# Guideline Document: Package Plants for the Treatment of Domestic Wastewater

water affairs

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# Guideline document:

# Package plants for the treatment of domestic wastewater

Report to the Department of Water Affairs

by

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# CHAPTER 1

## 1.0 INTRODUCTION

### 1.1 Background information

Typical applications for package plants include:

- Schools
- Residential estates
- Fuel resting stations
- Border posts
- Toll gates
- Prisons
- Hospitals
- Recreational facilities

Rapid urban expansion has resulted in an increase in the number of small onsite domestic wastewater treatment systems. These treatment systems will be referred to as package plants in the document. A definition of a package plant can be found in Section 1.2. The reasons for these installations are numerous. Some of the main reasons for these installations include:

- proposed developments being in a remote area;
- no municipal sewer connection available for the foreseeable future;
- existing municipal sewer/municipal wastewater treatment works does not have adequate capacity; and
- reuse of treated effluent for water conservation reasons.

It is important to understand the impacts from these installations, whether it is from irrigation of the treated effluent on a golf course, or the cumulative impacts on a water resource because of several package plant discharges. Considering that raw domestic wastewater or even partially treated domestic wastewater is extremely hazardous to both human and ecological health, pollution in these cases not only affects water quality of the resource and consequently downstream users; due to the proximity of the package plants to people within developments; can also have an impact on the community itself. The implications or costs of pollution are wide ranging, and include health, social, environmental, and downstream user costs. In this respect these installations require considerable management, technical expertise, monitoring and reporting.

The guideline is **not** intended for use in the design of such wastewater treatment plants. **Adequately qualified professionals** are still required for the design of these small wastewater treatment plants.

A previous Water Research Commission (WRC) study found that package plant manufacturers and operators face a number of challenges including:

- small plant scale;
- high variability of influent domestic wastewater; and
- a lack of maintenance and operational skills.

Both within South Africa and abroad, package plant failures are most commonly ascribed to poor design and construction, insufficient or no maintenance, and mechanical breakdown.

It cannot be stressed enough that the onus to ensure that the correct design, operation and maintenance of the plant rests with the professional registered with a relevant body. Approval of a plant by an authority is based on ensuring that the protocol set out in these guidelines has been adhered to.

Legislation must be adhered to before such plants can be installed. Current legislation however, is not necessarily aligned to dealing with these cases in the most appropriate manner.

The purpose of this study was to develop a guideline document for use by Water Service Authorities (WSAs), Department of Water Affairs (DWA), and suppliers and owners of package plants. The DWA and WSAs will use the document as a guide when authorising and subsequently inspecting package plants. Package plant suppliers and owners will use the document to understand their roles and responsibilities regarding the authorisation, operation, maintenance, monitoring, and reporting on these plants.

Zitholele Consulting (Pty) Ltd, together with Golder Associates (Pty) Ltd and Stewart Scott Incorporated were appointed by the Water Research Commission to compile a guideline document on package plants. This project is a follow-up to WRC Report 1539/1/06 entitled: Evaluation of Domestic wastewater

Treatment Package Plants for Rural, Peri-urban and Community Use. It is therefore recommended that this report be read in conjunction with the previous report.

## 1.2 What is a Package Plant

For the purposes of this document, a package plant will be defined as follows:

A **package plant** is any onsite, waterborne, domestic wastewater treatment system; whether it consists of one or many modules; with a total capacity less than 2 000 $m^3$/day. It typically includes equipment largely constructed and packaged off site and brought onsite for installation. Where,

**Domestic wastewater** is defined as wastewater predominantly from residential and housing developments, schools, prisons, retail centres and resting fuel service stations, incorporating a small component of non-domestic activity, contributing less than 20% of the total waste loading, e.g. a restaurant, hospital and clinic, laundry, car wash or hairdresser.

## 1.3 Purpose of the guideline

The purpose of the guideline is to set out minimum requirements for the installation, and operation and maintenance of package plants in South Africa, as well as to provide basic design criteria, so that developers and regulators can ensure the installation of appropriate designs for local climatic conditions; while at the same time achieving effluent compliant with the relevant water quality requirements; and encouraging the reuse of the treated effluent.


In the case of new developments, property owners must be made aware of the package plant and responsibility associated with it, as they will collectively become the owner when the developer moves off site. The developer will hand over responsibility of the package plant once the development has been completed.

## 1.4 Typical users of the guideline

### 1.4.1 Water Services Authorities

Water Services Authorities are tasked with the approval of the installation of the package plant and carry the responsibility for inspecting the package plant on a regular basis. Notwithstanding the minimum requirements set out in this guideline, each application will also be evaluated against any additional approval criteria established by the Municipality or Water Services Authority. An inspection checklist has also been provided. The WSA may choose to appoint a Water Services Provider (WSP) or in smaller towns and cases in which the WSA does not have the capacity for monitoring, the DWA regional office may be requested to assist with these tasks.

### 1.4.2 Department of Water Affairs

The Department of Water Affairs (DWA) (formerly the Department of Water Affairs and Forestry) is tasked to authorise the package plants through the water use authorisation process in terms of the National Water Act, 1998 (Act 36 of 1998); and in terms of comments on the environmental impact assessment (EIA) in the form of input to the Record of Decision (RoD). As such, DWA are responsible for assessing the cumulative impacts of disposal and discharge within a catchment and in this respect this may require the determination of the Reserve for the particular resource.

### 1.4.3 Manufacturers and Distributors

The guideline will provide an indication of the authorisation and inspection criteria that will need to be met, to enable manufacturers and distributors to ensure compliance.

### 1.4.4 Owners

The package plant owner will ultimately be responsible for the operation and maintenance of the package plant. The guideline document will provide the owner with a description of various types of plants available, minimum requirements for operation and maintenance, monitoring and reporting, as well as a hand-over checklist for change in ownership.

## 1.5 Guideline Structure

The section to follow summarises the structure of the guideline.

**Chapter 2: Package plant characterisation,** provides a description of the various package plants available and discussion on different disinfection options that can be used in package plants. A summary table is provided for easy comparison.

**Chapter 3: Regulatory aspects,** provides the user/owner with a flow diagram and description of the regulatory process that must be followed, as well as ongoing monitoring and auditing that must take place.

**Chapter 4: Minimum requirements,** sets out the minimum requirements for each stage of the regulatory process.

**Chapter 5: Package plant classification,** goes into further details on the waste being treated in terms of composition and flows. The classification system also considers the process parameters and environment into which the waste is discharged.

