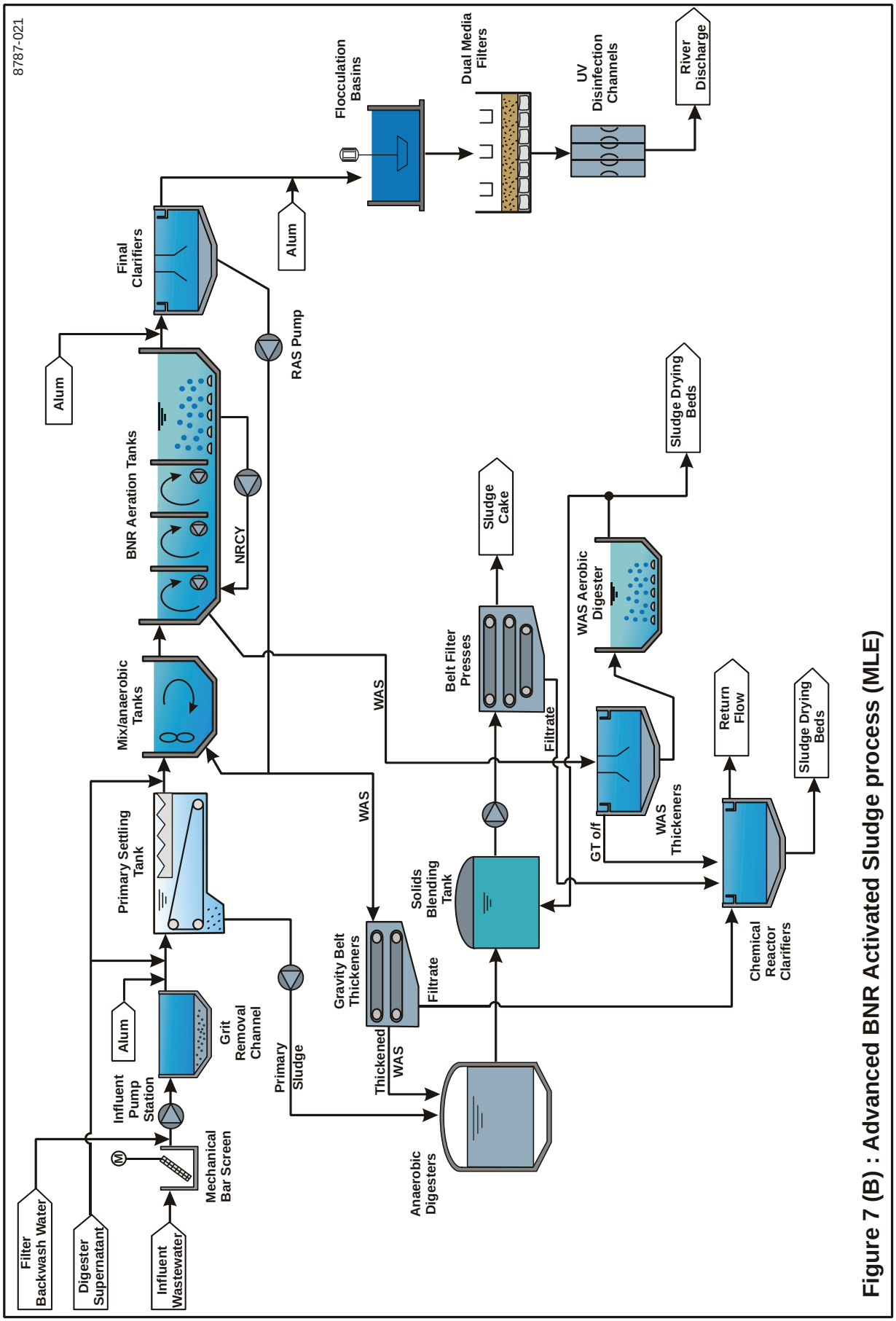


Figure 7 (B) : Advanced BNR Activated Sludge process (MLE)

