1. Purpose

The Bridgend Paper Mill Effluent Treatment Plant is described throughout this manual, together with plant discharge records, performance data against consent limits, and maintenance strategies.

Commissioned in 1991, the plant has consistently provided reliable and effective treatment of paper mill effluent. Designed for operational flexibility, it continues to deliver stable performance and high-quality treated effluent while meeting the requirements of the site's Environmental Permit.

The Bridgend Paper Mill Effluent Treatment Plant operates a two-stage treatment process. Primary treatment is provided by two Dorr-Oliver Clariflocculators and one Aquascreen filter, while secondary treatment comprises a Biwater activated sludge process followed by a final settlement clarifier.

2. Scope

This procedure applied to the Bridgend Paper Mill Effluent System

3. Definition and Acronyms

AOX	Adsorbable Organic Halides
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
EAM	Enterprise Asset Management
ETP	Effluent Treatment Plant
FST	Final Settlement Tank
HSB	High Sludge Blanket
IBC	Intermediate Bulk Container
MLSS	Mixed Liquor Suspended Solids
NRW	Natural Resources Wales
N&P	Nitrogen & Phosphorus
RAS	Return Activated Sludge
RPH	River Pump House
SAS	Surplus Activated Sludge
SSD	Stirred Sludge Density
SSVI	Stirred Sludge Volume Index
TDS	Total Dissolved Solids
TSS	Total Suspended Solids

4. Responsibility

It is the responsibility of the environment manager to control and implement this procedure.

5. Related Documentation

6. KPI

This procedure has no KPIs directly associated with it.

7. Procedure

System Overview

Pre-treatment

Two effluent streams initially enter the effluent mixing and distribution box.

The primary stream from the mill passes through an Aquascreen, which removes coarse solids such as plastics and wood prior to treatment. A bypass is provided to maintain flow in the event of screen blockage. The secondary stream, originating from the former Jonathan machine house drain, enters the mixing and distribution box directly and normally contributes only a small proportion of the total flow.

The mixing and distribution box serves as the central collection point for all mill effluent. A series of valves and penstocks allows the operator to direct the incoming flow to the primary treatment stage.

Effluent is gravity fed from the mixing and distribution box to either or both operational Dorr-Oliver Clariflocculators (Nos. 5 and 6). Clariflocculators Nos. 1 to 4 are no longer in routine service; however, Nos. 3 and 4 remain available for emergency operation if required.

Prior to entering the clariflocculators, the effluent passes through Inlet Inspection Chambers 1 and 2.

Primary Treatment

Primary treatment is provided by two Dorr-Oliver Clariflocculators (Nos. 5 and 6), each with a capacity of 3,050 m^3.

The clariflocculators utilise a Dorr-Oliver design incorporating a half-bridge rotating outer scraper and a central flocculation zone fitted with internal rakes and paddles to promote effective solids separation.

Settled primary sludge is removed by four Willet reciprocating ram pumps, while clarified supernatant flows over the peripheral launder into Manhole 1, the primary effluent collection chamber.

Balance tank

The balance tank is a reinforced concrete buffer tank that collects all primary treated effluent prior to the secondary treatment process.

Associated equipment includes:

- One Archimedean screw pump (M1), with a maximum flow capacity of 316 L/s. A screw failure alarm is monitored at the Security Gatehouse.
- Penstock No. 4 effluent diversion valve.
- Overflow arrangement to the Return Activated Sludge (RAS) Pump Station.
- High-level float alarm linked to the Security Gatehouse.

RAS pump station.

The RAS Pump Station receives Return Activated Sludge via an 825 mm pipeline into a 730 m^3 collection tank.

Associated equipment includes:

- Two Archimedean screw pumps (M10 and M11), each with a maximum capacity of 475 L/s, configured as one duty and one standby unit.
- High- and low-level float switches for automatic pump control.
- High sump level warning float alarm monitored at the Security Gatehouse.

Premix tank

Clarified primary effluent is pumped from the Balance Tank by the M1 Archimedean screw pump and mixed with Return Activated Sludge (RAS) delivered by either M10 or M11.

Mixing is achieved by the injection of air through two aerators, ensuring thorough blending of the primary effluent and return sludge prior to biological treatment.

Oxidation Ditch.

The oxidation ditch comprises two main aeration tanks, each divided into two sections by a central separating wall incorporating a 2.5 m × 2.5 m interconnecting opening.

Each tank is 55 m long, 17.7 m wide, and 3.5 m deep, providing a total treatment volume of approximately 6,800 m^3.

Each ditch is equipped with two 37 kW Mammoth brush rotors. Rotors M4 and M7 operate continuously to maintain mixed liquor circulation and provide oxygen transfer, while rotors M5 and M6 are automatically controlled in response to dissolved oxygen concentration. Each rotor has a maximum oxygen transfer capacity of 9 kg O_2 per metre of rotor length per hour.

Dissolved oxygen concentration is continuously monitored by an Endress+Hauser oxygen transmitter, with readings displayed in the Control Room and recorded on the PI Process Book.

Mixed liquor level is regulated by a movable weir system, which also influences the degree of oxygen transfer provided by the Mammoth brush rotors.

Mixed liquor flows over the outlet weir and is conveyed through a 900 mm concrete pipeline to the centre feed well of the Final Settlement Tank.

Final Settlement Tank

The Final Settlement Tank is a sludge blanket clarifier with a diameter of 45 m, a surface area of 1,591 m², and a total volume of 6,100 m³.

Influent mixed liquor enters through a central feed well fitted with a distribution skirt to promote even flow distribution. Settled sludge is collected by a full-bridge scraper fitted with a trailing scraper arrangement and is continuously withdrawn from the central hopper under hydrostatic head.

Return Activated Sludge flow is manually controlled by a telescopic valve located at the end of the sludge draw-off pipe. A drain valve is fitted beneath the telescopic valve to facilitate maintenance and draining operations.

Sludge blanket level is continuously monitored by a Bestobell Mobrey sludge blanket detector. A high sludge blanket alarm is transmitted to the Security Gatehouse.

The peripheral launder is fitted with a high-pressure spray cleaning system mounted on the rotating bridge. The system may be operated continuously or on a timed cycle.

Clarified effluent passes over adjustable peripheral V-notch weir plates (±50 mm adjustment) before flowing by gravity to the Final Effluent Chamber.

Final Effluent Chamber

The Final Effluent Chamber is a reinforced concrete distribution structure that receives treated effluent from the Final Settlement Tank together with flows from the Nant Gwyn stream. A series of penstock valves allows the operator to regulate the proportion of effluent and stream flow in accordance with operating conditions and discharge requirements.

Sludge Handling (activated)

Surplus Activated Sludge (SAS) is withdrawn from the Return Activated Sludge (RAS) line at the SAS collection pit by two positive displacement pumps (M3 and M4), configured as one duty and one standby unit. The pumps have a variable flow rate of up to 20 m³/h.

The SAS is transferred directly to the screw press for dewatering.

Associated equipment:

- Low-level float switch installed in the SAS pit to provide protection and control of pumps M3 and M4.

Picket Fence Thickener (taken out of service)

The Picket Fence Thickener was originally installed to increase the solids concentration of sludge received from the RAS system, with an inlet solids concentration of approximately 0.7%.

The unit comprises an 8 m diameter thickening tank with a side water depth (SWD) of 3.5 m and is fitted with a full-width fixed access bridge, central drive tube, picket fence scraper mechanism, tilting valve assembly, and inlet deflector drum.

Drain and overflow arrangements return flow to the RAS system.

This equipment is no longer in service.

Sludge Handling (Primary)

Settled sludge collected in the primary clariflocculators is fed to the screw press at a consistency of approximately 4-5% via Willet reciprocating pumps (see above) and pressed to approximately 50% dryness.

The sludge collects in a holding tank and enters an integral flow distributor which directs it into the disc thickener. This raises the consistency to about 20%. Filtrate is returned to effluent drain.

This thickened sludge is fed into the screw press via an inlet chute. The screw then propels the material towards the pressing zone, which builds up a counterpressure and drives the free water of the material treated through the basket. Solids are retained and expelled by the screw through the press exit aperture at a consistency of about 50%.

Filtrate from the press re-enters the sludge holding tank.

Sludge generated is collected from the floor below the drum by mechanical means, loaded onto open top truck and disposed of via agricultural land-spreading or animal bedding.

Responsibilities

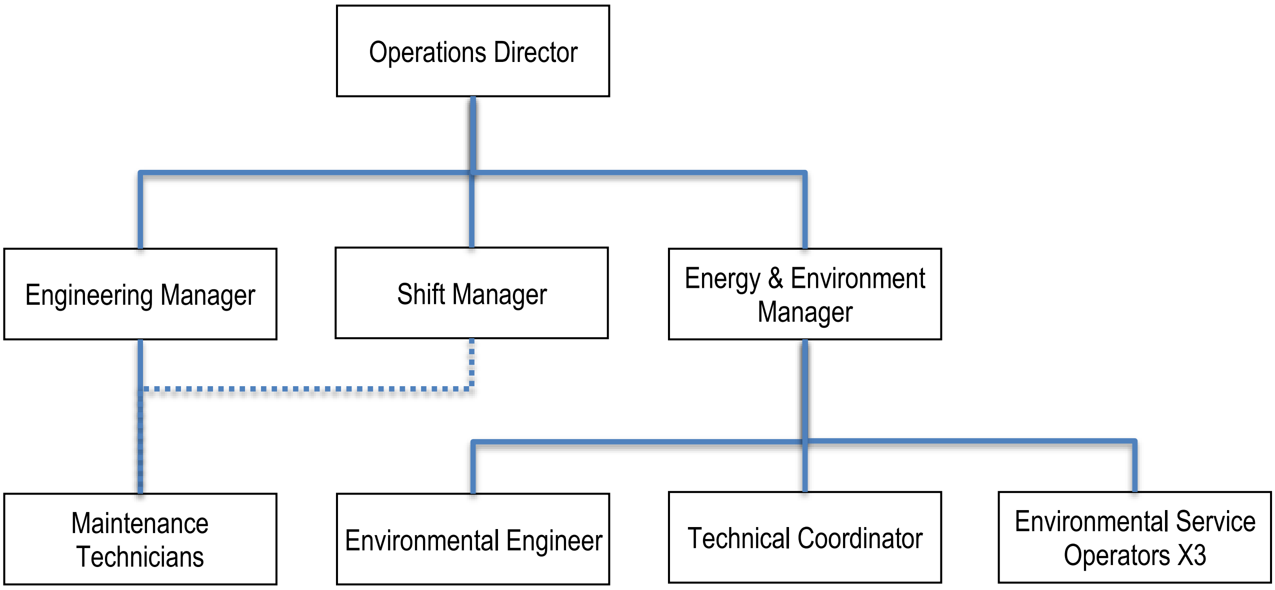
Technical Coordinator – see current RR&Es

Environmental Engineer - see current RR&Es & deputises for Technologist re effluent sampling

Environmental Service Operators – see current RR&Es

Manning

Organogram for effluent plant responsibility



The effluent plant is continuously monitored by the PI system, which reports all major problems. Periodic manning is by 3 ESOs for the primary treatment system and screw press plant, and by the Technical Department for the secondary treatment. Plant inspection is performed at least once per day, every day.

Cover is provided 24hrs a day and 7 days per week. Out of normal hours cover is provided by the Shift Manager.

Chemical Addition

Nutromex

Nutrient addition, based upon a liquid mix, supplies nitrogen and phosphorus supplement to the activated sludge process.

Storage of the nutrient is in a bunded vented tank of 25m³ capacity.

Nutrient is pumped into the sewage stream to maintain predetermined nitrogen and phosphorus levels.

Adjustment is done manually under the direction of the Technical Department.

Sodium Hypochlorite

Used to control filamentous bulking. Fed from semi-bulk container by gravity into the RAS pit, the feed rate is varied according to the degree of bulking and plant viability.

Plant loading

Based on 917Kgs/ day BOD

0.11Kg BOD per m³ Aeration tank volume

0.03KgBOD per Kg Sludge Solids

Plant design capabilities

Average flowrate	-	18200m³/day
Maximum flowrate	-	27300m³/day
Peak hourly flowrate	-	1136m³/hr
Average BOD loading	-	1273Kg/day
Maximum BOD loading	-	3363Kg/day
Average Suspended Solids	-	546Kg/day

Current NRW consents (October 2018)

Maximum flow	**17500m³/day**
BOD	10mg/l
Suspended Solids	25mg/l
pH	6.5 – 8.5
Ammonia NH_3	1.0mg/l
Max Temp	25ºC

Effluent Plant controls

Personnel - 24hr coverage via Environmental & technical departments and shift manager.

Flow Control

Flow into the plant is by gravity and buffered by the balance tank to maintain a constant flow to the oxidation ditch via the Archemedian screw pump.

Flows from the effluent treatment plant are monitored continuously by Pulsar Flowcert Lite ultrasonic flow meter. Flows are registered locally on the meter and trended on the PI system.

Oxygen Level

Both oxidation ditches have Endress and Hauser DO transmitters linked to Mammoth Rotors M5 and M6 that bring in a rotor when the oxygen level falls below 1ppm.

DO level probes are set to control between 0.5 and 2ppm.

Sludge Blanket Level

Monitored by Bestobell Mobrey sludge blanket detector and set at 0.45m. Alarmed locally in the main switch room and at the security gatehouse.

Remote Monitoring

The PI Process Book provides a comprehensive overview of the plant's operational data by capturing information from all online instrumentation, continuous monitoring systems, motors, pumps, and other process equipment. It also incorporates the results of manually performed laboratory analyses. This enables real-time monitoring of plant performance and provides historical trending of process parameters to support operational control, performance assessment, and troubleshooting.

Sampling regime

The following samples are taken as and when required:-

<u>Primary Outfall</u>

BOD (Biochemical Oxygen Demand)
COD (Chemical Oxygen Demand)
Suspended Solids
Nutrient levels (total N & total P)

<u>Secondary Aeration</u>

Mixed liquor solids
Stirred Settled Sludge Volume
Nutrient levels (total N & total P)
Microscopic analysis of sludge

<u>Final Settlement Tank</u>

Sludge blanket level.
RAS solids
Nutrient levels (total N & total P)

Final Effluent Outfall

Suspended Solids
pH
BOD
COD
Nutrient levels (total N & total P)
AOX

Primary Sludge

Moisture
Ash
Fibre fractionation

External analysis regime

Influent and effluent samples are taken annually for GCMS multiscreen of SHVC and the following metals (total & dissolved): Zinc, copper, cadmium, lead, mercury, nickel

Plant Failure

All pumps are doubled up as Duty/Standby. Pumps are linked to level sensors that start the standby pump if levels increase in tanks due to pump failure.

Rotors for aeration are also Duty/Standby and are started when Oxygen concentration falls below 1mg/l.

In the event of a total power failure to the plant, there is a backup 'House Set' that can be activated to provide power to essential plant and prevent spill of untreated effluent to river.

Indication of power failure is registered at the security gatehouse alarm panel and relayed via radio to all relevant personnel.

In the event of effluent being below discharge specification, there is a facility on site to recycle all effluent generated by the mill, via a series of penstocks situated at the final distribution box.

Effluent is returned to the Water Filtration Plant via the River Pump House and all water is retained within the mill water courses.

Isolation of the River Pump House from the river is also possible by the closing of valves situated within the pump house.

In the event of a total plant failure due to power, mechanical breakdown or biomass problems, there is facility to bypass the BOD plant and recycle primary treated effluent back to the mill.

Abnormal working

Abnormal working occurs during mill cleaning operations or at shut periods.

Highly alkaline liquors flushed through the papermaking system as a cleaner are segregated from all other effluent streams and collected in a previously prepared clariflocculator. Effluent held in this tank is pH adjusted to neutral by manual addition of an acid solution.

Once neutralisation has been achieved the effluent is discharged into the main effluent stream.

There is a procedure for total mill periods to run the BOD plant on oxygen and level controls only, to maintain a viable biomass for mill start up.