**Chapter 6: Best practice criteria,** provides a guide for sizing and designing package plant. The guidelines have been made as generic as possible, but it must be noted that each case is unique and must be designed as such.

**Chapter 7: Operational requirements,** discusses aspects such as inspections, monitoring, auditing and trouble shooting.

**Chapter 8: Checklists,** provides customised checklists that have been developed for regulators as well as owners.

# CHAPTER 2

## 2.0 PACKAGE PLANT CHARACTERISATION

## 2.1 Types of plants available

*Example of a package plant installation*

Several package treatment technologies exist for the treatment of domestic wastewater. The most common types installed in South Africa include:

- Activated sludge /extended aeration plant;
- Trickling filter;
- Submerged bio-contactors ; and
- Rotating bio-contactors.

Systems which usually form the pre-treatment step or polishing step include:

- Purely anaerobic systems;
- Pond systems; and
- Constructed wetlands.

Investigations are being carried out on high rate algal ponds (HRAP), which can be used for small scale domestic wastewater treatment. While these plants do not fall within the package plant definition, as it will be constructed onsite, these have been included in the document.

The following sub-sections briefly describe the various package plant types.

### 2.1.1 Activated sludge/extended aeration

In most cases, these systems consist of a septic tank, followed by an aerated tank, a clarifier and a disinfection tank as indicated in Figure 1. Microorganisms are suspended in the sludge by means of aeration and mixing. Activated sludge systems can be continuously or intermittently fed or operated as a fill and draw system.

Chemical dosage might be required for appropriate nutrient removal, but this is not recommended for onsite plants.

Activated sludge systems were found to be favoured in South Africa for wastewater treatment (Hulsman, 2003). In some systems, the septic tank is replaced by a screen or macerator. Aeration is achieved by means of mechanical equipment.

There are two generic configurations for activated sludge reactors:

- Completely mixed reactor where it is assumed that wastewater entering the reactor is uniformly dispersed throughout the reactor within a short time and the oxygen demand is uniform throughout the reactor; and
- Plug flow reactor where it is assumed that the wastewater progresses through the reactor in a plug pattern and the oxygen demand decreases along the length of the reactor.

Continuous flow activated sludge processes typically consist of a tank compartmentalised into the following:

- A flow equalisation chamber;
- An aeration chamber;
- A clarification chamber;
- A sludge holding/digesting chamber.

Activated sludge package plant

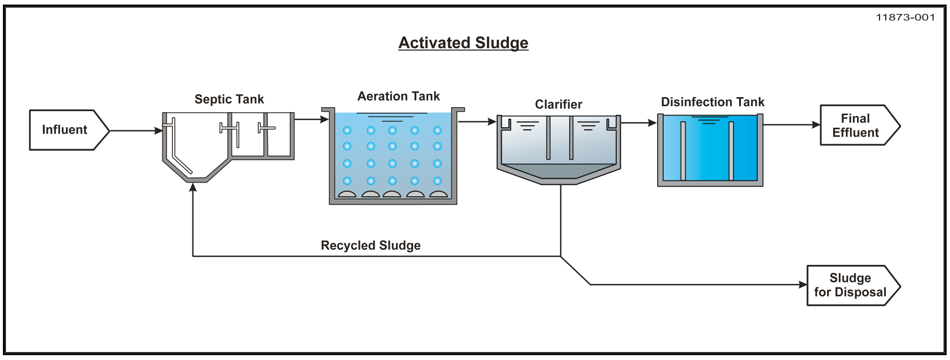



*Figure 1: Process flow diagram for a typical activated sludge system*

The sequencing batch reactors (SBR) differ in that a single tank is used for the different stages of treatment. In order to accommodate continuous influent flow, two parallel tanks are generally used. The different stages in the SBR operation include:

Activated sludge package plant

- Fill and mix where the raw wastewater enters the tank and is mixed with the settled bio-mass from the previous phase;
- Aeration when the tank is aerated to allow for oxidation and nitrification to take place;
- Settling where mixing and aeration are stopped, allowing for the solids to settle; and
- Decant where treated water is discharged from the surface leaving the solids behind in the tank.

Sludge wasting is an important step, and is determined by the performance requirements of the system.

Consensus amongst German engineers was that the activated sludge plants are typically less reliable than alternative technologies, unless they are of larger scale (Bugsteek, 1990 cited in Gaydon, 2007).

Extended aeration installation

One of the activated sludge plants investigated at the Darville wastewater works as part of the WRC study on the evaluation of package plants was the SBR. Results obtained were positive in that the system almost completely complied with standards more appropriate to larger scale treatment systems (Gaydon, 2007). Apart from the failures occurring at start-up phase, very few failures were experienced during the seven month evaluation period. It must, however be noted that the test unit was considerably larger than the other units evaluated.

Extended aeration is a modification to the activated sludge process where the process is designed so that the mass of cells synthesised per day equals the mass of cells endogenously degraded per day. Thus, theoretically, there is not net production of cell mass.

### 2.1.2 Rotating bio-contactors

The Rotating Bio-Contactors (RBC), developed in the late 1960s, consist of a series of discs attached to a horizontal shaft. These systems are modular and additional shafts and discs can be added in series. The pre-treatment step is generally a septic tank.

Components of a rotating bio-contactor

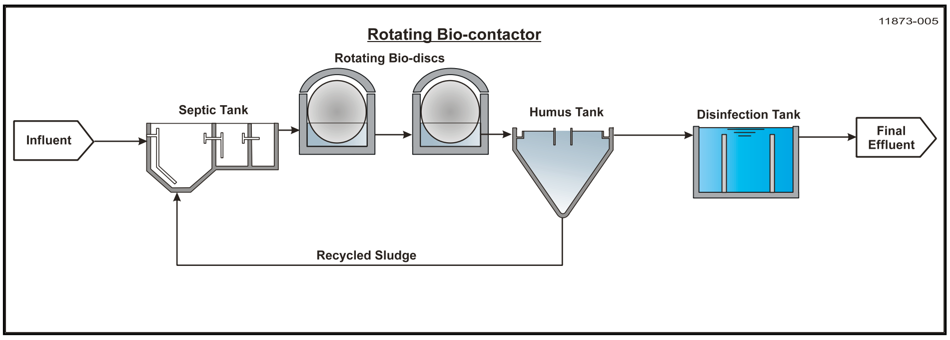



*Figure 2: Process flow diagram for a typical rotating biocontactor*

RBCs are generally housed in a concrete or carbon steel tank, such that 40% of the disc surface area is submersed in the wastewater. The shafts rotate at a rate of between 1 and 4 revolutions a minute. The biomass is aerated whilst exposed to air above the wastewater. The bio-discs must however, not be exposed to sunlight and are therefore covered with a fibre glass cover with air vents. The biomass attaches to these discs and drops off into the wastewater as the biofilm becomes too thick.