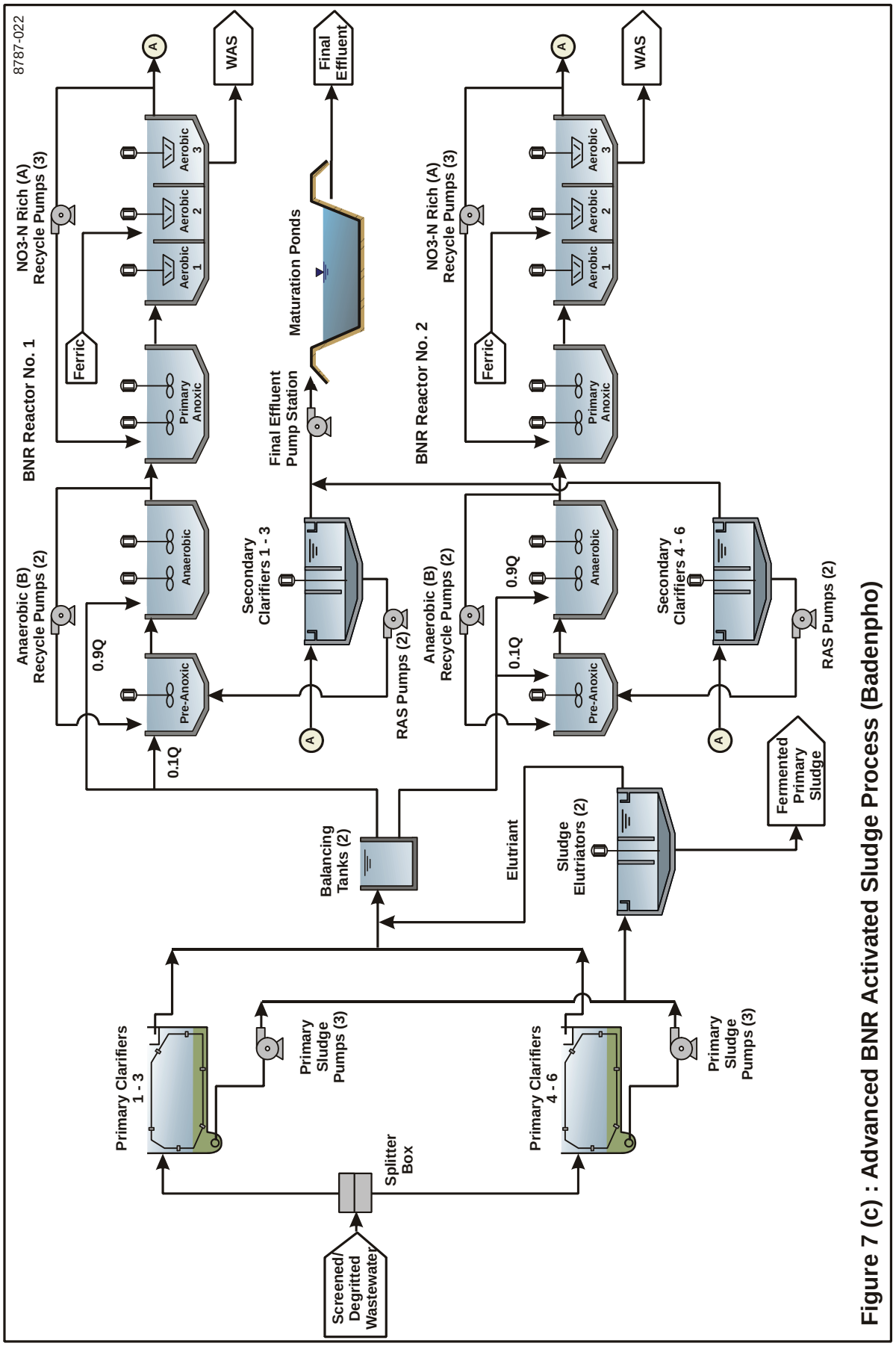


Figure 7 (c) : Advanced BNR Activated Sludge Process (Badenpho)