Effluent Recycle

Treated effluent from the mill can be either discharged to the River Llynfi or recycled by gravity to the River Pump House and pumped to the Water Filtration Plant, where it is reused in the process.

Generally the mill runs with a recycle flow of ~40%, though this can range from 0 – 100% dictated by process conditions and River Llynfi flow and effluent quality.

Responsibility for recycle/discharge flows is taken by the technical department or day operator. Out of hours responsibility is assumed by the shift manager.

Flow through the recycle channel is monitored using a Endress and Hauser ultrasonic flow meter and recorded locally on the meter and also at the Water Filtration Plant.

Maintenance

The design of the plant allows minimal regular maintenance due to the flexibility of the plant. Generally, the plant can be allowed to run to failure because of the back up systems. There are however, regular lubrication regimes in place to ensure that all critical plant is kept in optimum condition.

The EAM system produces a job ticket at set intervals to ensure that the routine lubrication takes place. Records of lubrication are maintained on the EAM system database.

Visual integrity checks are carried out as part of the daily routines on the plant and faults or concerns logged on the BOD plant log and acted upon using the EAM system.

For general repairs an EAM Request is submitted and scheduled for repair at the earliest opportunity.

Records of general repair maintenance are maintained on the mills EAM maintenance system.

Instrumentation maintenance is carried out on a weekly basis in accordance to a (PWR) ticket being produced. Records of instrument repair and calibration are maintained for inspection at the BOD plant 'Biox' cabin.

There is an ongoing programme to replace original plant equipment with equipment of improved design and capability. This is done when failure of existing plant occurs.

Measurement

All measurements on consents are monitored continuously and the instruments used are serviced and calibrated according to the manufacturer's recommendations.

Records of servicing and calibration are maintained at the BOD plant cabin.

Flow monitoring equipment and methodologies of discharge and recycle flows are MCERTS accredited and subject to independent audits every 2 years.

Continuous BOD measurement instrument BIOX 1010 is serviced and calibrated to manufacturer's guidelines. These records are maintained in the wet laboratory IPPC file.

Operating Procedures

The first stage of the effluent treatment at Bridgend is by physical means, the second stage effluent treatment utilises both physical separation and conversion processes.

Operating procedure for BOD plant

Biological Controls

There are several elements to the correct and proper operation of the activated sludge Biochemical Oxygen Demand (BOD) plant, each of which interrelates with the other. Due to these interactions reference must be made to the other prior to making any decision to make changes to the plant.

The sections of the BOD plant have been described in detail earlier in the overview of the plant.

The primary design of the plant is to remove soluble organic biodegradable compounds that remain after the primary settlement treatment stage.

The plant relies on two main elements:

1. Water loading (referred to as Hydraulic load)
2. BOD load (the dissolved organics in the water)

The plant which is made up of several tanks is filled with aerobic bacteria which uses the BOD content as a source of food, the water phase effectively being the transportation for the food, so in simple terms it's a balancing act between the amount of load (food) entering the plant and the mass of the solids (activated sludge in the plant). Maintaining a proportionate balance will give good conversion:-

Effluent (soluble organics) **+** Oxygen → Bio-conversion **=** Extra Biomass **+** Carbon Dioxide

It is important to maintain a constant flow with as few spikes or surges of flow as possible and a constant BOD loading.

The feed of organics to the plant is supplemented by a dose of nutrient that contains nitrogen and phosphorus, this is added to promote biomass growth.

F/M Ratio

The biological loading for the plant is expressed as:

Activated sludge loading or Food to Biomass F/M ratio

$$F = Kg\ BOD\ fed\ to\ plant\ per\ day = \frac{BOD(mg/l)\ x\ flow\ (m^3/d)}{1000}$$

$$M = Kg\ Biomass\ in\ the\ bioplant = \frac{MLSS\ (mg/l)\ x\ V(m^3)}{1000}$$

where V = *volume of oxidation ditch (6800m³)*.

Typically activated sludge plants would run at an F/M ratio of 0.2 – 0.4

Bridgend mill activated sludge plant typically runs on a ratio 0.005 to 0.012

The plant will run efficiently at what would be seen as a critically low F/M ratio, but biomass growth is much slower than if F/M was higher

Sludge Production

As the activated sludge is a living plant, the plant will continually produce sludge due to the conversion processes involved

Higher sludge production occurs at high f/m rations and conversely low sludge production occurs when the F/M ratio is low.

To maintain sludge levels in the plant consistent with the loading of the effluent entering the plant (F/M ratio) the sludge is 'wasted' when the levels reach a point where the plant is either saturated (too much sludge) or if the loading on the plant reduces (not enough food). These results are obtained from weekly measurements of the solids content of the MLSS (mixed liquor suspended solids) and RAS (return activated sludge).

Biomass wasting is done via P3 or P4 SAS (surplus activated sludge) pumps. Sludge is pumped off the plant until the sludge levels reduce enough to achieve a suitable F/M ratio.

The sludge ratio is traditionally maintained between the RAS and MLSS with a ratio of 2:1 being ideal for a good plant balance. Plant design is for RAS 0.8% and MLSS 0.4%, though typical results would be 0.45 and 0.35 (1.3:1) respectively.

The ratio between RAS and MLSS is controlled via the telescopic valve (Bellmouth) at the top of the FST (final settlement tank) draw off chamber. The rate of return is approximately equal to the flow into the plant.

It is important that the rate of RAS return from the FST is sufficient as not to hinder the settlement of sludge in the tank and not too high as to disintegrate the sludge blanket in the tank.

Sludge Settlement

The sludge within the FST must settle to produce a clear supernatant liquor or final effluent. Settlement varies and is dependent on a number of factors.

1. Concentration of the sludge.
2. Biological make up of the sludge
3. Hydraulic load on the plant
4. Rate of RAS draw off from The FST
5. Nutrient level
6. Sludge age

There are three stages to sludge settlement:

1. Free settlement. - Initial settlement where sludge particles/flocs are free to settle easily
2. Hindered settlement. – As the flocs get closer and the sludge thickens, they interfere with each other and slow down the rate of settlement.
3. Compaction. – When flocs are clumped with little space between them they continue to concentrate slowly.

Controlling the level of the sludge blanket in the FST is crucial to prevent the solids building up to a point where the blanket could rise to the top of the FST and overflow to river. The blanket is continually monitored by the HSB probe which will alarm at the security gatehouse at 0.45 metres below the surface of the water.

Very high residence time in the FST can lead to the sludge becoming anaerobic. This should be avoided as this sludge will eventually rise to the surface of the clarifier and potentially break suspended solids consents.

A typical reason for poor settlement could be 'Bulking'. This must be closely monitored by regular microscopic evaluation of the sludge.

Determination of settlement is by SSD or Stirred Sludge Density (see test methods).

Nutrient Dosing

Macronutrients in effluent will vary due to activities in the mill (chemicals/furnish etc), the effluent process conditions and the operation of the effluent treatment plant. Nutrient addition has to overcome these variations so control is necessary. Deficiencies can lead to an overall reduction in plant performance and undesirable changes in the bacterial ecosystem as more adaptable species dominate e.g. Filamentous bacteria

Rule of thumb for dosing of nutrients to an activated sludge plant is a ratio of:

100 BOD: 5 Nitrogen : 1 Phosphorous

Bridgend mill uses Omex Nutromex P as a source of nitrogen and phosphorus.

The majority of the nutrient will be taken up by the biomass and is so removed from the system in the surplus sludge.

Excess nutrient can lead to breach of ammonia consent and denitrification at the FST, which can lead to nitrogen build up in the flocs of the blanket, which will in turn cause the flocs to rise to the surface of the FST.

Dosage is via P1 or P2 nutrient dosing pump and is increased or decreased according to laboratory results of primary and final effluent testing.

Increase and decreases in nutrient addition should be done in small steps of 5 – 10% of existing dose, as small changes to dosing can lead to significant changes in residual levels

A small residual of Ammonia is required in the final effluent test to ensure that the biomass is receiving enough supplements ~0.01 – 0.1Mg/l

Consent on Ammonia is 1.0mg/l

Action should be taken to reduce dosage at 0.6mg/l

ANALYTICAL TEST METHODS

The following test methods are available in ***S:\Environmental\Environmental Mgt System (EMS)\4.4 Implementation and Operation\4.4.6 Operational Control\Effluent Test Methods***

- **LTM 019** Determination of ammonia in water
- **LTM 020** Determination of phosphate LR in water
- **LTM 029** Determination of nitrate in water (Palintest)
- **LTM 041** Determination of AOX in water (Hach)
- **LTM 042** Determination of total nitrogen in water (Hach)
- **LTM 043** Determination of total phosphorus in water (Hach)
- **LTM 045** Determination of COD (LR) in water (Hach)
- **LTM 066** Determination of BOD (rapid method)
- **LTM 089** Visible oil contamination of water courses
- **LTM 090** Stirred Specific Volume of biomass
- **LTM 091** Determination of MLSS (Mixed Liquor Suspended Solids)
- **LTM 093** Determination of low level suspended solids in water

Ammonia

To comply with the variation to our IPPC permit No. BJ5805 Bridgend paper mill is required under the amended permit (commencing 02.11.11) to conduct a daily test on the final effluent from the plant to ascertain ammonia concentration (in the form ammoniacal nitrogen). Maximum values are reported to NRW within the quarterly returns report.

Note

The permit has a consent level of **1.0mg/l**.

The operating levels are set between 0.01mg/l and 0.6mg/l

The laboratory normally takes care of ammonia testing and controlling, but in the event of the results being higher than 0.6mg/l at weekends, inform the mill manager, who will take measures to reduce the ammonia levels to normal operating range.

Check List

Check the ammonia level of the incoming waters i.e. River Llynfi at the abstraction point and Nant Gwyn (if it is being used).

Measure the Nutromex (nutrient) dosing

Check the BOD plant for any pump and or motor malfunction

Check the MLSS (mixed liquor suspended solids) and RAS (return activated sludge levels

Current and historic results are stored on the mill computer system:

S:\Green Dragon\Supereffluent (year)

Microbiology of the BOD plant

The microorganisms that comprise activated sludge are microscopic and cannot be seen with the naked eye. They must be examined using a microscope to assess the condition and performance of the biological treatment process.

The activated sludge process at the Effluent Treatment Plant relies primarily on bacteria, which are the principal microorganisms responsible for the biological treatment of wastewater. These bacteria utilise organic contaminants within the effluent as a source of both energy and carbon, making them the primary driving force behind the removal of Biochemical Oxygen Demand (BOD).

Under favourable operating conditions, bacteria reproduce rapidly by binary fission, where a single cell divides into two identical cells. Depending on environmental conditions, cell division can occur every 15 to 45 minutes. However, microbial growth is influenced by several factors, including the availability of nutrients, dissolved oxygen, temperature, pH, and the food-to-microorganism (F/M) ratio. As the availability of food decreases, the rate of microbial growth also reduces.

The condition of the activated sludge can be assessed by routine microscopic examination. A magnification of ×100 to ×200 is generally sufficient to evaluate sludge floc structure and identify the predominant microorganisms. Although interpretation is largely based on operator experience, regular microscopic examinations enable trends to be identified and provide early indication of changes in plant performance.

Routine microscopic examination should assess:

- Floc size, form, and structure.
- The type and abundance of filamentous organisms.
- The number and diversity of protozoa and higher life forms (metazoa).
- The overall condition and health of the activated sludge.

Activated sludge flocs typically comprise:

- Living microorganisms, predominantly bacteria.
- Dead microbial cells.
- Undigested organic material, such as paper fibres entrapped within the floc.
- Inorganic materials, including grit, chalk, clay, and other inert solids.

A healthy activated sludge should exhibit a well-formed floc structure, a diverse microbial population, and a balanced community of protozoa, metazoa, and filamentous bacteria. Filamentous organisms play an important role in binding the floc together; however, excessive filamentous growth may indicate an imbalance within the treatment process and can adversely affect sludge settling characteristics.

For guidance on the identification of activated sludge microorganisms, refer to **Appendix 3**.

PROCEDURE BOD PLANT SHUT DOWN AND START UP

The BOD plant normally operates in full automatic mode. Each major function has back-up facility to preclude, as far as possible, the accidental shut down of the plant. However, the plant requires an orderly shut down for extended periods of zero effluent flow e.g. holidays of more than 7 days. During such times it is important that the activated sludge is kept 'healthy'.

SHUT DOWN PROCEDURE

1 Switch the Main inlet screw pump M1 to AUTO for the duration of the shut. This will ensure that any extraneous waters entering the system will not overflow the default level and discharge to river via the ditch bypass.

2. Switch off the two duty rotors and switch on the two standby rotors to keep the sludge mixed and aerated.

3. Switch of Blowers.

4. Leave RAS pumps in Auto Mode –M10 and M11.

5. Leave Final settlement tank bridge running – M8 and M9.

6 Turn off the nutrient pumps -PI and P2.

7. Switch off SAS pumps, Pumps 3,4

8. Switch off any other chemical dosages to plant (if being used)

The Biox will continue to run until the final effluent chamber is empty whereupon the low water protection switch will trip the unit.

NB

When the plant is shut, ensure that the effluent is switched to 100%recycle at the effluent distribution box

START UP PROCEDURE

1. Allow mill effluent to flow through the plant.

2. Return MI to 'MANUAL' operation.

3. Return rotors M4 and M7 to ‘Manual’ and M5 and M6 to 'AUTO' mode.

4. Restart air blowers

5. Switch on Nutrient pumps PI or P2. (Manual Mode).

6. Start up the BIOX 1010 unit

7. Restart chemical dosing if necessary

Leave the effluent on 100% recycle until the plant has settled and all parameter are within consents

Procedure For Recycling Effluent at Bridgend Paper Mill ETP

Bridgend Paper Mill aims to reduce overall water use at the mill.

To keep in line with the IPPC (Integrated Pollution Prevention and Control) guidelines and a benchmark of 20m3/te, (based on effluent discharged to the river Llynfi), the recycling or closing up the water system is the simplest way of reducing water figures to within the benchmark figure.

Reasons for recycling

There are two main reasons for recycling;

1. To reduce overall water consumption
2. To protect the river from contamination when the effluent is out of consent, set out in our licence to discharge.

Recycling more than 50% for prolonged periods can cause process issues within the plant and must be monitored closely.

Restrictions

Closing the system (recycling) increases the demand on the disinfection systems and extra vigilance is required to ensure that biocide residual levels are maintained within the set limits. Conductivity, hardness, alkalinity and COD of mill water are likely to increase and should be monitored frequently.