Rotating Bio-contactor installation

The next step in the process is a humus tank, in which the solids and liquid phases are separated. The effluent flows into a disinfection chamber, whilst the settled solids are wasted to the septic tank. The septic tank will need to be desludged regularly.

On-site RBCs should be constructed of non-corrosive materials and the disc shafts, bearings and mechanical drives must be designed for heavy duty use. Easy access to the bearings, discs and mechanical drives is required for maintenance. Other important design criteria for RBCs include adequate cover and insulation against cold weather and sunlight and proper ventilation to ensure adequate oxidation (EPA, 2000).

### 2.1.3 Submerged bio-contactors

Packing material in a submerged bio-contactor – Note that the shape and size of the packing may vary with different units

Plastic media, which allows for biomass attachment, is used in Submerged Bio-Contactors (SBC). The primary treatment, in most cases, consists of a septic tank. The wastewater is then pumped to a bio-contactor tank, which is filled with the plastic media. Air is introduced to the tank by means of an aeration blower. The wastewater is then clarified, before the disinfection phase (Laas, 2004).

Several PWTP manufacturers in South Africa use the SBC approach. These systems have variations, but employ a similar concept of placing plastic media in a tank to allow surface area onto which the biomass can attach. Adequate aeration is critical to the performance of these treatment systems.

Most installations include a septic tank upfront. The bio-contactor, is a closed tank filled with specially designed media which maximises the surface area for the microbiological action. The next step is a clarifier, which in most cases returns all the solids to the septic tank. The solids returned to the septic tank act as a seed for the bio-contactor.

*Submerged bio-contactor installation*

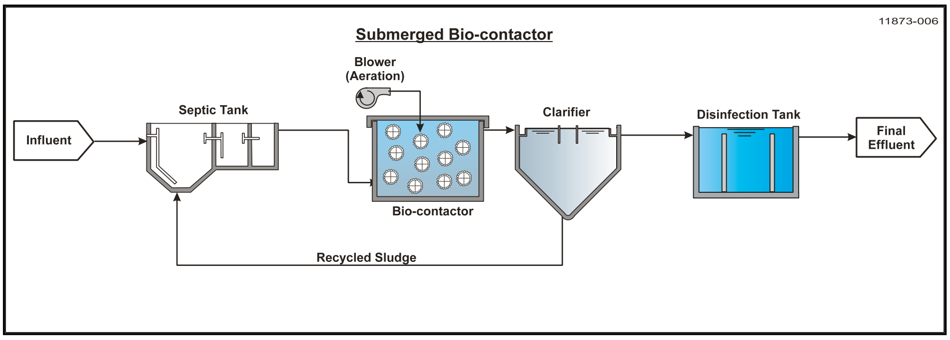
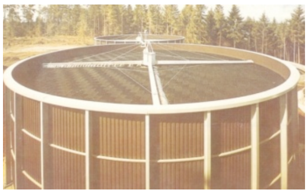



*Figure 3: Process flow diagram for a typical submerged bio-contactor*

### 2.1.4 Trickling filters



*Trickling filter example*

Trickling filers are similar to the SBCs in that a tank is filled with a rock or synthetic media to allow for biomass attachment. The wastewater is sprayed at the top of the media surface and the tank is open to the atmosphere allowing for natural ventilation and aeration. As the wastewater gravitates to the bottom, organic matter and ammonia are metabolized by the biofilm which forms on the media surface.

Factors influencing the performance of these systems include:

- Wastewater characteristics;
- Media type;
- Optimal dissolved oxygen levels; and
- Sludge recirculation rates.

Chemical dosage might be required for appropriate nutrient removal, but this is not recommended for onsite plants

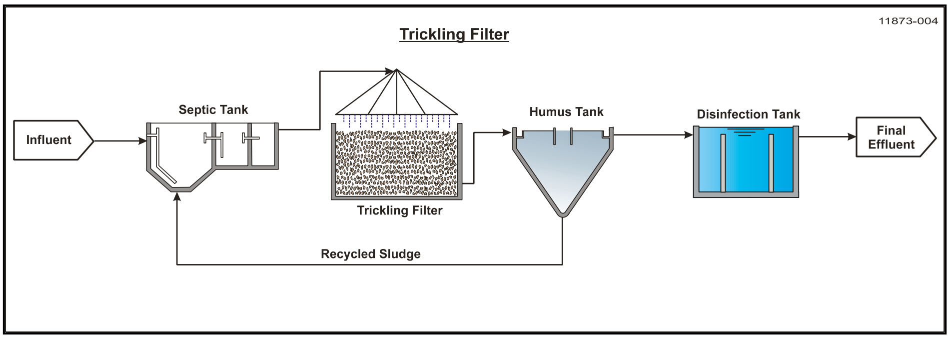



*Figure 4: Process flow diagram of a typical trickling filter*

The trickling filter is an open tank with vents at the bottom. The tank is filled with stones which allow biomass to attach onto it. The next step is a clarifier, where treated effluent is separated from the biomass. The sludge is returned to the septic tank.

### 2.1.5 Membrane bioreactors

Membrane bioreactors, including submerged membrane bioreactors, are a relatively new technology in South Africa. These reactors make use of the activated sludge process, but in a modified form. The clarifier step is replaced by semi-porous membranes arranged is sheets or tubes. The membranes can be costly and it is therefore important to screen wastes in membrane type bioreactors. It is recommended that a two stage septic tank is followed by a

2-4 mm screen prior to the membrane bioreactor. Flow balancing is also essential in membrane bioreactors as membranes operate best in a limited flux range.

Membrane systems can produce a high quality effluent, suitable for reuse applications or feed to reverse osmosis treatment.