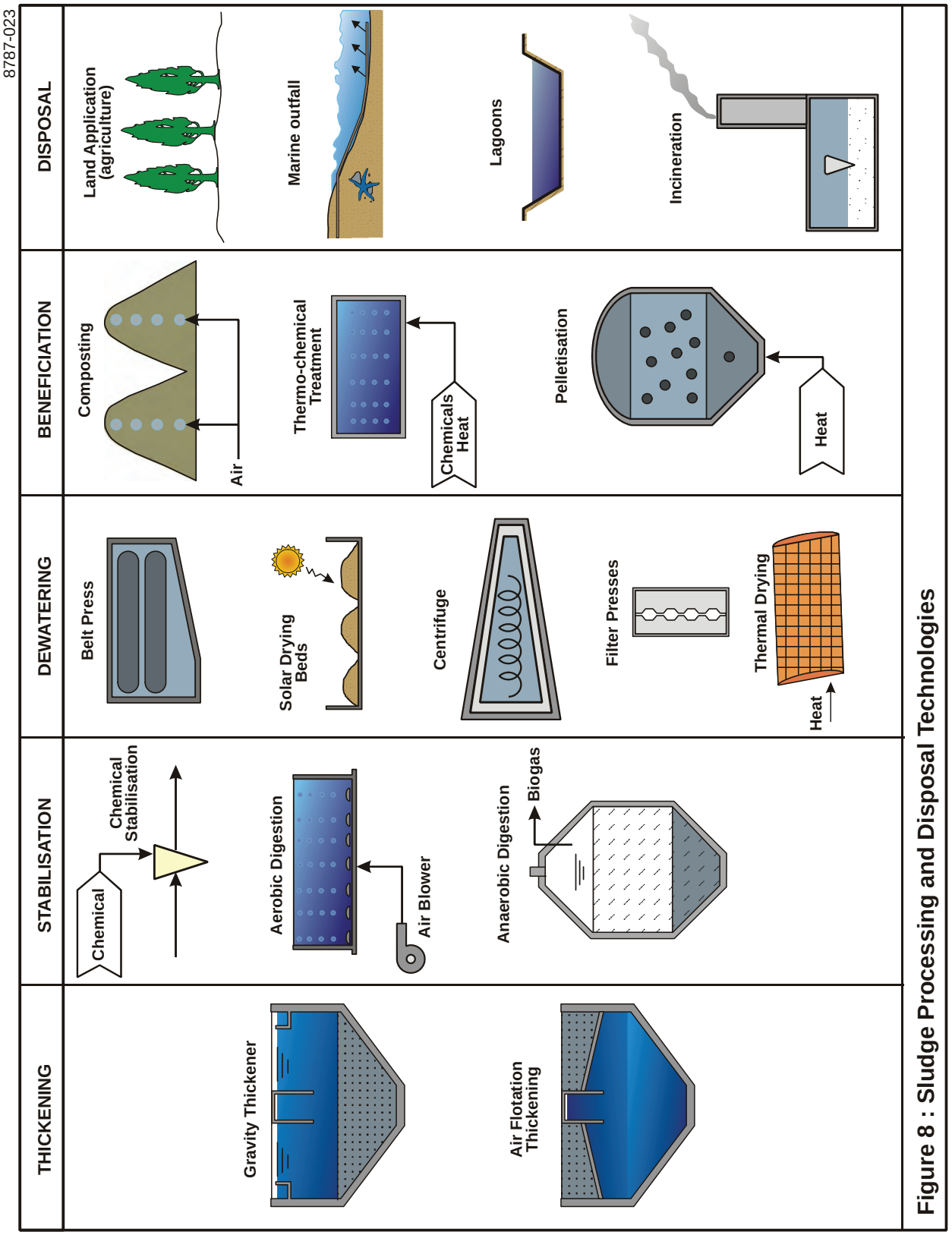


Figure 8 : Sludge Processing and Disposal Technologies

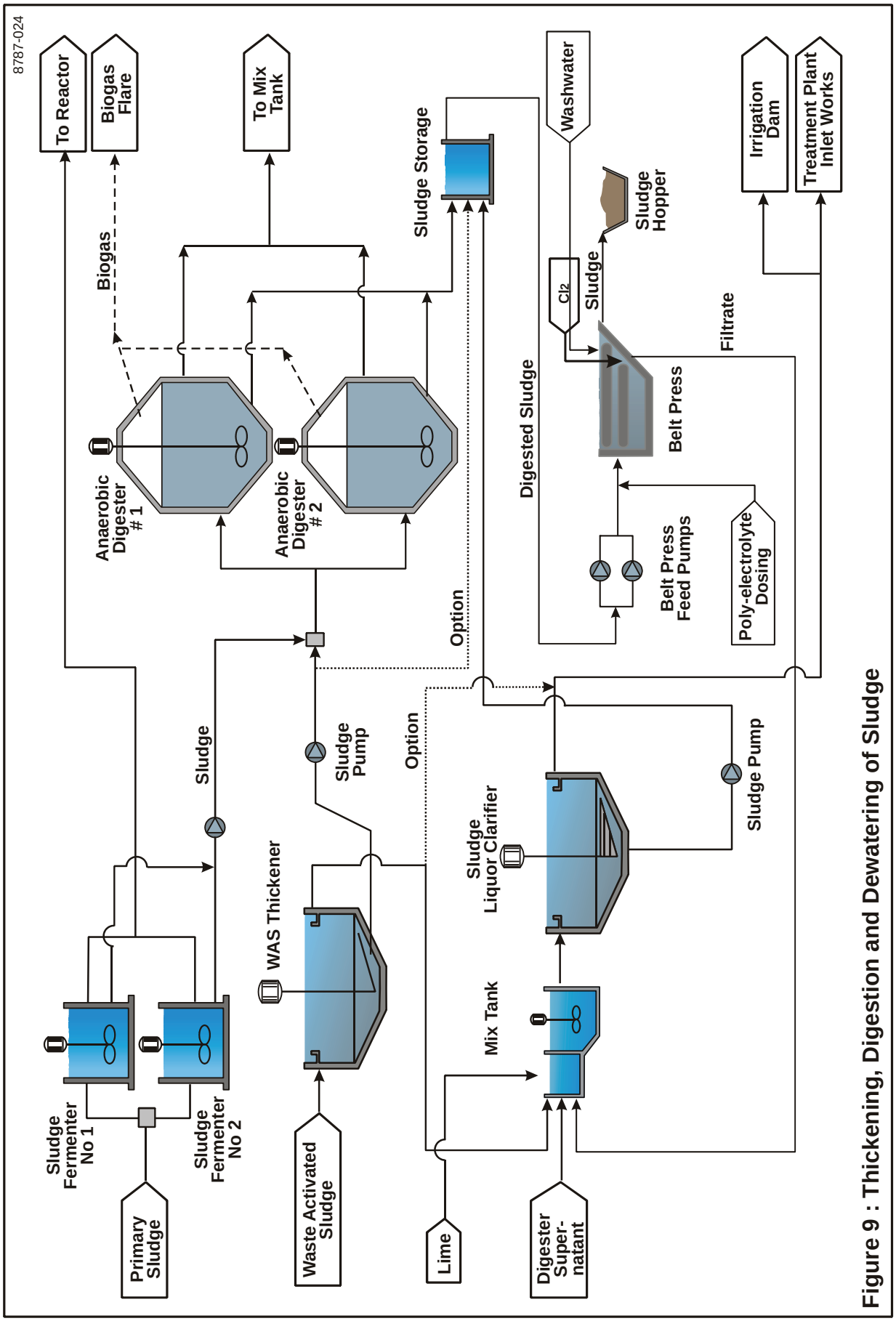


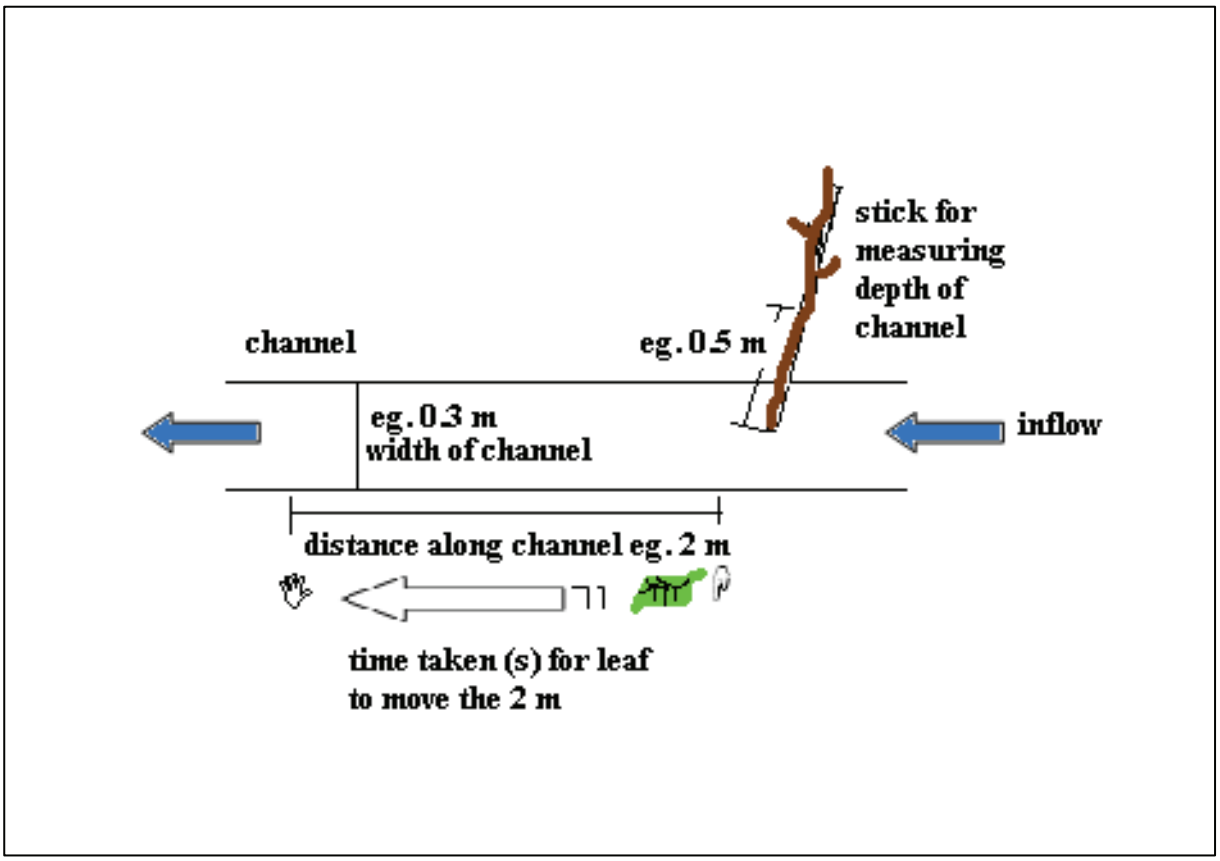
Figure 9 : Thickening, Digestion and Dewatering of Sludge

APPENDIX D

A SIMPLE METHOD TO ESTIMATE THE FLOW INTO A WWTW

ESTIMATING THE FLOW TO A WWTW

- Pace out and mark a length (l) (e.g. 2 metre (2 m)) along the straight channel
- Measure the depth (d) of the channel in metres (m)
- Measure the width (w) of the channel in metres (m)