Normal running

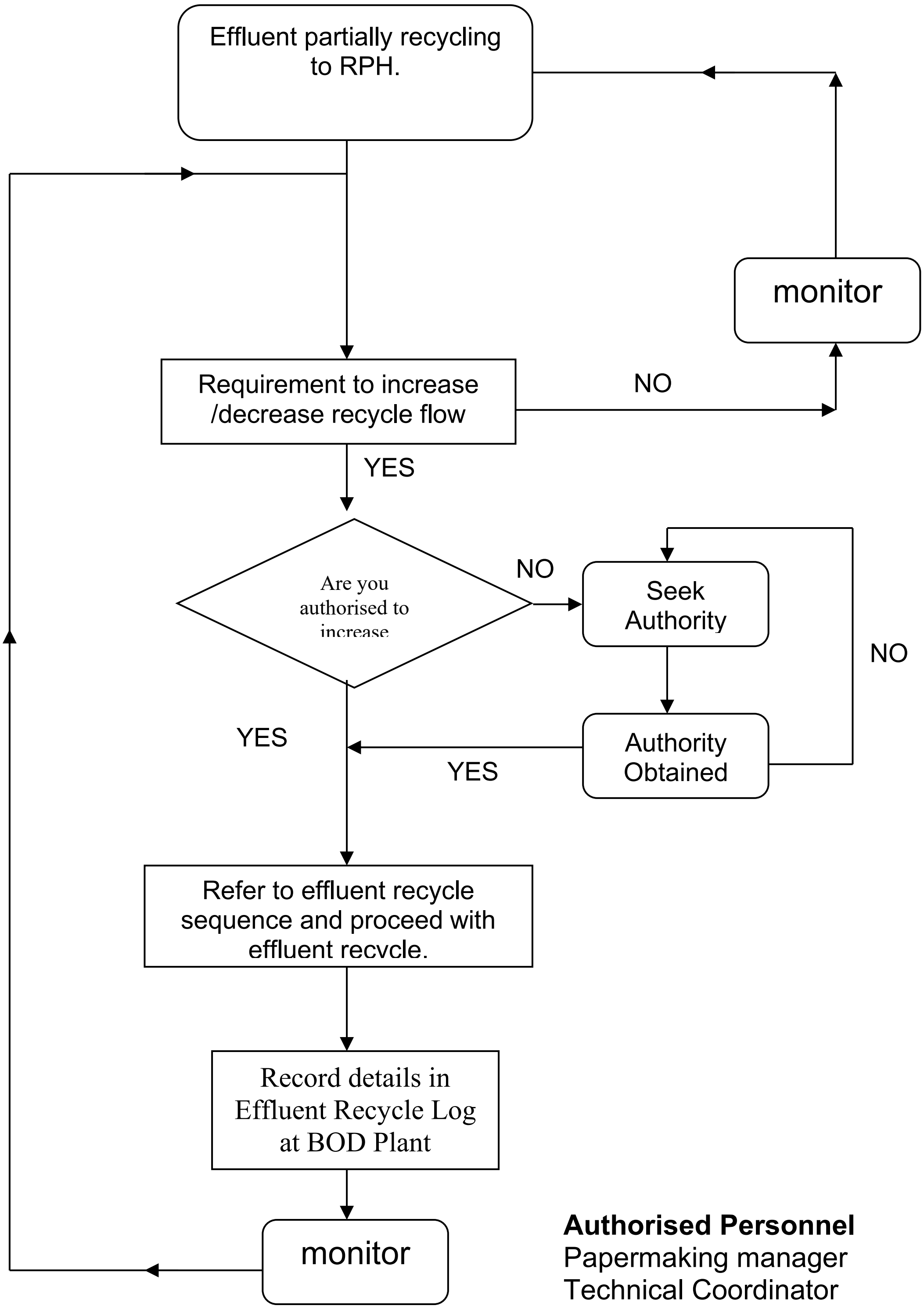
During ‘normal’ running, effluent should be recycled back to the River Pump House at a rate that ensures that:

The overall discharge from the plant to the river Llynfi does not exceed the 17500m³/day i.e. average flow of 730m³/hour

Procedure

Refer to flow chart.

EFFLUENT RECYCLE FLOW CHART

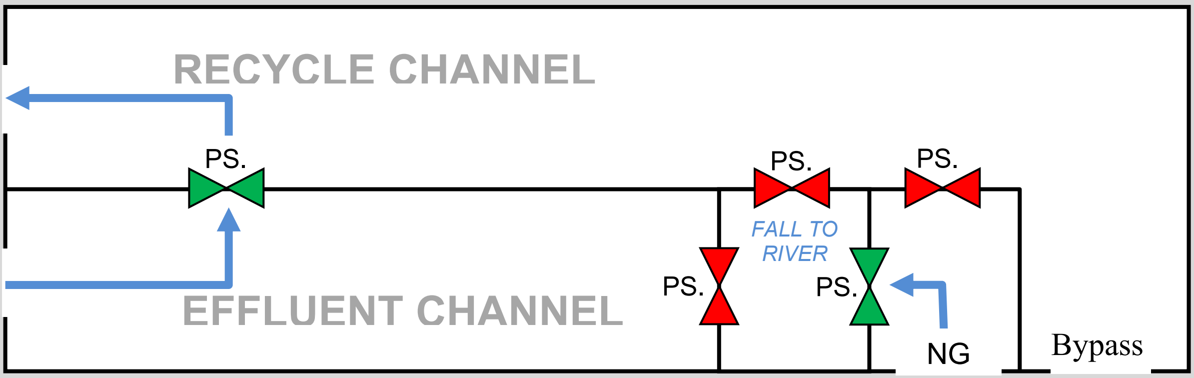


Authorised Personnel
Papermaking manager
Technical Coordinator
Environmental Engineer
Process engineer
Shift manager
Environmental Service Operators

VALVE SEQUENCE FOR EFFLUENT RECYCLE AND DISCHARGE

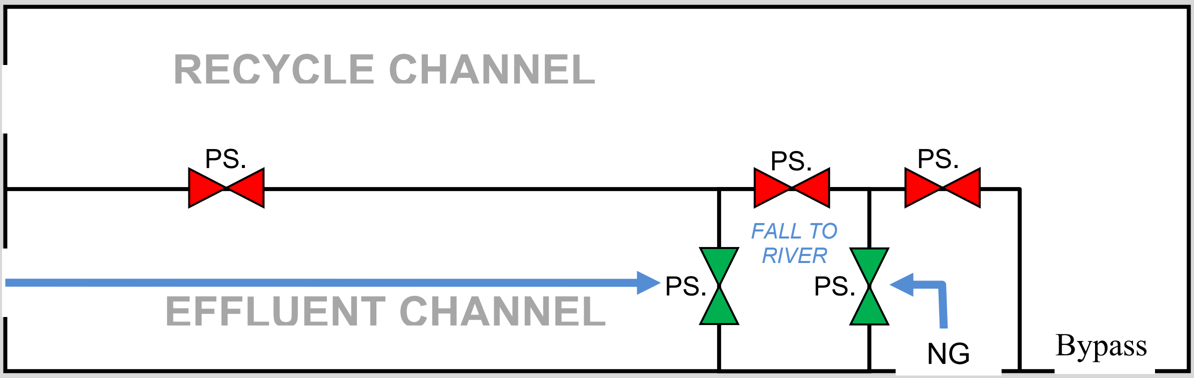
Sequence for 100% effluent recycle (0% discharge)

- Open Penstock 9 fully
- Close Penstock 6 fully



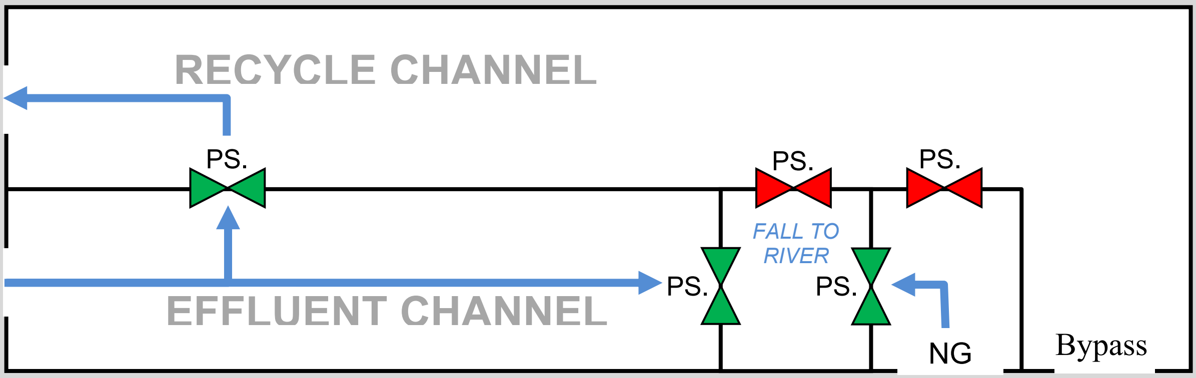
Sequence for 0% effluent recycle (100% discharge)

- Open Penstock 6 fully
- Close Penstock 9 fully



Sequence for increasing / decreasing effluent recycle

- Open Penstock 6 fully
- Open / Close Penstock 9 partially



At the River Pump House

The 2014 pump house renovation ensures that no recycled water / Nant Gwyn water backflows into the river but if the flow is greater than mill requirements, the level in the pump house chambers will rise and stop the flow through the recycle line. The effluent chamber will then overflow into the discharge outfall. To make sure this does not happen when recycling effluent or Nant Gwyn 100%:

Check, via PI or flow meter readings, that the recycle flow is less than the river pump flow. If not, increase flow from P3 by the following method (filtration plant computer):

Override inverter-driven river pump P3

1. Select Main menu
2. Select F2 – River Pump House
3. Select F1 Pump control
4. Select Pump P3, Click MANUAL
5. Increase set point (S/P) to 100% using the + icon

Monitor evacuation of water from river pump house. If insufficient, start river pump P2:

Start river pump P2

1. Select Main menu
2. Select F2 – River Pump House
3. Select Pump P2
4. Click START (The RUNNING box will flash red).

Pump P2 is not inverter-driven and pulls a fixed flow of 6000 l/m. Pump P3 may need its set-point lowered after starting P2. Monitor and adjust regularly throughout the incident.

Emergency Procedure

In the event of a major spillage, or when effluent is out of consent, e.g. sludge blanket lift, high or low pH or high suspended solids and high BOD, the priority is to contain the effluent within the mill regardless of conditions at the mill.

Emergency Procedure

BOD PLANT BLANKET LIFT PROCEDURE

If a HSB (High Sludge Blanket) alarm is activated at the security gatehouse, a visual inspection of the BOD plant is necessary to determine whether the clarifier sludge blanket has lifted.

Security officers must contact one the following:

Between 08:30 and 16:30

	Name	Mobile
Technical Coordinator	Richard Mordecai	07891 537 190
Environmental Engineer	Matthew Bradwell	07483 147 442
Energy & Environment Manager	Richard Lewis	07816 109 584

Outside these hours, the shift manager is responsible for the operation of the plant

If on inspection from the FST bridge, no blanket is visible, remove and clean the sensor in the clarifier then reset the HSB warning light in the switch room. No other action is required. However if the blanket has lifted significantly or indeed has overflowed the clarifier launder and is being discharged to river, then the following procedure should be implemented **immediately**, as our priority in this situation is to protect the river from pollution.

1. Recycle final effluent 100%, ensuring that the river is isolated. Make sure Nant Gwyn discharges to river as normal. These actions will protect against polluting the river.
2. Stop the flow into the balance tank at MH1, this will automatically start the primary effluent bypassing the plant and in turn recycling via the recycle channel.
3. For reducing the level in the oxidation ditches quickly, shut off M1. Be aware that M1 can only remain off until the balance tank is full to ground level.
4. If necessary, increase the RAS flow by opening the bell mouth.
5. Isolate the RPH from the river to prevent unauthorised discharge from the mill at the RPH.
6. A detailed inspection of the plant is now required, to ascertain the cause of the blanket lift before any remedial action can be taken as there can be several causes of blanket lift.

PARAMETERS TO CONSIDER WHEN ASSESSING PLANT

1. Flow – has the plant become unstable due to excessive hydraulic load
2. Nutrient levels – Is the clarifier denitrifying and causing the sludge to lift with the gas
3. MLSS/RAS ratio / concentration – Is the plant overloaded with sludge or is there enough sludge to form a blanket?
4. Sludge make up – What type of bacteria is the sludge made up of ? Is there an excess of filamentous?
5. DO levels. What is the oxygen concentration of the oxidation ditch?
6. Toxic shock – Has anything been released to drain from the mill that may have killed off the plant or caused the sludge to rise
7. F/M ratio – Is the plant being underfed or overfed?
8. Mechanical / electrical breakdown.- Is there a breakdown or malfunction of any part of the plant that may give rise to the poor settlement?
9. Recent historical data – what has been happening on the plant during the past month?

Standard Procedure for Control of Run off Waters from a Major Fire

1. Introduction

In the event of a major fire, it is essential that watercourses within the mill site and surrounding boundary areas are protected from contamination arising from fire-fighting activities.

All reasonable measures must be taken to ensure that contaminated fire-fighting run-off is contained within the mill effluent treatment system and prevented from entering controlled watercourses.

Where there is a potential risk of fire-fighting run-off contaminating the Nant Gwyn stream, the following two-stage response procedure shall be implemented.

2. Scope

This procedure applies to any major fire or similar emergency incident occurring within the Bridgend Paper Mill site where contaminated run-off water may be generated.

3. Responsibility

The Mill Controller (normally the Shift Manager) is responsible for ensuring that this procedure is implemented. The Mill Controller will coordinate the response and request assistance from additional personnel as required.

4. Procedure

Procedure 1 – Amber Alert

1. The Mill Controller shall monitor the volume and condition of run-off water generated from fire-fighting activities.
2. If assessment indicates that there is a risk of contaminated run-off entering the Nant Gwyn stream:
    - Notify Natural Resources Wales (NRW) via the incident hotline (0300 065 3000).
    - Notify the Energy & Environment Manager, Environmental Engineer, Technical Coordinator, and Environmental Support Officers (ESOs) where the incident occurs during normal working hours.
3. Instruct the Shift Technician to divert Nant Gwyn flows to the River Pump House using the following procedure:

At the BOD Plant diversion box (refer to Diagram 1):

i. Close Penstock 9
ii. Open Penstock 6
iii. Close Penstock 8
iv. Open Penstock 7

Following completion of these actions, all effluent flows will be discharged through the mill effluent system, increasing available capacity for the containment and treatment of Nant Gwyn flows.

Flows shall be monitored at the final effluent outfall and the River Pump House abstraction grid.

Escalation to Procedure 2 – Red Alert

Procedure 2 shall be implemented if:

- The fire is considered a major incident, with extensive fire-fighting activities and a potential risk of contamination to both the Nant Gwyn and River Llynfi.
- Following implementation of Procedure 1, there remains a risk of contamination of the River Llynfi due to fugitive emissions or contaminated run-off.

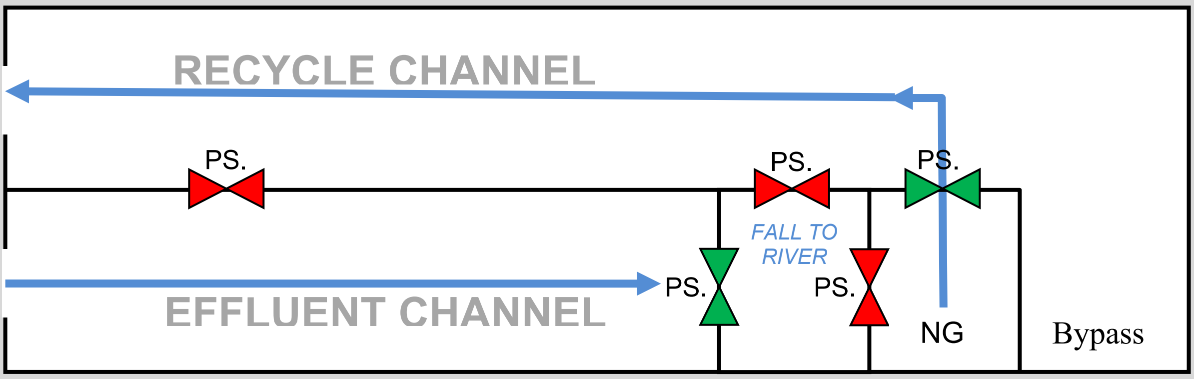
Procedure 2 – Red Alert

1. Switch the River Pumps to manual control to override the automatic level control system (refer to River Pump Override Procedure).
2. Ensure that all Nant Gwyn flow is directed through the mill influent and effluent treatment systems for containment and treatment.
3. Continue monitoring flows and system operation until fire-fighting activities have ceased and the risk of contamination has been removed.