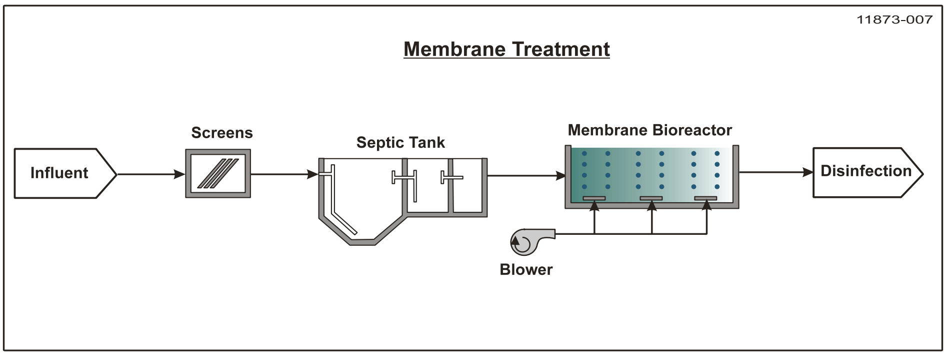



*Figure 5: Process flow diagram for a membrane bioreactor*

## 2.2 Emerging treatment options

Various advances have been made in terms of sewage treatment in recent years. With an increased demand for decentralised sewage treatment systems and package plants, research is constantly being carried out on new systems. One such system is the high rate algal pond.

A high rate algal pond is a shallow pond with mechanical mixers in which algae and bacteria grow (Gargia, 2000). The mixing promotes algal growth and prevents biomass mixing, which is essential for the successful operation of the system.

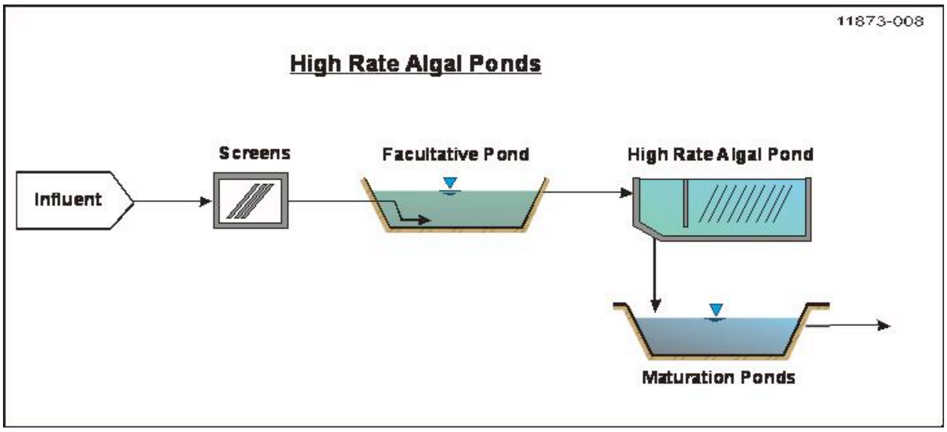



*Figure 6: Process flow diagram for the AIWPS process.*

Rhodes University have carried out successful studies on treating domestic wastewater in an Advanced Integrated Wastewater Ponding Systems (AIWPS) (Rose, 2002). The AIWPS system consists of four ponds in series:

- Primary Facultative Pond (PFP) – an anaerobic bottom zone is overlayed with surface aerobic waters, creating thereby two functionally separate components.
- High Rate Algal Pond (HRAP) – the paddle-mixed oval pond with a race track type layout required a shortened retention time and produced more dissolved oxygen than conventional secondary pond.

- Algal Settling Pond (ASP) – the harvesting and removal of algal biomass is required prior to discharge to the environment
- Maturation pond – maturation pond may be used instead of chlorination for adequate reduction in bacterial count.

The anaerobic systems are discussed as pre-treatment systems in the document. They would not meet the general discharge standards if installed as standalone systems

## 2.3 Pre-treatment and Post Treatment Options

### 2.3.1 Anaerobic Systems

While anaerobic systems alone cannot meet the general discharge standards prescribed for package plants, these generally are suitable pre-treatment for most of the package plants discussed above.

Septic tanks

Septic tanks are anaerobic systems that generally require sufficient retention time. Heavy solids settle in the septic tank and undergo anaerobic decomposition.

Anaerobic systems are probably the simplest and least demanding to operate and maintain of any on site system. Most package plant manufacturers include a septic tank as a pre-treatment step with their plants.

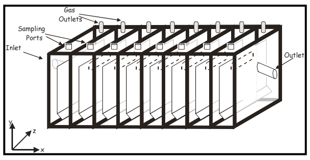
In most package plant applications, solids are recycled to the septic tank. The biodegradable solids will break down anaerobically over time. There will however be a build-up of solids in the septic tank over time and the tank will need to be desludged.

The septic tank will require desludging. Refer to the operating manual for recommended frequency of desludging.

Upflow Anaerobic Sludge blanket reactor (UASB)

The upflow anaerobic sludge blanket reactor (UASB) was developed by Lettinga in the 1970s (Haandel, 1994). Since then several full-scale plants have been put into operation. The UASB reactor is based on the concept that anaerobic sludge inherently has satisfactory settling properties provided the sludge is not exposed to mechanical or hydraulic mixing. To achieve the necessary contact between the influent wastewater and the biomass, the system relies on proper hydraulic configuration and agitation brought about by the release of biogas (Lettinga, 1995).

Anaerobic Baffled Reactor (ABR)




The anaerobic baffled reactor (ABR) is essentially a series of UASBs which do not require granular bio-growth (Boopathy, 1988). The ABR consists of a series of hanging and standing baffles which force the wastewater being treated over (or through), and under, from the inlet to the outlet of the reactor.

The ABR may be characterised as a series of well mixed continuously stirred tank reactors (CSTRs) with low dead-space and very little mixing between the compartments (Grobicki, 1991). Lower hydraulic retention times results in a higher gas production and a greater degree of mixing.

## 2.4 Post treatment options

### 2.4.1 Maturation ponds

Maturation ponds can be used for post treatment of effluent treated in package plants. The purpose of a maturation pond with a package plant is to:

- Allow re-aeration of the treated effluent,
- Dissipate chlorine residuals,
- Provide solar disinfection
- Settle solids
- Provide a barrier against severe impacts on the receiving waters.

As a guideline, the following sizes can be applied to maturation ponds in the case where a package plant is followed by a maturation pond/river.

**Table 1: Recommended sizing for maturation pond used as a post treatment for effluent treated in a package plant**

| Plant capacity ($m^3/d$) | Maturation pond volume ($m^3$)[1] |
|---|---|
| 5-100 | 1 days flow |
| 101-500 | ¾ days flow |
| 501-1000 | ½ days flow |
| 1001-1999 | ¼ days flow |

The maturation pond should have a length to breadth ratio of approximately 3:1 to promote plug flow. They must be kept as shallow as possible (1 to 1,5 m).