- Calculate the volume:

Volume (m^3) = (l) x (w) x (d)

Remember: 1 m^3 = 1 000 ℓ

- Take a leaf and drop it into the channel
- Time in seconds (s) of how long it takes for the leaf to move the 2 m distance in the channel
- Calculate the flow rate in litres per second (ℓ/s) where:

$$\text{Flow (ℓ/s)} = \frac{\text{Volume (ℓ)}}{\text{Time taken for the leaf to move 2 m (s)}}$$

EXAMPLE:

Length of channel measured (l) = 2 m
Width of channel (w) = 0.8 m (800 mm)
Depth of channel (d) = 0.3 m (300 mm)
Time taken for leaf to travel 2m = 6 s

Therefore, Volume = (l) x (w) x (d)
= 2 m x 0.8 m x 0.3 m
= 0.48 m^3

And since 1 m^3 = 1 000 ℓ,
then 0.48 m^3 = 480 ℓ

So, Flow (ℓ/s) = $\frac{\text{Volume (ℓ)}}{\text{Time taken for the leaf to move 2 m (s)}}$

= $\frac{480\ ℓ}{6\ s}$

= 80 ℓ/s

How to convert ℓ/s to Mℓ/d

The basic calculation to convert ℓ/s to Mℓ/day:

Example: What volume is entering the WWTW per day if the flow meter records a volume of 25 ℓ/s?