Diag.1

Sequence for 100% Nant Gwyn recycle

- Open Penstock 7 fully
- Close Penstock 8 fully
- Close Penstock 9 fully



River pump override procedure

Override inverter-driven river pump P3

6. Select Main menu
7. Select F2 – River Pump House
8. Select F1 Pump control
9. Select Pump P3, Click MANUAL
10. Increase set point (S/P) to 100% using the + icon

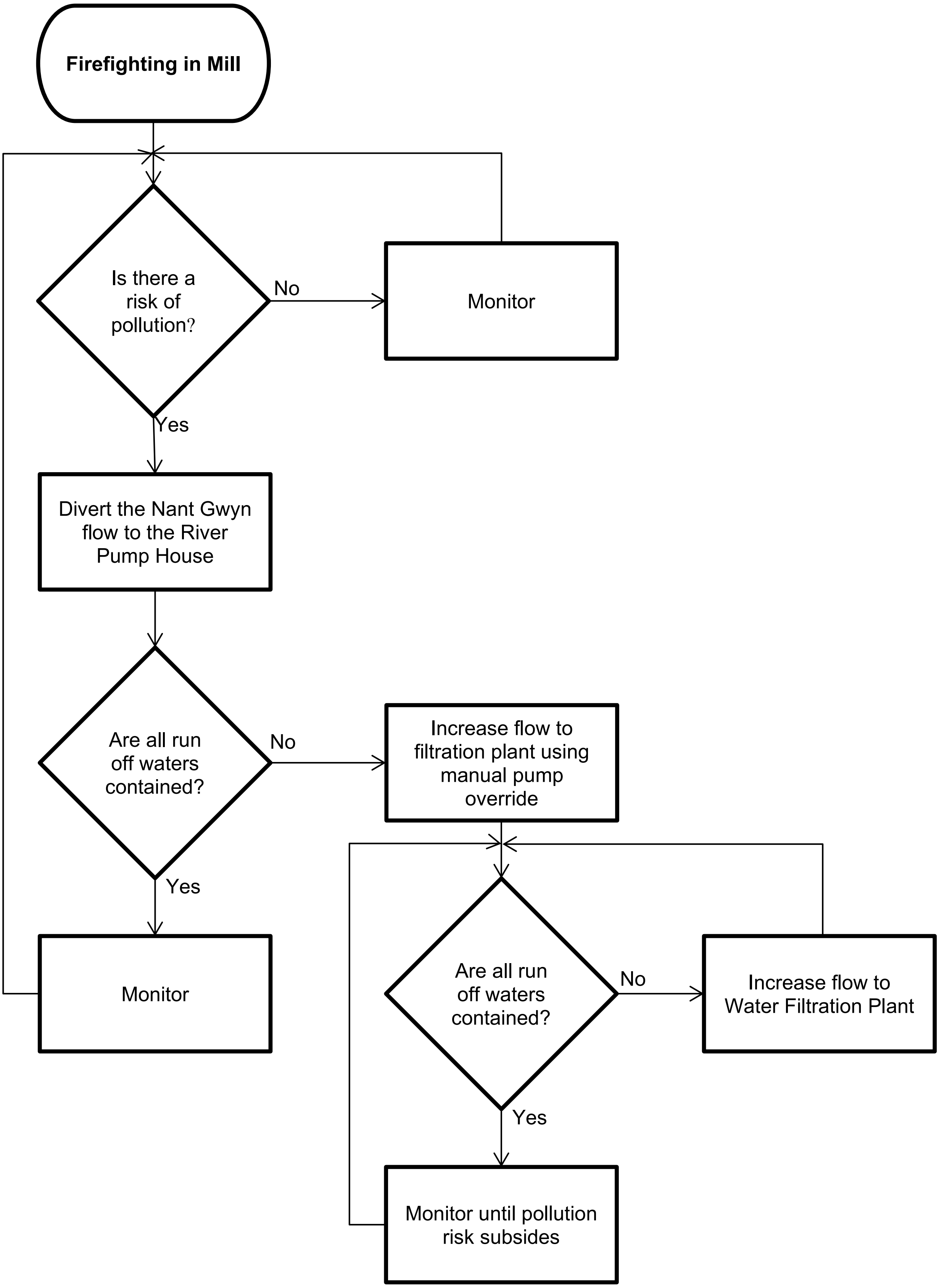
Monitor evacuation of water from river pump house. If insufficient, start river pump P2:

Start river pump P2

5. Select Main menu
6. Select F2 – River Pump House
7. Select Pump P2
8. Click START (The RUNNING box will flash red).

Pump P2 is not inverter-driven and pulls a fixed flow of 6000 l/m. Pump P3 may need its set-point lowered after starting P2. Monitor and adjust regularly throughout the incident.

9. Procedure in event of Firefighting



Problem Solving

What can go wrong?

The Effluent Treatment Plant is a dynamic biological system, and changes in plant performance may not always be immediately apparent following a process upset. There can be a significant delay between the initial cause of a problem and the resulting impact on plant operation.

The response time can range from several weeks, where gradual changes occur within the mixed liquor microbial population, to an immediate effect, such as that experienced during a toxic shock event.

Process problems generally follow the sequence:

Cause → Effect → Consequence

A deterioration in biological treatment performance will ultimately affect final effluent quality. Parameters such as Biochemical Oxygen Demand (BOD), Suspended Solids, pH, and Ammonia may be adversely affected.

Where poor effluent quality is identified, the final effluent must be diverted to 100% recycle until the treatment process has recovered and the discharge is consistently within consent limits.

Toxic Shock

Certain chemicals used within the papermaking process have the potential to adversely affect the activated sludge process if discharged to drain in significant quantities. Lower-level continuous releases may also have an impact, although this is less common.

A toxic discharge can inhibit the activity of the biological population or, in severe cases, cause significant loss of biomass. Inhibition of the biomass will reduce biological treatment efficiency, resulting in increased BOD and deterioration in final effluent quality.

In the event of a complete loss of biological activity, the plant may require reseeding with suitable activated sludge to restore treatment performance.

Any accidental chemical spill within the mill must be contained, cleaned up, and disposed of correctly. Under no circumstances should contaminated material be allowed to enter the drainage system.

Where poor plant performance is attributed to toxic shock, the final effluent must be diverted to 100% recycle until the treatment process has recovered and effluent quality is consistently within consent limits.

Foaming

Two types of foam may occur within the Effluent Treatment Plant:

1. Chemical foaming caused by process chemicals entering the effluent system.
2. Biological foaming caused by the growth of specific filamentous microorganisms.

Chemical Foaming

Chemical foaming is generally associated with mill process activities and may appear as a white froth within the Balance Tank and, in severe cases, at the final effluent discharge point.

Chemical foam can be controlled through the addition of a suitable defoamer at the Balance Tank. The defoamer reduces foam formation and assists in the breakdown of existing foam.

A small amount of foaming at the river discharge point is considered normal and is generally caused by the mixing action as treated effluent enters the receiving watercourse. Under normal conditions, this foam should dissipate approximately 20–30 metres downstream of the discharge point.

If foaming becomes excessive, defoamer should be applied as described in the Defoamer Use procedure.

If foam remains untreated, activated sludge organisms can become trapped within the foam, causing it to change colour from white to brown. This stabilised foam can encourage the growth of filamentous organisms and may result in increased Suspended Solids in the final effluent when the foam collapses.

Defoamer Use

To apply defoamer, an IBC containing suitable defoamer is positioned within the bunded area adjacent to the ditch weir.

A small outdoor chemical dosing pump can be connected to the available 110 V power supply. The defoamer is pumped directly into the weir.

The defoamer pump should initially be operated at a low dosing rate and adjusted according to the severity of the foaming condition.

Denitrification

Denitrification may occur when excessive nitrogen is present within the wastewater or when nitrate is produced through the nitrification process.

Denitrification can occur within the Final Settlement Tank (FST), where nitrogen gas bubbles become attached to activated sludge flocs. This can cause the sludge blanket to rise, resulting in poor settling performance, pin floc formation, and increased Suspended Solids in the final effluent.

In severe cases, the activated sludge blanket may rise sufficiently to be lost over the final settlement tank weir.

Control of Denitrification

Denitrification can be controlled by:

1. Maintaining correct nutrient addition and ensuring the appropriate nutrient balance is achieved.
2. Maintaining a good oxygen level in the mixed liquor flow to the FST

Filamentous Bulking

Filamentous bulking is one of the most significant microbiological issues that can affect the performance of the Effluent Treatment Plant. It occurs when filamentous bacteria become dominant within the activated sludge population, disrupting normal floc formation and adversely affecting sludge settling characteristics.

Common filamentous organisms associated with activated sludge bulking include *Microthrix parvicella*, *Sphaerotilus natans*, and other filamentous bacterial species.

Under normal operating conditions, activated sludge forms well-structured flocs that settle effectively within the Final Settlement Tank (FST). During filamentous bulking, excessive filamentous growth extends beyond the floc structure, preventing effective compaction and causing poor settling performance. This is typically identified by increased Sludge Volume Index (SVI) values and, in severe cases, excessive sludge blanket rise within the FST. If uncontrolled, the sludge blanket may reach the tank overflow level and result in increased Suspended Solids within the final effluent.

Filamentous bulking is generally associated with unfavourable operating conditions within the biological treatment process. Filamentous organisms have a long, thread-like structure that provides a high surface area for the uptake of food and nutrients. Under stressed conditions, this advantage allows filamentous organisms to compete successfully against floc-forming bacteria and higher organisms, resulting in a shift in the microbial balance of the activated sludge population.

Some common causes of increased filamentous growth:-

- **Nutrient imbalance**

Deficiencies in essential nutrients, particularly nitrogen and phosphorus, can encourage filamentous growth.

- **Low dissolved oxygen concentration**

Oxygen is an essential requirement for aerobic biological treatment. Dissolved oxygen levels should typically be maintained within the range of 1–2 mg/L to support a healthy microbial population.

- **Slowly biodegradable carbon sources**

Slowly degrading materials, such as starch and paper fibres, can promote filamentous growth. Increased starch usage within the mill may result in higher organic loading to the effluent system. Inefficient solids removal during primary treatment may also allow excessive fibre carry-over into the oxidation ditch.

- **Intermittent flow and loading conditions**

Significant variations in flow or organic loading can result in periods of overloading or under-loading, creating conditions favourable for filamentous organisms.

Remedial Actions and Controls in the event of filamentous bulking

Long-term control of filamentous bulking is achieved by identifying and correcting the underlying cause. Short-term measures may be required to restore settling performance and protect final effluent quality.

Potential control measures include:

1. Reducing mixed liquor suspended solids (MLSS) concentration to improve sludge settling characteristics and reduce the sludge blanket level within the FST.
2. Applying sodium hypochlorite treatment. Filamentous organisms are often located externally on the floc structure and may therefore be selectively affected by controlled chemical dosing.
3. Applying selective biocides designed to target filamentous organisms while minimising impact on the beneficial activated sludge population.
4. Dosing with coagulants, such as Polyaluminium Chloride (PAC), to improve floc formation and enhance sludge settling.
5. Bioaugmentation, through the introduction of suitable microbial populations to assist recovery of the biological process.

Appendix 1

Troubleshooting: Effluent Treatment Monitoring System

If the power is lost to the monitoring system, the system should auto-restart, but in case of loss of Pi data, check the following components of the signal path.

- PLC (Programmable Logic Computer) in effluent plant switch room.
- Computer in corner of effluent plant switch room.
- Wireless transceiver connected to above computer.
- Wireless receiver at top of office block (attic of board room).

Appendix 2

Procedure for Responding to Effluent Monitoring System Alarms

The PI Process Book provides the primary interface for monitoring the operation of the Effluent Treatment Plant. The system displays a comprehensive overview of the process, including plant status, process trends, equipment operation, alarms, and online instrumentation. Historical data, trends, and alarm events are automatically recorded within the PI System, providing a continuous record of plant performance.

To comply with the requirements of the site's Environmental Permit, the Effluent Treatment Plant must be monitored 24 hours a day, seven days a week. During normal working hours, monitoring is carried out by day personnel. Outside normal working hours, responsibility transfers to shift personnel. In addition to routine monitoring via the PI Process Book, selected critical plant alarms are sounded at the Security Gatehouse to provide notification of significant process or equipment faults outside normal working hours.

Any abnormal operating conditions, equipment failures, or critical alarms must be investigated promptly and reported in accordance with site procedures.

Note: The PI Process Book records and archives alarm events; however, operators should routinely review the alarm displays and process trends to identify active alarms and developing process conditions.

Monitoring Procedure

1. Access the PI Process Book and review the plant overview, process trend, status, and alarm displays.
2. Respond promptly to any critical alarms received at the Security Gatehouse by reviewing the corresponding alarm and plant status within the PI Process Book.

3. Check for active alarms, equipment trips, abnormal operating conditions, and adverse process trends, paying particular attention to parameters approaching consent limits or operational set points.
4. Where an alarm, equipment fault, or abnormal process condition is identified, attend the Effluent Treatment Plant, investigate the cause, and take the appropriate corrective action.
5. Record all alarms, abnormal conditions, and corrective actions taken in the plant monitoring log.
6. Where additional assistance is required, contact the appropriate day personnel using the emergency contact list held by the Mill Shift Manager.

Permitted levels

	Minimum	Maximum	95%ile
BOD mg/l	n/a	10mg/l	5mg/l
Suspended Solids mg/l	n/a	25mg/l	25mg/l
pH	6.5	8.5	n/a
Temperature ° C	n/a	25	Daily Average
Discharge Flow m^3/day	n/a	17500	n/a
Ammonia mg/l	n/a	1.0	n/a

6 Protozoa and metazoa

Protozoa, and frequently also metazoa, are almost always present in activated sludge. Some species are attached to the flocs whereas others are free in the water between the flocs. These organisms are (much) larger than bacteria, their 'length' varying from 10 to 10,000 µm (table 2). In addition, they also possess a characteristic shape. On account of the combination of characteristics, they are very conspicuous on a microscopic slide.

Like bacteria, protozoa are single celled organisms. As long as the sludge loading level is not extremely high, they are present in practically every activated sludge. Their population is always much smaller than that of the bacteria. The biomass of protozoa present in the treatment plant comprises, at most, a few percent of the total biomass.

Table 2 Order of magnitude of(micro-)organisms in activated sludge

Group	Cell length (µm)	Remarks
bacteria	1–5	occasional colonies or filaments
protozoa		
-flagellates	10–30	occasional colonies
-amoeba	30–400	
-testate amoeba	30–200	
-heliozoa	40–200	
-ciliates	25–400 [1)]	occasional colonies
metazoa		
-rotifers	100–500	
-nematodes	500–3,000	
-tardigrades	200–1,200	
-worms	3,000–10,000	

I) A few species are much longer (up to 1000 µm)

Many protozoa/metazoa mainly feed on bacterial cells which are present free in the liquid or at the edges of the flocs. In this manner they remove many bacterial cells that are not firmly bound to the flocs. Free bacterial cells cannot be separated from the treated water through settling in the final clarifier. Protozoa are also indispensable for a far-reaching COD reduction, viz. a clear effluent.

Furthermore, protozoa/metazoa that consume sludge flocs (~ reduction of the sludge production) or consume other protozoa also exist.

The presence of certain species is relevant for the process conditions in the treatment plant. Assessing the composition of the population is, therefore, an important aspect of microscopic sludge investigation. This indicator function is further referred to in paragraph 6.3.

More than 200 different strains can be observed in activated sludge. Identification of these organisms is not really very easy and requires specialist knowledge. It is also unnecessary to identify all of these species for the purpose of process monitoring, distinguishing the most important main groups is sufficient. The following paragraphs contain a short description of these main groups, referring to several species that are regularly observed in activated sludge.

6.1 Protozoa

Like bacteria, protozoa are single celled organisms. As long as the sludge loading level is not extremely high, they are present in practically every activated sludge. Their population is always much smaller than that of the bacteria. The biomass of protozoa present in the treatment plant comprises, at most, a few percent of the total biomass.

Protozoa are divided into four groups:

. ciliates

. flagellates

. amoeba;

. testate amoeba;

. heliozoa

Ciliates are characterised by the presence of cilia (= vibrating hairs) on their cell surfaces. For some ciliates, the surface is completely covered with cilia whereas other species are only partly covered. Ciliates also exist which cilia are only present during a certain phase of their lives.