### 2.4.2 Pond systems

Ponds are easy to construct, have low operational requirements and display good flow/load equalisation properties. They do however, require large areas of land and can produce offensive odours if not properly operated.

The treatment process in the pond system is dependent on natural conditions such as temperature, sunshine, wind action, humidity and exposure time (WISA, 1988). Stabilisation or oxidisation ponds are used to treat raw wastewater. The different types of pond systems available include:

- Facultative-aerobic pond systems that comprise a primary pond and several secondary ponds, all of which are basically aerobic;
- Anaerobic-aerobic pond systems that comprise two anaerobic ponds followed by several aerobic ponds; and
- Aerated pond systems that are similar to a facultative-aerobic pond system, although in this case a smaller primary pond is maintained in an aerobic condition by means of mechanical aeration.

Pond systems are generally constructed on-site, and are thus by definition not considered as typical package plants. They are, however particularly effective when used in combination with other technologies and can therefore be installed either upfront or downstream of a package plant.

[1] Sizes are based on maturation ponds used as a post treatment option, and not for stand alone maturation ponds

Maturation ponds are used as tertiary, polishing treatment and are effective for disinfection of treated effluents.

The nuisance free operation and treated effluent quality of a pond system is governed by the size, loading and operation of the pond system.

### 2.4.3 Constructed Wetlands

*Constructed wetland at a hotel*

As with ponds, wetlands are constructed onsite and thus by definition are not considered as typical package plants.  They are however very effective as a polishing treatment.

Natural and constructed wetlands consist of reeds and other emergent hydrophytes. Wetlands improve water quality by removing or retaining inorganic nutrients, processing organic wastes and reducing suspended sediments (Potgieter, 2002).

The two types of constructed wetland configurations include surface flow wetlands and subsurface flow wetlands. Surface flow wetlands are better suited for large community systems in milder climates. In a subsurface wetland, the water level is maintained below a gravel substrate by a stand-pipe structure. This minimises the risk of exposure to people and greatly reduces potential for mosquito breeding.

A constructed wetland can be an aesthetic feature in a housing development while serving as additional wastewater treatment.

## 2.5 Options for disinfection

A common problem noted during the situational assessment, is that operators forget to add chlorine tablets in the dosing bucket and in many cases, unchlorinated water is discharged into the environment. This can result in a health risk downstream and operators must be made aware of the importance of disinfection.

Disinfection is necessary for destroying pathogens in the treated wastewater before release to the environment. Disinfection is the final step in the treatment process and it is essential that the water is adequately treated prior to this step in order to ensure that the disinfection step is effective.

Common methods of disinfection include:

- Chlorination;
- Ozonation; and
- Ultraviolet radiation.

Other disinfection methods available but are often not practical for onsite applications due to the hazardous nature of the chemicals used or the complexity of the process.

### 2.5.1 Chlorination

Chlorine, which has been used as a disinfection method for both water and wastewater for a century can be added as a gas, liquid or solid in the form of sodium or calcium hypochlorite to the treated water (EPA, 1999).

The disinfection method selected should be ***safe, reliable, simple and cost effective***.

**Chlorine gas** is toxic and requires special equipment and trained personnel to work with and is not suggested for use in package plants.

Calcium hypochlorite tablets are currently the preferred disinfection method by most package plant distributors as it is a simple and cost effective method for disinfection. On larger applications, chlorine gas is sometimes used. However, there are health and safety risks associated with this.

Over dosing is an ecological risk, and thus long grass swales/ditches or wetlands are recommended prior to direct discharge into sensitive water resources. Under dosing poses a health risk in terms of residual pathogen exposure to humans.

Advantages of using chlorine as a disinfection system include:

- It is a simple technology to apply;
- It has a long history of data showing success; and
- Residual addition of chlorine in controlled measures prevents the spread of life threatening diseases.

Remember that residual chlorine can be harmful to aquatic life. Always allow for de-chlorination when discharging to a water resource.

Disadvantages of using chlorine as a disinfection system include:

- Free chlorine and chlorine residuals have proved detrimental to aquatic life;
- Chlorine will react with organic materials to form trace concentrations of trihalomethanes, suspected to be carcinogenic; and
- Health risks of direct exposure to chlorine include:
  - Irritation to mucous membranes, respiratory tract and eyes due to gaseous chlorine reacting with moisture to form hydrochloric acid;
  - Coughing, gagging, pulmonary oedema and even death when exposed to chlorine gas for prolonged periods; and
  - Skin irritation, such as burns, from contact with liquid chlorine.

It is therefore important to follow the necessary precautions prescribed when working with chlorine and ensure that all staff and operators are trained accordingly.

### 2.5.2 Ozonation

*Ozonation unit at a package treatment plant*

Ozone is becoming more popular with package plant distributors. Ozone dissociates rapidly and is therefore produced on site. Remaining ozone in the off gas is destroyed before release to the atmosphere, and it is thus better to ensure optimal ozone dosage for overall efficiency.

Disinfection depends on dosage, mixing and contact time. It is critical that an ozone disinfection system is pilot tested and calibrated prior to installation on site (EPA, 1999).

Advantages of using ozone treatment include:

- Ozone is more effective than chlorine in the destruction of viruses and bacteria;
- The ozonation process requires relatively short contact times;
- Ozone decomposes rapidly, reducing the risk of harmful residuals remaining in the water;
- There is no re-growth of microorganisms after ozone treatment, except for those protected by particulates;
- Sufficient quantities of ozone are generated on site as required, thereby eliminating the risks associated with the transport and handling of a hazardous substance.

Disadvantages with using ozone treatment include:

- Low dosages may not eliminate viruses, spores and cysts;
- Ozonation is a complex technology, requiring complicated equipment and contacting systems;
- Turbidity in the treated effluent can render ozone disinfection ineffective;
- Ozone is extremely irritating and possibly toxic, and off gases from the ozone contactor must be destroyed; and
- The cost of treatment can be high in terms of capital investment and power consumption.

### 2.5.3 UV Radiation

Ultra-violet (UV) radiation disinfection is not common in South Africa amongst package plant distributors. The effectiveness of UV disinfection is dependent on the characteristics of the treated effluent transmissivity, the intensity of the UV radiation and the amount of time that the micro-organism is subjected to the radiation (EPA, 1999).

UV radiation has no residual effect on humans or aquatic life.