There are 86 400 seconds in a day (60 seconds per minute x 60 minutes per hour x 24 hours per day), so:

25 ℓ/s x 86 400 s = **2 160 000 ℓ/day**

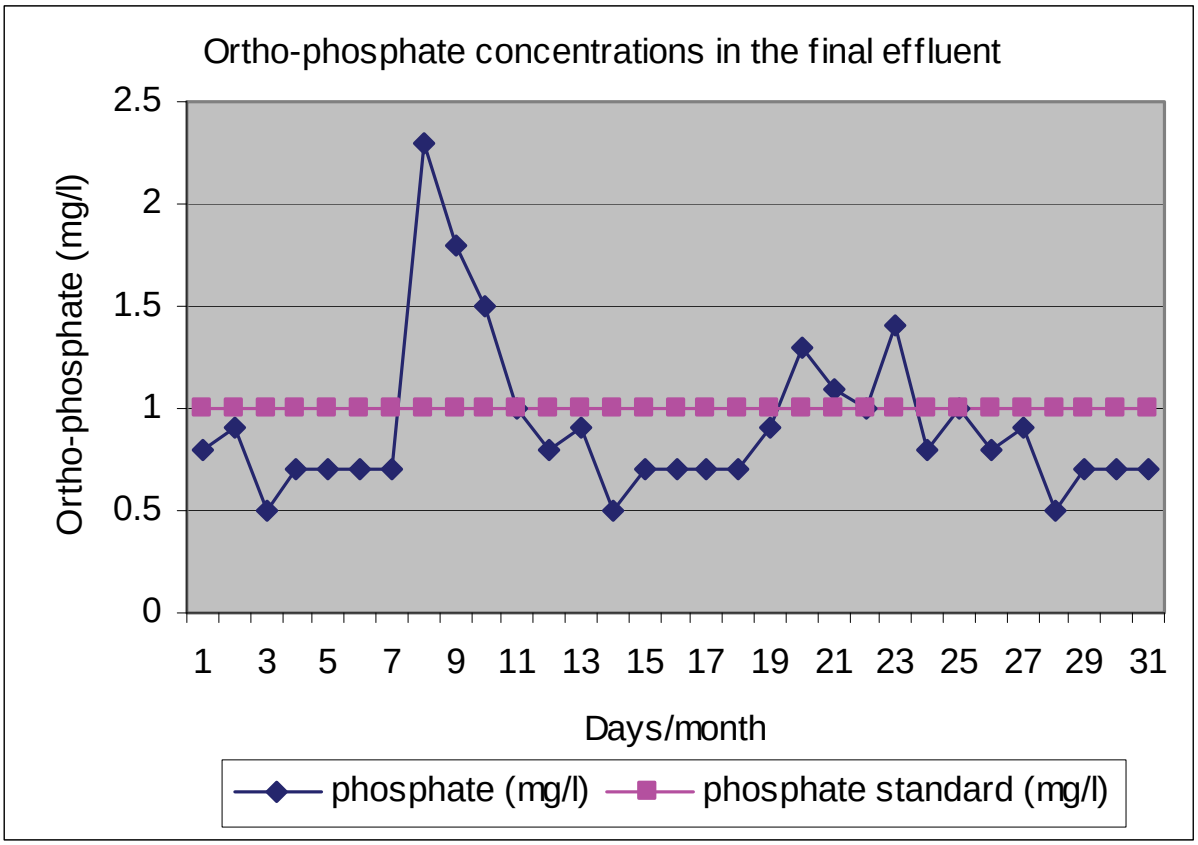
Also: 1000 litres (ℓ) = 1 kilolitre (kℓ) and 1000 kilolitres (kℓ) = 1 Megalitre (Mℓ)
Therefore, 1 000 000 ℓ = 1 Mℓ