For many species, the cilia are arranged in a certain manner around the mouth openings. As a result, these cilia make the water flow in their vicinity. They fan, as it were, the food towards their mouth openings. These nutrient particles are subsequently taken up from the water by filtration. In addition, cilia contribute to the locomotion of several species.

Ciliates take in food particles by means of their mouth openings. According to the type of organism, this food can comprise organic fragments as well as bacterial cells or other protozoa. Therefore, predation plays an important part within such a mixed population. Some examples are given below:

. ciliates that mainly eat bacteria: *Aspidisca, Blepharisma, Carchesium, Colpidium, Chilodonella, Epistylis, Opercularia, Vorticella;*
. omnivorous species that consume bacteria as well as flagellates and small ciliates: *Euplotes, Stentor;*

. carnivorous species that mainly eat other ciliates: *Litonotus, Trachelophyllum, Hemiophrys, Suctorea.*

Bacterial cells transported with the influent form an important source of nourishment for ciliates. Sewage contains some tens of mg/l of bacterial cell material, a level that can also vary markedly according to the type of sewer, the weather conditions, the time of year, etc. The number of cells that are consumed is closely linked to the format of the organism. In this manner, small ciliates consume ca. 10 cells/min., larger ones *(e.g.'Opercularia)* more than 10 times as much whereas some nematode strains consume 5000 cells/min. Ciliates mainly exploit their food for the production of new cells. Movement costs little energy. As a rule of thumb, it is reckoned that 50% of the available food is used for cell synthesis.

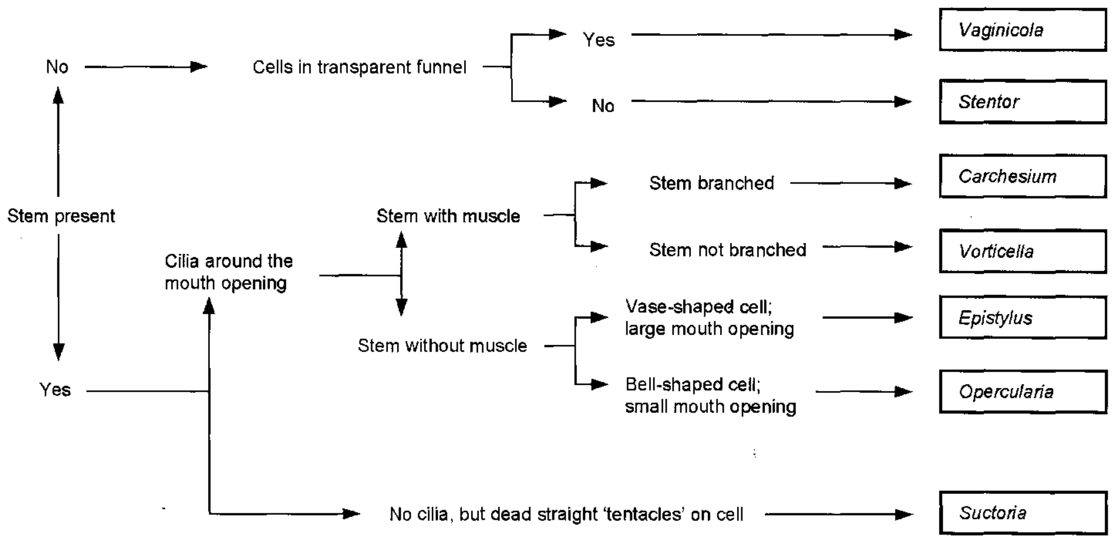
If the oxygen concentration is adequate, the size of the population is principally determined by the sludge load applied and the related sludge age. The population is at its maximum at a sludge load of ca. 0.3 kg BOO/kg MLSS.day (order of magnitude: 10^3-10^4 cells per ml). Fewer bacterial cells are available at lower sludge loading levels (floc more robust and relatively less transport with the influent), leading to a smaller ciliate population. At higher sludge loading levels, the sludge age is so short that the relatively slow-growing ciliates cannot be maintained in the sludge any more.

Quantities of thousands of specimens per millilitre are very suggestive of, and lead easily to, an over-estimation of the contribution of the ciliates to the total treatment process. The influence of a given group of organisms is not actually determined by quantity, but in terms of its contribution to the total amount of biomass in the treatment plant. The mass of several strains that frequently occur in activated sludge can vary from 0.1 ng to 10 ng, with peaks to 80 ng for *Stentor roesili,* a 'giant' among the ciliates. With 1 ng and 5000 specimens/ml and a total sludge concentration of 4 g/l, only 0.5% of the total biomass will comprise ciliates. The actual contribution of ciliates (and that of the other protozoa) to the total treatment performance is consequently very subordinate to that of bacteria.

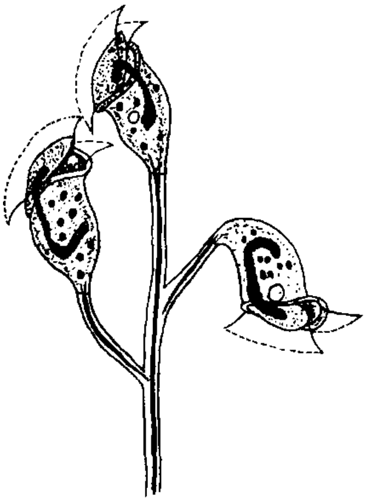
Ciliates are subdivided into sessile (= attached), crawling and free-living species.

6.1.1.1 Sessile ciliates

The cells of sessile ciliates are usually positioned on a stem which is often attached to a sludge floc. The stems are branched in some strains, through which colonies of sometimes numerous cells arise. Fig. 68 represents an identification key for distinguishing sessile ciliates commonly occurring in activated sludge.


No
Cells in transparent funnel
Yes
No
Vaginicola
Stentor
Stem present
Stem with muscle
Stem branched
Carchesium
Stem not branched
Vorticella
Cilia around the mouth opening
Vase-shaped cell; large mouth opening
Epistylus
Stem without muscle
Yes
Bell-shaped cell; small mouth opening
Opercularia
No cilia, but dead straight 'tentacles' on cell
Suctoria

Carchesium



Carchesium is a sessile ciliate with bell-shaped cells. These cells have a diameter of 50-125 µm. There is a wreath/ring of cilia around the mouth opening and the rest of the cell surface is bare. The stem contains a contracting 'muscle'. The stems are mostly branched, thereby creating colonies. These colonies can reach a diameter of a few mm. The 'muscle' in the stem is interrupted at the points where branching occurs.

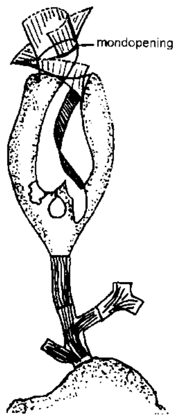
Carchesium sp. commonly occur in activated sludge at a sludge load less than ca. 0.2 kg BOD/kg MLSS.day.

Epistylis

Epistylis has somewhat 'vase' -shaped cells. They have a diameter of 70-100 µm. The stem is usually branched, which causes colonies to arise, but does not contain a 'muscle'. Therefore, the stems cannot contract (the cell actually does). The colonies can reach macroscopic dimensions (mm).

Epistylis sp. occur commonly in activated sludge, especially at sludge loading levels of 0.1 to 0.2 kg BOD/kg MLSS.day.

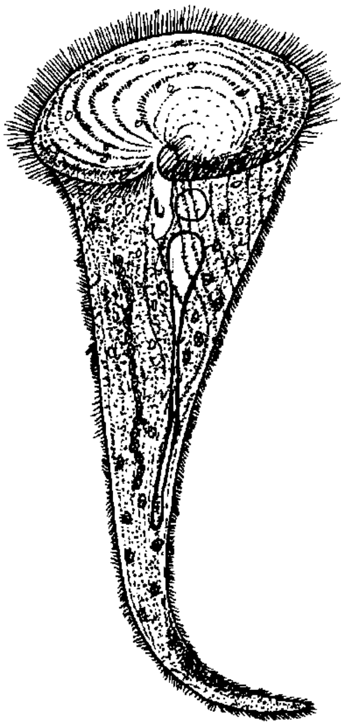
Opercularia



Opercularia has somewhat bell-shaped cells. The cell diameter is approximately 140 µm. The stems are branched, causing colonies to form. A noncontracting 'muscle' is present in the stem. In comparison with the other sessile ciliates, *Opercularia* has a small mouth opening.

Opercularia sp. mainly occur at higher sludge loading levels (0.2 to 0.3 kg BaD/kg MLSS.day).

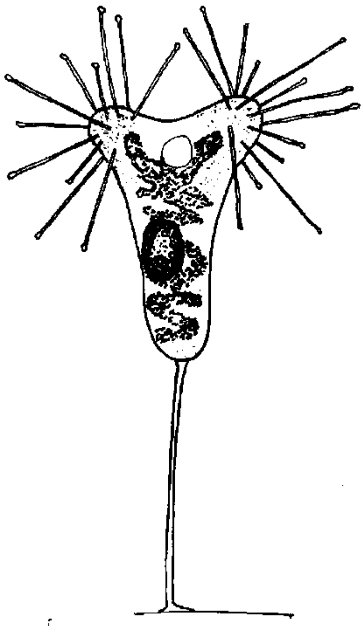
Stentor



Stentor is a ciliate with a very characteristic trumpet-shaped cell. It is usually, but not always, attached to a sludge floc. A wreath of cilia for transporting water and nutrient particles to the mouth opening is present at the broad extremity. The cell length can vary from 150 to 500 µm. It is, therefore, a large ciliate. *Stentor* does not possess a stem.

Stentor is chiefly observed in low-loaded treatment plants.

Suctoreans

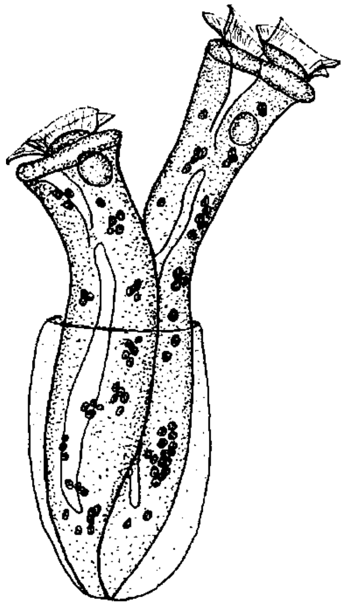


Suctoreans are ciliates, although cilia are absent on adult cells. The cilia disappear when the cell forms a stem with which the organism can attach itself to a surface, e.g. an activated sludge floc. Adults are therefore sessile. Some very characteristic, dead straight tentacles are present on the cell surface. These tentacles are thicker than the straight pseudopoda of the heliozoa. For most suctoreans, a small knob is present at the extremities of all the tentacles. This is a type of mouth for catching protozoa, which are sucked empty. Protozoa form the most important source of food for suctoreans. Depending upon the strain, both round and vase shaped cells can be observed in activated sludge. The cells in activated sludge usually measure 50-100 µm in length.

Suctoreans are regularly observed in activated sludge. The population is generally always small.

Vaginicola

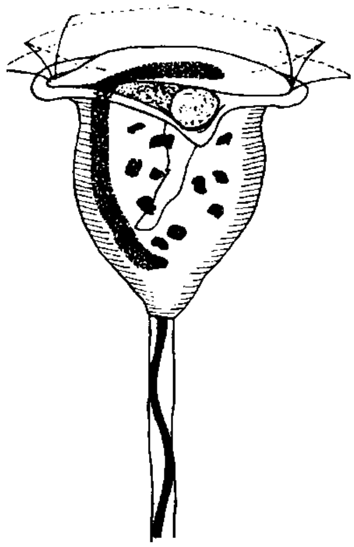
Vaginicola is a sessile ciliate with a trumpet shaped cell. The cell is contained in a distinctly transparent funnel. Two cells are often present in this funnel. The cell can contract, meaning that it can disappear completely into the funnel. A wreath of cilia, which transports water and nutrient particles to the mouth opening, is present on the 'head' of the cell. The cell measures approximately 100 µm in length.



Vaginicola is chiefly observed in low loaded plants (oxidation ditch conditions).

Vorticella

Vorticella is a sessile ciliate whose cells measure 50-150 µm. These are somewhat bell shaped. A wreath of cilia is present around the mouth opening by which the organism directs water (containing nutrients) towards the mouth opening. The stem is never branched, meaning that *Vorticella* is a solitary organism. A contracting muscle is present in the stem.



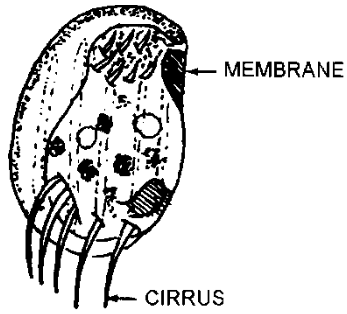
Vorticella sp. commonly occur at sludge loading levels < ca. 0.4 kg BOD/kg MLSS.day.

6.1.1.2 Crawling ciliates

The representatives of this group 'crawl' over the sludge flocs and graze their surfaces. Bacterial cells that are not firmly attached to the flocs are removed in this manner.

Aspidisca

Aspidisca is a ciliate that crawls, often at a high speed, over the flocs. Seen from above, the cell is round whereas the side view is more oval shaped. A distinct mouth opening is absent. Five ridges are present on the 'back'. The cilia are not individually implanted on the body but are present as cirri. Cirri are small bundles of cilia that come to a point and look like small feet. There are seven cirri on the front ventral side and five or more on the back of the cell. The cilia also form a membrane! ('strips' of cilia that are stuck together).



Onderkant

The sizes of the different Aspidisca strains can vary from 30 to 50 µm. The very common species Aspidisca costata has a diameter of 30µm. Aspidisca resembles Euplotes, which is larger (30-1 00 µm) and does not crawl over the flocs.

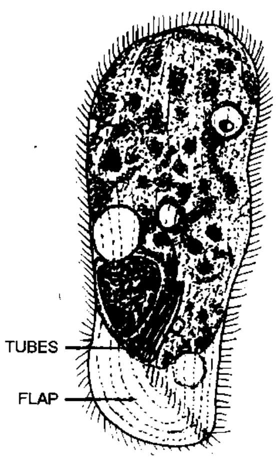

Zij-aanzicht

Aspidisca occurs very frequently. As long as the sludge load is not too high <ca. 0.4 kg BOD/kg MLSS.day), this ciliate can be observed in almost every activated sludge.

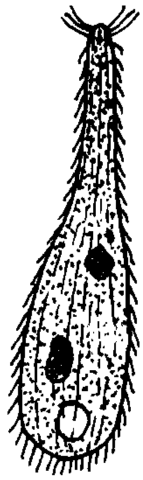
Chilodonella

Chilodonella is a crawling/grazing ciliate whose most important characteristic is an almost transparent flap on the front side. This flap often curls up when the organism crawls over the floc. Seen from the side, this flattened flap is also clearly recognisable. The mouth opening is surrounded by a bulge in the shape of a short tube. The cell length can vary from 40 to 125 µm.

Chilodonella commonly occurs in activated sludge if the sludge load is < ca. 0.2 kg BOD/kg MLSS.day.



Trachelophyllum



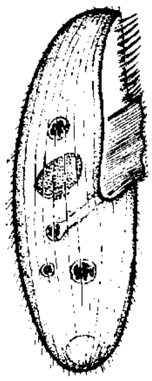
Trachelophyllum species are characterised by
their flat, elongated cells, which are completely covered with cilia. The cilia are longer around the mouth opening and are ordered in a characteristic manner (bowed 'moustache hairs'). *Trachelophyllum* usually move rapidly through the water between the flocs, but can also be observed crawling over them. The most common representative of this strain is *Trachelophyllum pusillum,* which has a cell length of 30 to 50 µm.

Trachelophyllum is a very commonly occurring ciliate at sludge loading levels less than ca. 0.4 kg BOD/kg MLSS.day.