Advantages of UV disinfection are:

- UV radiation is effective in inactivating most viruses, spores and cysts;
- It is a physical process, thus eliminating the need to generate, handle, transport or store toxic/hazardous chemicals;
- There is no residual effect on humans or aquatic life;
- UV radiation has a shorter contact time than other available disinfection options; and
- UV disinfection equipment requires relatively little space.

Disadvantages of UV disinfection method include:

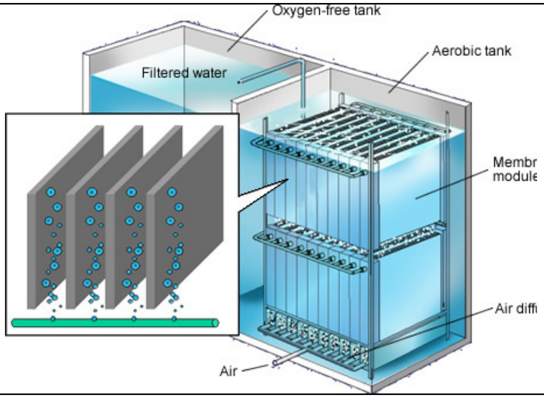
- Low dosage may not effectively inactivate some viruses, spores or cysts;
- Organisms can sometimes reverse the effects of UV through “dark repair”;
- A preventative maintenance program is necessary to control fouling of the tubes; and
- Turbidity in the treated effluent can render UV disinfection ineffective.

**Table 2: Categorisation of typical package plants**

| Type | Technology | Comment | Typical System |
|---|---|---|---|
| General | Anaerobic Treatment | The effluent from an anaerobic treatment system will not meet the standards for discharge or irrigation. It is recommended that anaerobic systems are used as a pre-treatment step only.<br><br>*Example of a pilot scale ABR (Courtesy of UKZN)* |  |
| | Wetlands | Many different engineered wetland systems exist in both the surface flow and submerged subsurface flow categories. Used for polishing effluents and assisting with disinfection.<br><br>*Example of constructed wetlands (Courtesy of Dekker Environtech)* |  |

| Type | Technology | Comment | Typical System |
|---|---|---|---|
| Suspended biomass | Activated sludge systems | Biomass is suspended by means of continuous aeration in activated sludge tanks. The plants are modular and additional tanks can be added to increase capacity. When designed, constructed and operated correctly, these systems can meet the discharge standards.<br><br>*Example of an activated sludge system (Courtesy of Prentec)* |  |
| Fixed Film Biomass | Rotating Bio-contactors | The system consists of a number of plastic discs attached to a rotating shaft. The plastic disc allows for a surface area onto which the biomass can attach. The rotation allows for the aeration of the system. If designed, constructed and operated correctly, these systems can produce an effluent that will meet the standards for discharge. The systems are modular and additional RBCs can be added to increase capacity.<br><br>*Example of a Rotating Bio-contactor (courtesy of Becon.)* |  |

| Type | Technology | Comment | Typical System |
|---|---|---|---|
| | Submersed bio-contactors | These systems are very common especially amongst land developers. The submersed bio-contactor consists of a tank filled with a plastic media that serves as a surface area for the biomass to attach. The tank content is aerated. If designed, constructed and operated correctly, these systems can produce an effluent that meets the standards for discharge. The systems are modular and additional tanks can be added to increase capacity. <br><br> *Example of a submersed bio-contactor (Courtesy of Biobox.)* |  |

| Type | Technology | Comment | Typical System |
|---|---|---|---|
| Fixed Film Biomass | Trickling filters | As with the submersed bio-contactors, these systems consist of a tank, filled with natural or synthetic material, allowing for the biomass to attach. The system is open to the atmosphere, to allow for ventilation and aeration and thus does not required mechanical aeration. If designed, constructed and operated correctly, these systems can produce an effluent that will meet the standards for discharge. The systems are modular and additional tanks can be added to increase capacity.<br><br>*Example of a trickling filter (Courtesy of TerBo Pac)* |  |
| Membrane systems | Membrane bioreactor | The activated sludge process is modified in these systems. The clarifier is replaced by membranes which are a semi porous material, arranged as sheets or tubes, allowing the treated effluent to pass through the membrane whilst the sludge remains behind.<br><br>*Example of a membrane bioreactor (courtesy of Hitachi Plant Technologies)* |   |

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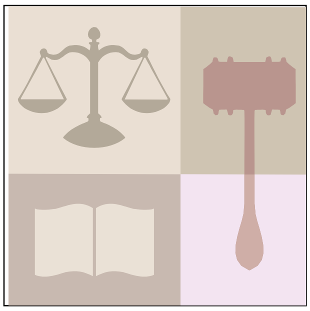

## 3.0 REGULATORY ASPECTS

### 3.1 Applicable legislation

The following legislation is currently relevant to the use of package plants:

- National Environmental Management Act (Act 107 of 1998);
- National Water Act (Act 36 of 1998);
- Water Services Act (Act 108 of 1997);
- National Building Regulations and building standards Act (Act 103 of 1977 Local Government: Municipal Structures Act (No. 117 of 1998); and
- Municipal By-laws, local policies and practices.

Section 11 (1) of the Water Services Act (Act 108 of 1997) (WSA) states that every Water Services Authority has a duty to all consumers or potential consumers in its area of jurisdiction to progressively ensure efficient, affordable, and sustainable access to water services. However, this is subject to:

- the availability of resources
- the need for an equitable allocation of resources to all consumers and potential consumers within the authority's area of jurisdiction;
- the need to regulate access to water services in an equitable way;
- the duty of consumers to pay reasonable charges, which must be in accordance with any prescribed norms and standards for tariffs for water services;
- the duty to conserve water resources;
- the nature, topography, zoning and situation of the land in question; and
- The right to relevant water services if there is a failure to comply with reasonable conditions set for the provision of such services.

Section 11(3) further states that in ensuring access to water services, a Water Services Authority must take into account, amongst other factors:

- alternate ways of providing access to water services;
- the need for regional efficiency;
- the need to achieve benefit of scale;
- the need for low costs;
- the requirements of equity; and
- the availability of resources from neighbouring water services authorities.

The WSA also states that a Water Services Authority may not unreasonably refuse or fail to give access to water services to a consumer or potential consumer in its area of jurisdiction. In emergency situations, a Water Services Authority must take reasonable steps to provide basic water supply and basic sanitation services to any person within its area of jurisdiction and may do so at the cost of that authority. It must also be remembered, however, that a Water Services Authority may impose reasonable limitations on the use of water services.