So that: $\frac{2\ 160\ 000\ ℓ/day}{1\ 000\ 000\ ℓ/Mℓ}$ = **2.16 Mℓ/d**

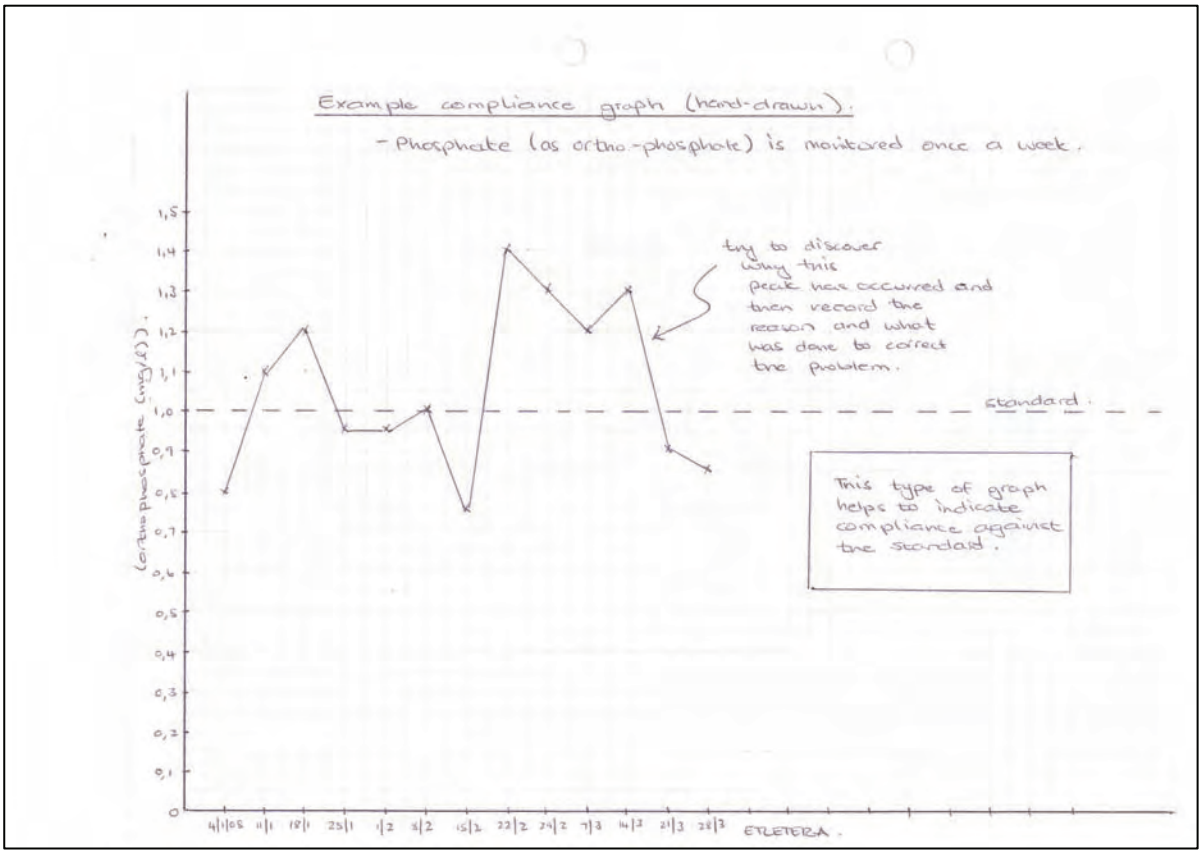
APPENDIX E

EXAMPLE FOR RECORDING WATER QUALITY COMPLIANCE

Example of a typical graph to present water quality results



The results can even be recorded by hand on a piece of graph paper. See the example below.



APPENDIX F

NORMS

Raw Wastewater Concentrations

Parameter (mg/l)	Weak	Strong	Typical Design
COD	500	800	750
TSS	250	400	350
TKN	50	80	70
TP	8	15	12

Sludge Volume Index (SVI)

Parameter (mL/g)	Bad	Good	Best
SVI	> 150	100-150	< 100

Mixed Liquor Suspended Solids (MLSS)

Parameter (mg/l)	Winter Operations	Summer Operations
MLSS	3000 - 4500	2500-3500

Effluent Discharge Qualities

Parameter	General Limit	Special Limit	Typical Large Metro Limits
Chemical Oxygen demand (mg/l)	75	30	55
pH	5.5-9.5	5.5-7.5	6.0-7.5
Ammonia (mg/l)	6	2	2-3
Nitrate (mg/l)	15	1.5	6-8
Suspended Solids (mg/l)	25	10	10
Free Chlorine (mg/l)	0.25	0	0
Ortho-Phosphate (mg/l)	10	1.0	1.0
Faecal Coliforms (per 100 ml)	1000	0	0
Electrical Conductivity (mS/m)	70	50	50

Anaerobic Digestion

Parameter (mg/l)	Typical operational guidelines for mesophilic digestion
Sludge feed	Sludge concentration of 5% total solids
Temperature control	Uniform temperature in the range 32-37°C (as close to 35°C)
pH control	pH 7-7.5
Solids retention time (SRT)	15-25 days
Volatile Acids	Typically in the range 50-300 $mg\ell^{-1}$ as acetic acid
Alkalinity	Typically in the range 2 000-3 000 $mg\ell^{-1}$ as $CaCO_3$
Volatile acids/total alkalinity ratio	Should be < 0.3