6.1.1.3 Free-living ciliates

As the name suggests, these ciliates move freely in the water between the flocs. The speed at
which they move is highly variable.

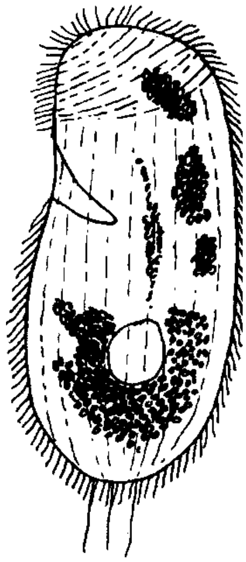
Blepharisma



The (light) pink cells of *Blepharisma* are very
characteristic. These free moving ciliates have somewhat oval cells of 200 µm in length. A zone with strips of relatively long cilia is present near the mouth opening. The cilia transport water, containing nutrients, to the mouth opening.

Blepharisma is mainly observed at some higher sludge loading levels (0.1-0.4 kg BOD/kg MLSS.day).

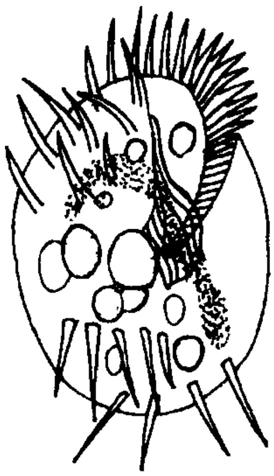
Colpidium



Colpidium is a free-moving ciliate possessing a kidney-shaped cell. The cell surface is covered with cilia. A few long vibrating hairs are present on the back of the cell. The zone around the mouth opening is dented inwards. The most usual species *(Colpidium colpoda)* has a cell length of ca. 100 µm.

Colpidium is less frequently observed than the other free-moving ciliates. This ciliate probably occurs most commonly at sludge loading levels of 0.1-0.4 kg BOD/kg MLSS.day.

Euplotes



Euplotes is a free-swimming ciliate with oval cells. The cilia are stuck together as cirri. There are nine cirri present on the front side and five on the back. These cirri function as pseudopoda. There is also a characteristic strip of joined cilia present on the cell, which transports nutrients to the mouth opening. Six ridges are present on the upper surface of the cell. The sizes of the different strains can vary from 30 to 100µm.

Euplotes resembles *Aspidisca,* but is usually bigger and is free swimming.

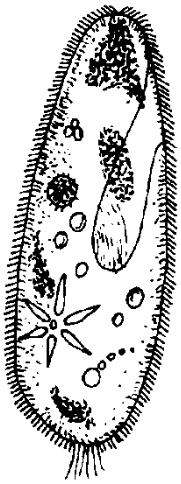
Euplotes commonly occurs in activated sludge, principally at sludge loading levels of 0.1-0.2 kg BOD/kg MLSS.day.

Litonotus (Lionotus)

The cells of *Litonotus* are shaped like a bottle (amphora). The neck, which is almost as long as the rest of the cell, is slightly bowed. The total length of the cell is ca. 100 µm.. The cilia on the outside of the neck are longer than those on the remainder of the cell surface. *Litonotus* usually moves through the water in an 'elegant' manner.

Litonotus commonly occurs in sludge loading levels lower than ca. 0.4 kg BOD/kg MLSS.day.

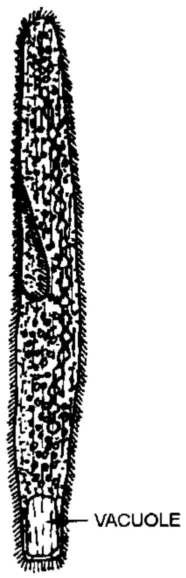
Paramecium



Paramecium is a free-moving ciliate whose cells slightly resemble slippers. It is a large ciliate. Cell length can vary from 180 to 300 µm. The cell surface is covered with cilia. The nucleus of the cell is large and usually clearly visible. The contractible star-shaped vacuole is very characteristic.

Paramecium is primarily observed at sludge loading levels of 0.1-0.3 kg BOD/kg MLSS.day.

Spirostomum



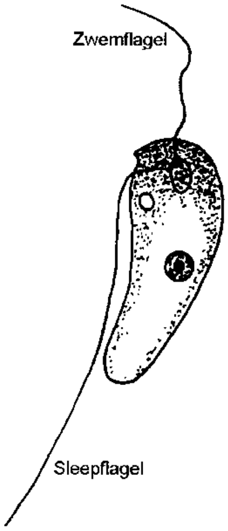
Spirostomum has a markedly elongated, flexible cell covered with cilia, with a characteristic vacuole present at the extremity. *Spirostomum* usually moves quickly through the liquid between the flocs. It is the largest ciliate present in activated sludge, the cell length varying from 500 to 900 µm.

Spirostomum commonly occurs in activated sludge, particularly in treatment plants with sludge loading levels less than ca. 0.2 kg BaD/kg MLSS.day.

6.1.2 Flagellates

Flagellates derive their name from the fact that they possess one or more (usually no more than eight) flagella. The flagella are longer than the cilia of ciliates. On account of their rapid movement, the flagella are quite often not clearly visible. The flagella assist the movement of the cell. Some species have a mouth opening with which they can consume nutrient particles such as bacteria cells. Other strains absorb dissolved nutrients through their cell walls. Because of their diameters of 10-30 µm, flagellates are noticeably smaller than ciliates. Therefore, a 40x objective should be used for microscopic viewing.

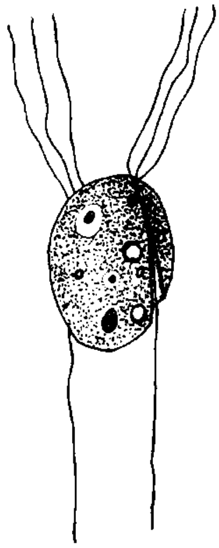
Bodo



Bodo is a free-swimming flagellate, which propels itself with a characteristic jerky movement. There are two flagella present, one swimming flagellum and one trailing flagellum at the rear. The flagella are longer than the oval cell. The cell wall is dented at the point where the flagella are implanted. The flagella are not always clearly visible. The cells are approximately 15 µm in length.

The presence of *Bodo* sp. indicates a high sludge load (> ca. 0.4 kg BOD/kg MLSS.day) and/or a lack of oxygen.

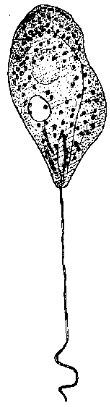
Hexamitus



Hexamitus is a free-swimming flagellate which moves rapidly in a straight line through the water (but does not rotate like *Trepomonas).* There are two groups of three flagella on the front side and two trailing flagella behind. The cell is somewhat oval-shaped and has a diameter of approximately 20 /lm.

The presence of *Hexamitus* indicates a high sludge load (>ca. 0.4 kg BOD/kg MLSS.day) an/or a lack of oxygen.

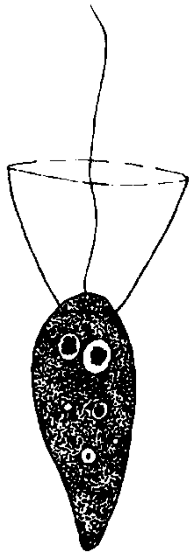
Peranema



Peranema is a free-swimming flagellate with a very characteristic, long, thick flagellum. A second much thinner (trailing) flagellum is also present, but this is hardly ever visible. Only the tip of the flagellum moves when the cell is in motion. The cell is usually 20-30 µm long.

This flagellate is regularly observed in activated sludge. In contrast to most other flagellates, the presence of *Peranema* is not indicative of specific process conditions such as a high sludge load or a lack of oxygen.

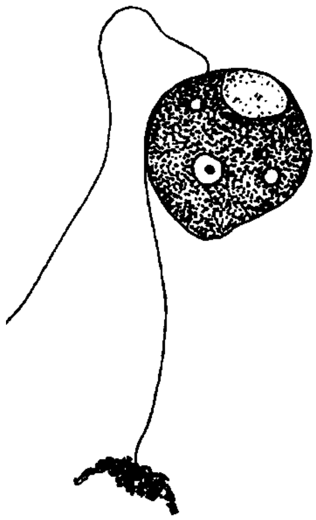
Monosiga



The cell is spherical to oval. A collar is present on its 'top' through which the flagellum emerges. *Monosiga* is usually fixed to a sludge floc. The cells are 1-15 µm in length.

The presence of *Monosiga* indicates a high sludge load (> ca. 0.4 kg BOD/kg MLSS.day) and/or a shortage of oxygen

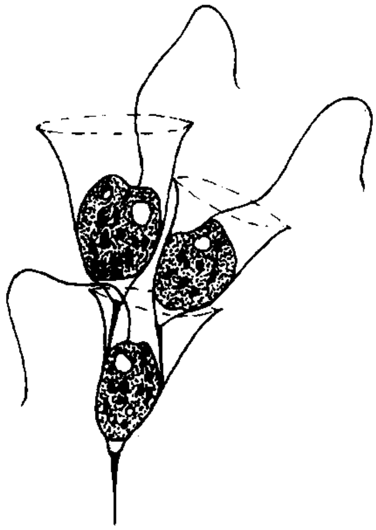
Poteriodendron



Poteriodendron is a flagellate whose most important characteristic is that it forms colonies of cells. The cells are contained in transparent funnels. These funnels are joined together into colonies by stems on their undersides. The diameters of the individual cells are ca. 20 µm. The cells have a flagellum which allows them to move inside the funnel but they cannot leave it.

Poteriodendron colonies are regularly observed in activated sludge. It is not known if this flagellate can be used as an indicator organism.

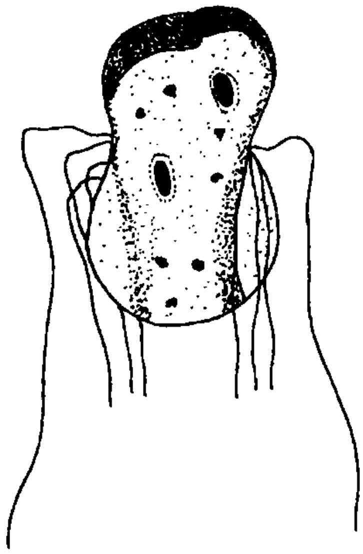
Pleuromonas



Pleuromonas is a flagellate that moves in a characteristically rapid and jumpy manner. The cells are usually not free-living in the water but are attached to the flocs. *Pleuromonas,* like *Bodo,* has two flagella. The cell is attached to the floc by the longest flagellum. Cell diameter is 5-10 µm.

The presence of *Pleuromonas* indicates a high sludge load (> ca. 0.4 kg BOD/kg MLSS.day) and/or a shortage of oxygen.

Trepomonas



Trepomonas is a free-swimming flagellate which moves through the water in a characteristic rotating manner. Seen from above, the cell is oval and from the underside it is spherical. The cells measure approximately 20 µm in length. *Trepomonas* possesses two groups of four flagella which are implanted on the side of the cell. Besides two long (20 µm).flagella, six short (8 /lm) ones are also present

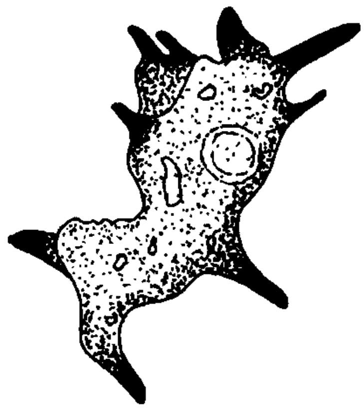
The presence of *Trepomonas* indicates a high sludge load (> ca. 0.4 kg BOD/kg MLSS.day) and/or a lack of oxygen.

6.1.3 Amoeba, testate amoeba and heliozoa

These organisms have in common that they can form pseudopoda. These pseudopoda are temporary extensions of the cell content.

Amoeba

Amoeba are single-celled organisms possessing a flexible cell membrane which allows the shape of the cell to constantly change. They absorb nutrient particles (bacteria cells, other protozoa, etc.) by engulfing them. This resembles the uptake of food by a mouth opening. The sizes of the various strains range from 50 to 400 µm. Amoeba can be as big as a sludge floc and their particular structure sometimes resemble sludge flocs. Apart from the odd exception, amoeba move extremely slowly (by means of the pseudopoda).

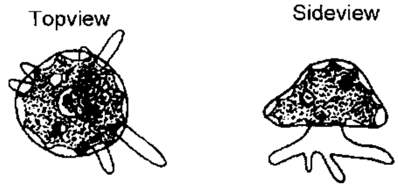


Amoeba are characteristic of somewhat higher sludge loading levels (0.1-0.4 kg BOD/kg MLSS.day) and/or shortages of oxygen. They are seldom observed in low loaded nutrient removal plants.

Testate amoeba

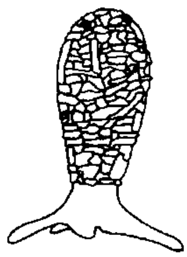
ARCELLA Topview

ARCELLA Sideview



In this group of amoeba, the cell is surrounded by a type of shell. There is an opening in the shell through which the pseudopoda can protrude. These pseudopoda are seldom visible on a microscopic slide. The cell form (round, beaker shaped, etc.) depends on the species in question.

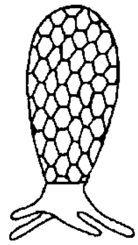
Arcella is a testate amoeba with a shell which, when seen from above, is round. The side view resembles the top of a toadstool. The shell has a clearly observable structure. In general, the shells are practically transparent, but in activated sludge they are usually coloured yellow-brown on account of the precipitation of iron compounds on their surfaces. The round opening on the underside of the shell is very characteristic.



DIFFLUGIA

The structure of *Euglypha* shells largely resembles that of a honeycomb. The sizes of the various testate amoeba can vary from 30 to 200 µm.

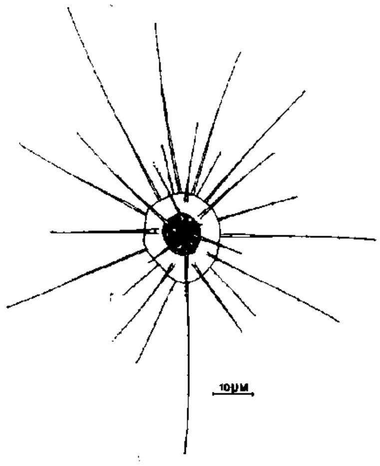
Testate amoeba are almost always present, and often in large numbers, in low-loaded activated sludge plants. *Arcella* is the most commonly occurring species. It mainly occurs under nitrifying conditions. Heliozoa are principally observed in low-loaded activated plants. The population is usually small.



EUGLYPHA

Heliozoa

Heliozoa belong to the amoeba. They have spherical cells which are surrounded by needle thin, dead straight, retractable pseudopoda. The pseudopoda are not used for propelling the cell but for catching bacteria and protozoa. Organisms that come into contact with the pseudopoda are 'paralysed' after which they are consumed by the heliozoa. The cell diameter can vary from 40 to 100 µm.



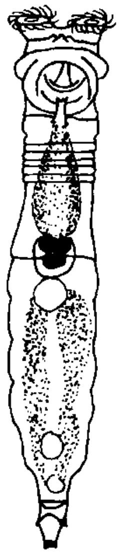
6.2 Metazoa

In contrast to bacteria and protozoa, metazoa are multi-cellular micro-organisms, meaning that they are 'higher' organisms. The sizes of the different species can vary from 100 µm to sometimes as much as 1-2 cm. Most metazoa feed on free-living bacteria cells or on very small floc particles. Species also exist that can consume whole sludge flocs.

The following metazoan groups can be present in activated sludge: .
Rotifers
. Nematodes
. Worms
. Tardigrades

Apart from exceptional cases, metazoa play a subsidiary role in activated sludge treatment plants. They are mainly observed at sludge loading levels lower than ca. 0.15 kg BOD/kg MLSS.day. To register the number of metazoa, a scale varying from 0 (= absent) to 3 (= numerous organisms/slide) is used.