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Chapter III, Section 19 of the WSA sets out the details of contracts and joint ventures that can be entered into with Water Service Providers. It states that the Water Services Authority may perform the functions of a Water Services Provider and it may enter into a written contract with a Water Services Provider or form a joint venture with another Water Service Institution other than a public sector Water Services Institution which will provide services within the joint venture at cost and without profit. Some relevant definitions from the WSA include:

| | |
|---|---|
| *Water Services Authority* | any municipality, including a District or Rural Council as defined in the Local Government Transitions Act, 1993 (Act No. 209 of 1993) responsible for ensuring access to water services; |
| *Water Services Institution* | includes a Water Services Authority, a Water Services Provider, a Water Board and a Water Services Committee; |
| *Water Services Intermediary* | any person who is obliged to provide water services to another in terms of a contract where the obligation to provide water services is incidental to the main object of the contract; |
| *Water Services Provider* | any person who provides water services to consumers or to another Water Services Institution, but does not include a Water Services Intermediary. |

The above is supported by Section 84 of the Municipal Structure Act (Act 117 of 1998) which discusses the functions and powers of Municipalities.

Firstly, integrated development planning must take place and the District Municipality must develop and Integrated Development Plan (IDP) as a whole, including a framework for the Local Municipalities (LMs) within its area, therefore also taking into account the IDPs of those LMs. The District Municipality is also responsible for the bulk supply of water that affects a significant proportion of Municipalities in the district, as well as the bulk wastewater purification works and main wastewater disposal that affects a significant proportion of Municipalities in the district.

Section 85 (1) (b) states, however, that these powers and functions may be given to the Local Municipality. Figure 7 is a flow diagram showing the relevant regulatory requirements for a development that would utilise a package plants. The regulatory process has been divided into 4 stages.

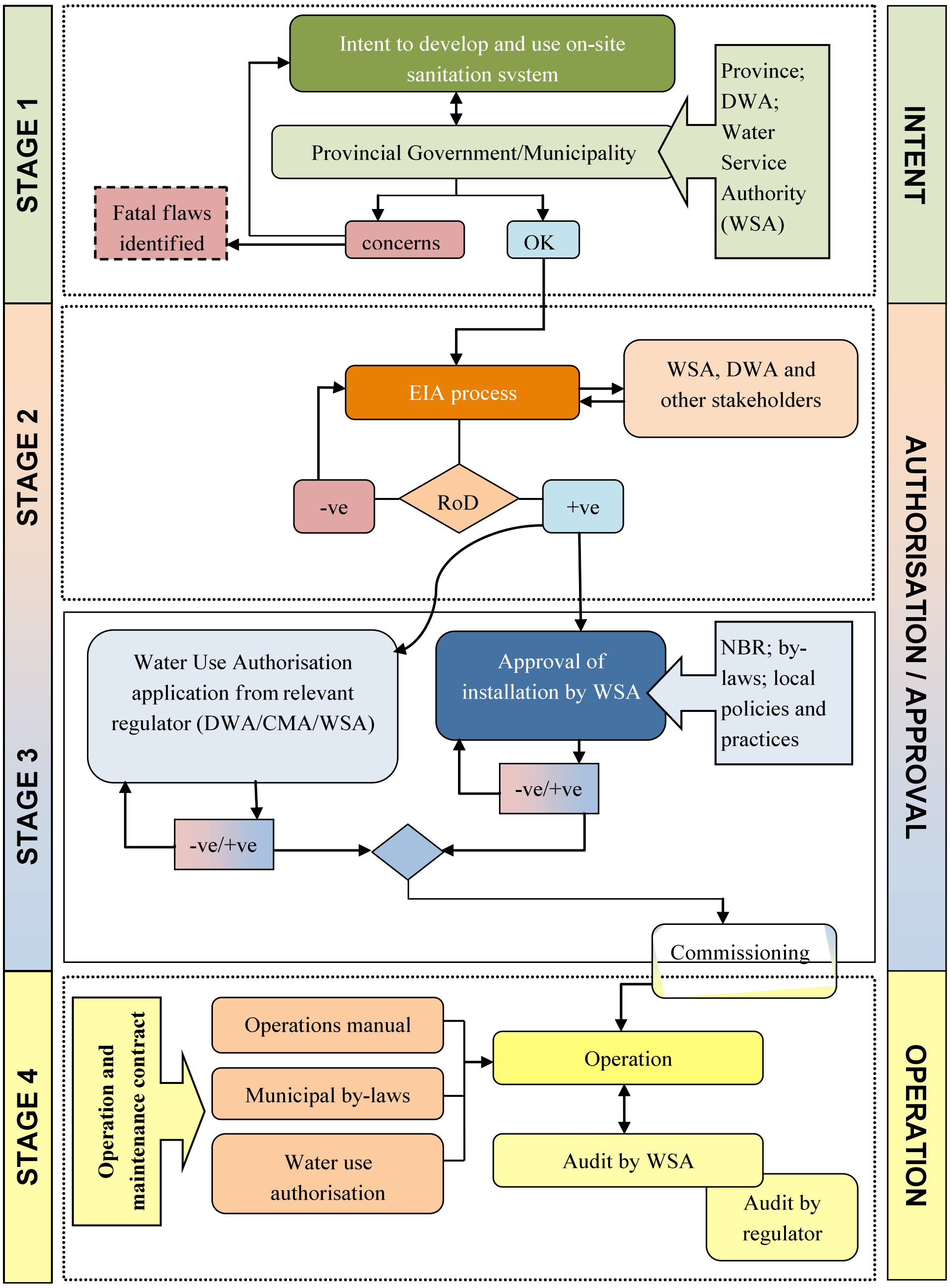


**Figure 7: Flow diagram showing the legislative requirements**

- Inform the municipality of intent to develop.
- Are there specific bylaw, policies or structures in place regarding package plants
- Applicant will be provided with process to be followed.

## 3.1.1 Stage 1: Intent to develop

For any development the first step is to inform the municipality, through the appropriate methods, of the intent to develop and to ascertain whether the land is correctly zoned and whether the municipality will be able to install the services needed. Importantly at this stage the developer needs to ascertain whether the municipality has any specific by-laws, policies or practices around the approval of package plants, and if so, what these are. This would require input from various sections of the municipality including planning, water and sanitation, roads and electricity. In certain cases this may require discussions with a Water Services Provider that is not part of the Municipality.

## 3.1.2 Stage 2: EIA Process

***Environmental impact assessment (EIA):*** the process of collecting, organising, analysing, interpreting and communicating information that is relevant to the consideration of that application

- The DWA and WSA must comment on the EIA application; and
- Department of Environmental Affairs will incorporate all comments in the RoD.