6.2.1 Rotifers

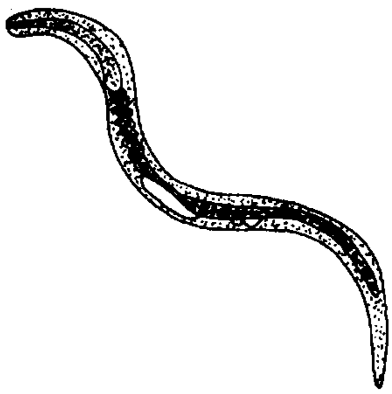


Rotifers are relatively large, distinctly mobile and elongated multi-celled organisms. The body length can vary from 100 to 500 µm and is surrounded by a type of armour into which the head and tail can be withdrawn. A few bunches of cilia are present on the head of the organism. These cilia can create a current in the direction of the mouth opening. They have a set of 'jaws' around their mouth openings by which they can crack particles filtered from the water. Particles larger than about 10 µm cannot actually fit in this mouth opening. Rotifers, therefore, principally consume free-living bacteria cells and small floc particles.

The tail is branched in a characteristic manner and is important to the movement of the organism. With this, a rotifer first attaches itself, after which the body is stretched. The tail is subsequently released, the head stays in place and the abdomen is drawn up. This manner of propulsion resembles the manner in which a slug moves.

Rotifers commonly occur in activated sludge with low loading levels. The size of the population is nearly always very limited in domestic treatment plants. Large numbers of rotifers are sometimes present in plants treating waste water from the agro- industry.

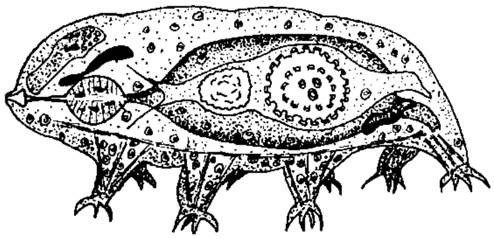
6.2.2 Nematodes



Nematodes have elongated, cylindrical and very flexible bodies. The extremities of this multicelled micro-organism are thinner than its central section. The cell length can vary from 0.5 mm to 3 mm. They are larger than most protozoa. They principally consume free-living bacteria cells and very small floc particles. They swallow/engulf food particles by contraction of the oesophagus. Owing to the fact that they do not possess 'jaws' and that their mouth openings are small, they cannot consume intact flocs. These exceptionally mobile animals are sometimes difficult to keep in focus during microscopic investigation. In addition, nematodes often 'crawl away' into the flocs and it can be a while before they reappear.

Nematodes are regularly observed in activated sludge with a low loading level, but they are almost never present in large numbers. It is not known if nematodes can be used as indicators for given process conditions.

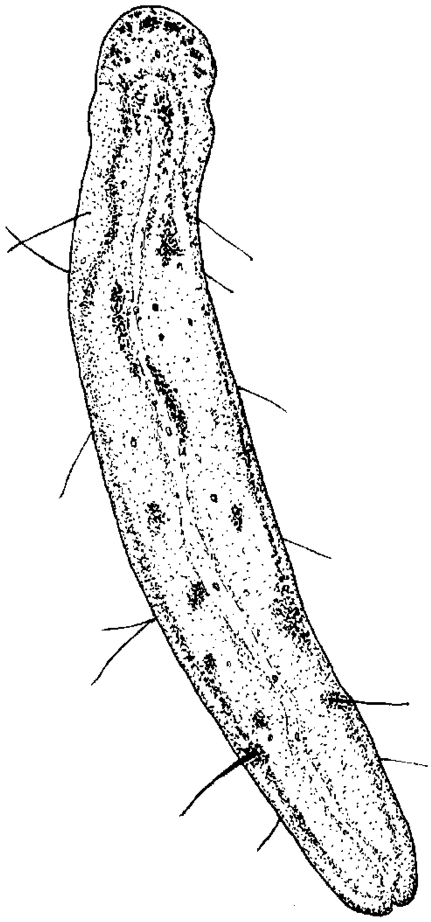
6.2.3 Tardigrades



This is a multi-celled organism with a very striking form. A tardigade, sometimes known familiarly (to the experts) as a water bear, has pseudopoda with small claws, with which it crawls over the flocs and grazes them. This organism moves around somewhat awkwardly when free in the water. The size can vary from 200 to 1200 µm.

Tardigrades are occasionally observed at sludge loading levels of < 0.1 kg BaD/kg MLSS.day.

6.2.4 Worms



Worms are the largest organisms observed during the microscopic investigation of activated sludge. With diameters of approximately 0.1 mm and lengths to a maximum of 10 mm, their presence is very apparent on a wet slide. Oligochaeta are almost always involved, often *Nais elingius* and *Aelosoma* spp. Worms are able to consume sludge flocs or particles of flocs. A worm bloom (ca. 10^5 worms/l) is also connected with a reduction in sludge production.

Little is known about the growth of worms in activated sludge plants. They do not grow particularly slowly. Under the best of conditions they have a generation time of a few days. More than enough nutrients, in the form of sludge flocs, seem to be present. Consequently, one would expect worms to be present in virtually all treatment plants. However, they are not often observed at low sludge loading levels (oxidation ditch conditions). Sludges containing many worms usually originate from treatment plants with a sludge load of ca. 0.1 kg BOD/kg MLSS.day and in which the influent is pre-settled. A definite connection between their presence or absence and the process conditions is usually missing.

6.3 Indicator function

A new activated sludge plant can be commissioned by introducing wastewater flow and establishing aeration within the biological treatment system. Under suitable operating conditions, activated sludge flocs will naturally develop within the aeration tank. These flocs are retained within the system through settlement in the Final Settlement Tank (FST) and returned to the aeration tank as Return Activated Sludge (RAS).

By continuously introducing fresh wastewater while initially minimising sludge wastage, the required biomass concentration can be established over a period of several weeks. During the start-up period, the Food-to-Microorganism (F/M) ratio gradually decreases as the concentration of activated sludge increases, resulting in improved biological treatment performance.

During start-up, a natural succession of microbial populations occurs within the activated sludge. This change in microbial community reflects the changing conditions within the treatment process as the sludge matures.

During the early stages of start-up, large numbers of free-swimming bacteria may be present (typically greater than 10^8 cells/ml). At this stage, organic compounds contained within the incoming wastewater have not yet been fully processed by the developing biomass. The high availability of food allows organisms such as flagellates and amoebae to multiply rapidly.

After several days, free-swimming ciliates begin to appear, while the populations of flagellates and amoebae reduce as available food sources become limited. As the activated sludge concentration increases, the sludge loading decreases and conditions become less favourable for rapidly growing organisms.

As the sludge matures, organisms that are unable to reproduce faster than the hydraulic retention time of the aeration tank are gradually removed from the system. Organisms associated with the sludge floc, such as attached ciliates (for example *Vorticella*) and crawling ciliates (for example *Aspidisca*), become dominant as they are retained within the biological process.

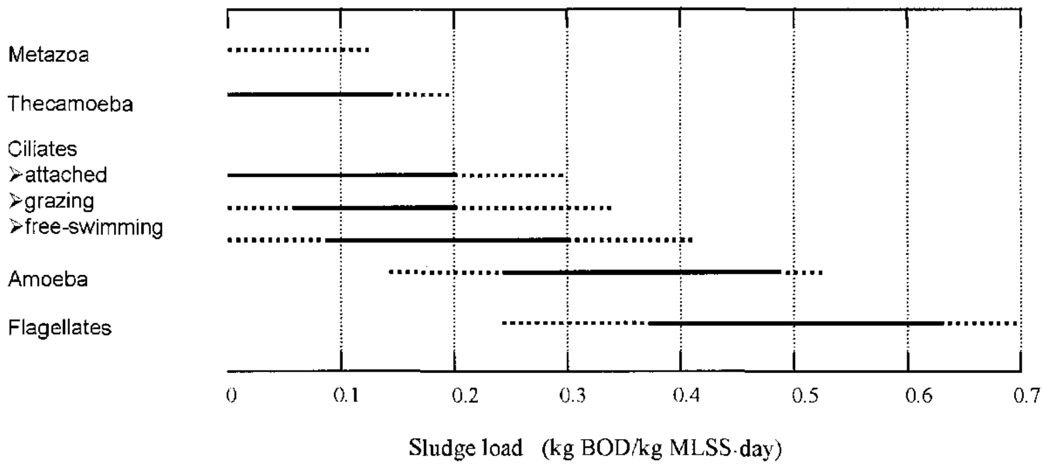
At longer sludge ages, other organisms including testate amoebae and, in some cases, metazoa may become established. At this stage, the plant generally achieves a high level of treatment performance, including effective nitrification. The number of unattached bacterial cells reduces significantly, with the majority of bacteria incorporated within the activated sludge floc structure.

The composition of the microbial population provides an indication of the operating conditions and treatment performance of the activated sludge process. Microscopic examination of activated sludge should therefore include an assessment of whether the organisms present are appropriate for the current sludge loading and plant operating conditions.

Under normal low-loading conditions, a healthy activated sludge population would typically contain a predominance of ciliates, testate amoebae, and occasional metazoa. Conversely, a reduction in dissolved oxygen within a low-loaded plant can result in reduced COD removal efficiency and a shift in the microbial population towards increased numbers of flagellates and amoebae.

Regular microscopic examination provides an effective method of monitoring the biological health of the plant and identifying developing process problems before they impact final effluent quality.

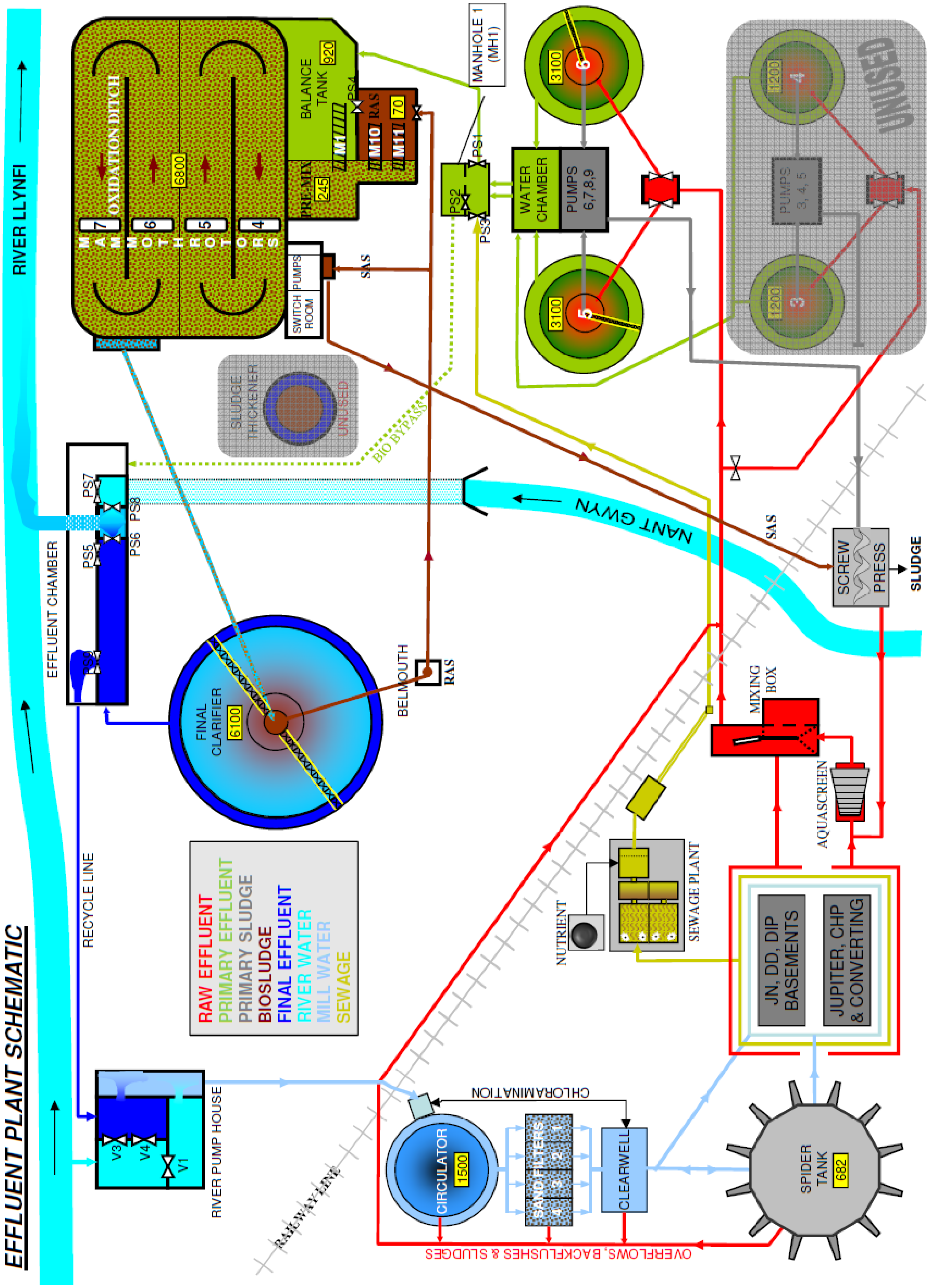
Figure 69 Effect of the sludge load on the occurrence of protozoa and metazoa (no lack of oxygen).



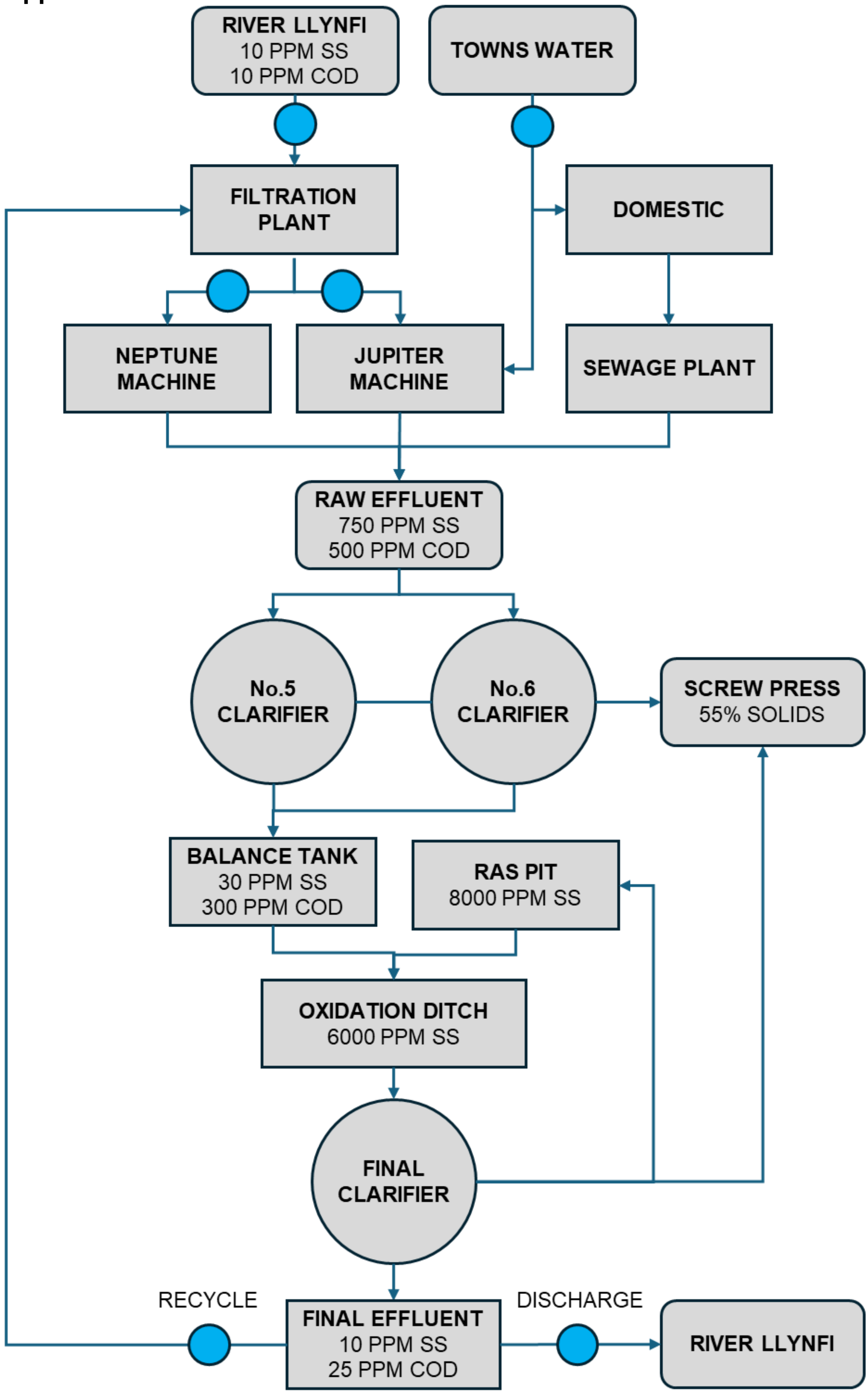
If protozoa and metazoa suddenly disappear, then toxic components are present in the influent. This can be followed within a few days by an explosive increase in the number of protozoa, because the number of free-living bacterial cells has considerably increased during their absence.

A strong increase in the number of worms in activated sludge can cause a decrease in the production of surplus sludge (see paragraph 9.7).

Appendix 4


EFFLUENT PLANT SCHEMATIC
RIVER LLYNFI
OXIDATION DITCH
6800
MOTORS
7
6
5
4
BALANCE TANK
920
PRE-MIX
245
RAS
70
M1
M10
M11
PS4
MANHOLE 1 (MH1)
PS1
PS2
PS3
WATER CHAMBER
PUMPS 6,7,8,9
3100
6
5
UNUSED
PUMPS 3,4,5
1200
4
3
SWITCH ROOM
PUMPS
SAS
SLUDGE THICKENER
UNUSED
BIO BYPASS
EFFLUENT CHAMBER
PS5
PS6
PS7
PS8
PS9
NANT GWYN
SCREW PRESS
SLUDGE
FINAL CLARIFIER
6100
BELMOUTH
RAS
MIXING BOX
AQUASCREEN
SEWAGE PLANT
NUTRIENT
RECYCLE LINE
RAW EFFLUENT
PRIMARY EFFLUENT
PRIMARY SLUDGE
BIOSLUDGE
FINAL EFFLUENT
RIVER WATER
MILL WATER
SEWAGE
JN, DD, DIP BASEMENTS
JUPITER, CHP & CONVERTING
RIVER PUMP HOUSE
V1
V3
V4
CHLORAMINATION
CIRCULATOR
1500
SAND FILTERS
CLEARWELL
SPIDER TANK
682
OVERFLOWS, BACKFLUSHES & SLUDGES
RAILWAY LINE

Appendix 5 - Effluent Treatment



Appendix 6

Procedure for Restarting BOD Plant
After Power Dip or Power Loss

On loss of power to the effluent treatment plant, the plant must be checked to ascertain what parts of the plant require resetting and or restarting. Refer to the table below for normal process running conditions.

Pump/Motor	Status	Mode
M1 Archimedes screw (balance tank)	Run	Manual
M10 Archimedes screw (RAS pit)	Run	Manual
M11 Archimedes screw (RAS pit)	Standby	Auto
M4 Mammoth rotor	Run	Manual
M5 Mammoth rotor	Standby	Auto
M6 Mammoth rotor	Standby	Auto
M7 Mammoth rotor	Run	Manual
M8&M9 Final clarifier bridge motors	Run	Manual
P1 Nutrient pump	Run	Manual
P2 Nutrient pump	Off	Off
P3 SAS to screw press	Off	Manual
P4 SAS to screw press	Off	Manual
FST Spray	Run	Manual
Biox 1010	Run	
Flow meters	Display value	
Turbidity meter	Display value	
Temperature monitors	Display value	
pH	Display value	
Effluent monitoring system	Reboot	
Aquacell sampler	Run	
Ammonia meter	Run	

All pumps and motors are fitted with a black reset button.
Ensure these buttons are depressed before pressing the start buttons.

On restarting the plant, monitor the Final Settlement Tank sludge blanket level as increased hydraulic load at start up can destabilise the plant.

In the event of a prolonged power loss (if known) refer to Emergency Power Supply Procedure. **Emergency_Power_Supply_Procedure**

Appendix 7

Security Gatehouse Alarm Summary

Bridgend Paper Mill security gatehouse is the designated area for critical alarms from the effluent treatment plant to alarm to. The alarms are monitored on the GENT system.

All alarms activated on this system must be reported to the duty shift manager immediately for further investigation and remedial action(s).

Below is a list of items from the effluent treatment plant that will alarm on the GENT system:-

HSB – High Sludge Blanket **blanket lift**
M1 – M1 Archimedes Screw Pump failure
RAS Sump – High Level in RAS sump indicating potential failure of M10/M11

	Alarm level	Max permitted	
BOD- High BOD level	5mg/l	10mg/l	Quick guide
Suspended Solids – High SS	25mg/l	25mg/l	Quick Guide
PH – High/Low pH	6.6 – 7.9	6.5 – 8.0	**Quick Guide**
High Discharge flow	15000m ^{3}	17500m^3	Quick Guide
High Discharge Temp	24°	25°	Quick Guide

Appendix 8

Procedure for Running the BOD plant from Emergency Generator Supply (House Set)

1. INTRODUCTION

In the event of a major power outage, it is imperative that the effluent treatment plant (BOD) is maintained in a running condition to ensure that no overflows occur direct to river.

It must be the first priority to go direct to the plant and establish whether the electrically driven equipment is still operating.

If the equipment has stopped then it must be restarted after the auxiliary power supply is switched over.

2. SCOPE

This procedure covers any such incident within the Bridgend Mill site.

3. RESPONSIBILITY

The Mill Controller (Normally the Shift Manager) is responsible for ensuring that this procedure is followed. He will call for the support of other personnel as required.

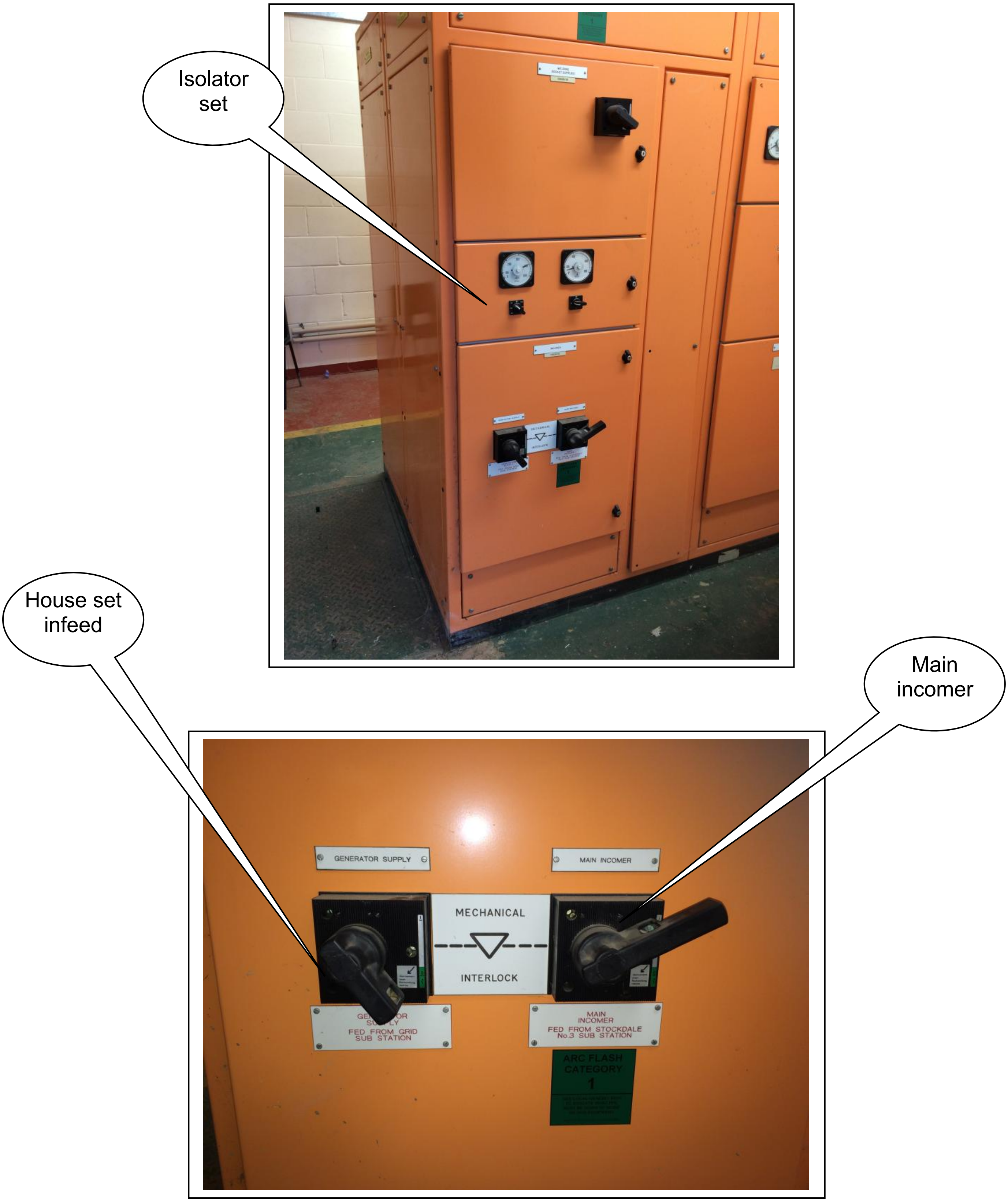
4. PROCEDURE

1. The mill controller will establish that the House Set generator is running. If not it will need to be started before checking the BOD plant.

2. The mill controller will then go directly to the BOD plant together with a competent electrical technician.

3. On entering the switch room at the BOD plant, check all drives to ensure that they are operational.

4. If the equipment has stopped and supply has been lost, then instruct a competent electrical person to switch in the auxiliary power supply identified below. (This is fed from the House Set generator which should be running in the event of a power failure).


Isolator set
House set infeed
Main incomer
GENERATOR SUPPLY
MAIN INCOMER
MECHANICAL
INTERLOCK
FED FROM GRID
SUB STATION
MAIN
INCOMER
FED FROM STOCKDALE
No.3 SUB STATION
ARC FLASH
CATEGORY
1

5. Please note that the auxiliary power supply is 100 amps and will only provide enough power to run the equipment specified below. Restart the following equipment <u>one at a time</u>.

Note: All pumps and motors are fitted with a black reset button. Ensure these buttons are depressed before pressing the start buttons.

a. One mammoth rota only, either no 4 or no 5

b. Either M10 or M11 screw pump

   c. Final settlement tank bridge drive

6. Check to ensure that the equipment starts correctly and that all flows through the plant are restored.

7. Check the Effluent Chamber/Discharge Point and Manhole 1 to ensure that no overflow has occurred. If it has then contact the Environment Manager immediately.

8. Once mains power is restored then visit the BOD plant and switch the mains power back on.

9. THIS MUST BE DONE AS SOON AS THE HOUSE SET SWITCHES OFF AS OTHERWISE NO POWER WILL BE SUPPLIED TO THE BOD PLANT.

10. To switch back to mains power, visit the BOD switch room and reverse the position of the switches so that the main incomer is now live and the auxiliary incomer is switched off.

11. Then restart the following equipment <u>one at a time</u>:
    a. Both M10 and M11 Archimedes screws.
    b. M4 or M5 plus M6 or M7 mammoth rotors (2 running)
    c. Final clarifier bridge drive
    d. PI computer in corner of switch room.

12. Check to ensure that the equipment starts correctly and that all flows through the plant are restored.

When power is re-established the power switch over must be reversed and plant started as per normal running **(Start up procedure)**

Appendix 9

Shift Managers Check /Quick Reference Sheet for Responding to Security Alarms

BOD

Check trends via PI.
Do Trends show high BOD value?
NO.
The problem is probably the signalling between the two systems. **Action**: Request further investigation from engineering department and report via environmental near miss reporting system.
YES
Check Biox 1010 unit at the BOD plant.

Is the display showing a high value i.e.>5mg/l
YES
Action: Monitor the trend. If the BOD approached 10mg/l put the Effluent to 100% recycle whilst the issue is investigated, call out if necessary and report via environmental near miss reporting system.
NO
The problem lies in the communication between the BIOX 1010 and the Effluent monitoring system. **Action**: Request further investigation from engineering department and report via environmental near miss reporting system.

Shift Managers Check /Quick Reference Sheet for Responding to Security Alarms

Suspended Solids

Check SS trends within PI

Do Trends show high SS value?

NO
The problem is probably the signalling between the two systems. **Action**: Request further investigation from engineering department and report via environmental near miss system.
Yes
Action: Check the probe in the discharge channel for debris (algae/plastics). If debris is found around the probe, remove and replace probe and wait for alarm to reset.

If no debris is found, check the channel for water quality. Remove a sample and examine visually.
If the sample is turbid or contains higher than normal concentrations of suspended solids,
Action: Put the effluent to 100% recycle while the issue is investigated further and call out if necessary and report via environmental near miss reporting system.

Shift Managers Check /Quick Reference Sheet for Responding to Security Alarms

PH High/Low

Check pH trends with PI system

Do Trends show high or low pH value?

NO
The problem is probably the signalling between the two systems. **Action**: Request further investigation from engineering department and report via environmental near miss reporting system.
YES
Check the pH meter at the BOD plant.

Does the meter at the BOD plant show a high or low pH value?
NO
The problem lies in the communication between the pH meter and the Effluent monitoring system. **Action**: Request further investigation from engineering department and report via environmental near miss reporting system.
YES
Action: Take a sample and check with hand held pH meter (available from Lab)

Is pH outside consent limits? 6.5 & 8.0

YES
Action: Put effluent to 100% recycle, call out if necessary, report via environmental near miss reporting system.
NO
Action: Request further investigation from engineering department and report via environmental near miss reporting system

***The pH meter probes have pre-determined shelf lives so holding spares can be an issue. The same type of pH meter is used on the incoming river water. If issues are detected with the effluent pH meter then the incoming water meter can be used*.**

Shift Managers Check /Quick Reference Sheet for Responding to Security Alarms

High Discharge flow

Check trends within PI system.

Do Trends show high discharge flow value?

NO
The problem is probably the signalling between the two systems. **Action**: Request further investigation from engineering department and report via environmental near miss reporting system.
YES
Action:
1.Increase recycle rates so that the discharge flow reduces to within acceptable limits and monitor.
1. Check for excessive flows on machines and reduce as far as practicably possible.
2. Check for overflows etc from water filtration plant.
3. Report via environmental near miss reporting system

Shift Managers Check /Quick Reference Sheet for Responding to Security Alarms

High Discharge Temperature

Check trends via PI system.

Do Trends show high Temperature value?

NO
The problem is probably the signalling between the two systems. **Action**: Request further investigation from engineering department and report via environmental near miss reporting system.

YES

Action:
1. Reduce the discharge flow to a level that the Nant Gwyn is effectively cooling the effluent to within consented limit (currently 25°C)
2. Check for sources of heat through machine systems.
3. Report via environmental near miss reporting system.

High Mixing Box level

When the high mixing box level alarms at the security gatehouse, the shift manager must **immediately** visit the mixing box to confirm the alarm.

If the level is high, there is a danger that the mixing box could overflow to the Nant Gwyn stream.

Immediate action should be taken to reduce flows to the mill and on machine to prevent overflow.
Inspections must be made to check there are no fugitive overflows and close any drains that may be open. This includes water and stock.