If the developer decides to proceed with the proposed development and the land has been correctly zoned, then the process enters the second phase which includes the aspects considered under the NEMA, 1998 (Act 107 of 1998). In other words the developer enters the phase in which an impact assessment is undertaken to determine what impacts the development will have on the environment and the socioeconomic conditions of the area. Some relevant definitions are included in the box below.

| | |
|---|---|
| ***Environment*** | the surroundings within which humans exist and that are made up of:<br>i. the land, water and atmosphere of the earth;<br>ii. microorganisms, plant and animal life;<br>iii. any part or combination of (i) and (ii) and the interrelationships among and between them; and<br>iv. the physical, chemical, aesthetic and cultural properties and conditions of the foregoing that influence human health and wellbeing; |
| ***Pollution*** | means any change in the environment caused by:<br>i. substances;<br>ii. radioactive or other waves; or<br>iii. noise, odours, dust or heat, emitted from any activity, including the storage or treatment of waste or substances, construction and the provision of services, whether engaged in by any person or an organ of state, where that change has an adverse effect on human health or wellbeing or on the composition, resilience and productivity of natural or managed ecosystems, or on materials useful to people, or will have such an effect in the future; |
| ***Activity*** | any activity identified as a listed or specified activity; |

Chapter 5 of the National Environmental Management Act (NEMA) discusses Integrated Environmental Management (IEM). The purpose of the chapter is to promote the application of appropriate environmental management tools in order to ensure the integrated environmental management of activities.

Section 24 of NEMA discusses the implementation of IEM. The objectives of IEM described above means that the potential impact on the environment, socioeconomic conditions, and the cultural heritage of activities that require authorisation or permission by law and which may significantly affect the environment, must be considered, investigated and assessed prior to their implementation. The results of the assessments must be reported to the organ of state charged by law with authorising, permitting, or otherwise allowing the implementation of an activity. It is therefore extremely important that all the stakeholders and especially the municipality are involved in this step.

Regulations, in terms of the above, were promulgated in 2006 and include the listed activities as set out in the box below. At this stage it is important that the developer takes note of these to identify the type of assessment that will be relevant to the proposed development.

As stated in NEMA integrated environmental management aims to:

- promote the integration of the principles of environmental management;
- identify, predict and evaluate the actual and potential impact on the environment, socioeconomic conditions and cultural heritage;
- ensure that the effects of activities on the environment receive adequate consideration;
- ensure adequate and appropriate public participation;
- ensure the consideration of environmental attributes in management and decision making; and
- identify and employ the modes of environmental management best suited to ensuring that a particular activity is pursued in accordance with the principles of environmental management.

**Schedule 2 Activities**

Schedule 2 activities are those activities that require that an Environmental Impact Assessment (EIA) be undertaken. These include:

- the treatment of effluent, wastewater and wastewater with an installed capacity of > 15 000 $m^3$ per annum;
- golf estates of any size and residential housing; and
- any new development greater than 20 hectare (ha).

**Schedule 3 Activities**

Schedule 3 activities are those activities that require that a basic assessment be undertaken and include:

- resorts, lodges, hotels and other tourism or hospitality facilities where –
  - more than 20 guests stay overnight or there are more than 10 guest units;
  - the facility covers more than one (1) ha; and
  - there is no connection to a municipal sewerage system.
- pipelines transporting wastewater and water;
- development or redevelopment including for residential. This may, however, be excluded where an authority has an approved environmental management framework.

### 3.1.3 Stage 3: Water Use Authorisation and Installation Approval

The water use authorisation process and the approval by the municipality are two separate processes.

#### *3.1.3.1 Water Use Authorisations in terms of the National Water Act*

The definitions from the National Water Act (Act 36 of 1998) (NWA) included in the boxes in the margin are important for the developer to understand.

In terms of the National Water Act all water use must be authorised. Water Use Authorisations are the primary instrument for source directed management, in other words for point sources of pollution. Water uses requiring authorisation in relation to a water resource, means the maintenance of the quality of the water resource to the extent that the water resource may be used in an ecologically sustainable way; the prevention of the degradation of the water resource; and the rehabilitation of the water resource; are defined in terms of Section 21, as in **Table 3** below.

**Table 3: Water use as defined by Section 21 of the NWA**

| Water Use | Description |
|---|---|
| S 21 (a) | Taking water from a water resource |
| S 21 (b) | Storing water |
| S 21 (c) | Impeding or diverting the flow in a watercourse |
| S 21 (d) | Engaging in a stream flow reduction activity |
| S 21 (e) | Engaging in a controlled activity – activities which impact detrimentally on a water resource (activities identified in Section 37(1) or declared as such under Section 38(1)) namely:<br>• irrigation of any land with waste or water containing waste which is generated through an industrial activity or a waterwork;<br>• an activity aimed at the modification of atmospheric precipitation;<br>• a power generation activity which alters the flow regime of a water resource; or<br>• intentional recharge of an aquifer with any waste or water containing waste |
| S 21 (f) | Discharging waste or water containing waste into a water resource through a pipe, canal, sewer, sea outfall or other conduit; |
| S 21 (g) | Disposing of waste or water containing waste in a manner which may detrimentally impact on a water resource; |
| S 21 (h) | Disposing in any manner of water which contains waste from, or has been heated in, any industrial or power generation process; |
| S 21 (i) | Altering the bed, banks, course or characteristics of a watercourse; |
| S 21 (j) | Removing, discharging or disposing of water found underground if it is necessary for the efficient continuation if an activity or for the safety of people; and |
| S 21 (k) | Using water for recreational purposes |

Authorisation of the package plants will be done either in terms of relevant General Authorisations or a Water Use Licence.

***Pollution**:* the direct or indirect alteration of the physical, chemical or biological properties of a water resource so as to make it less fit for any beneficial purpose for which it may reasonably be expected to be used; or harmful or potentially harmful to the welfare, health or safety of human beings; to any aquatic or non-aquatic organisms; to the resource quality; or to property.

***Protection**:* in relation to a water resource, means the maintenance of the quality of the water resource to the extent that the water resource may be used in an ecologically sustainable way; the prevention of the degradation of the water resource; and the rehabilitation of the water resource;

***Resource quality**:* the quality of all the aspects of a water resource including the quantity, pattern, timing, water level and assurance of in-stream flow; the water quality, including the physical, chemical and biological characteristics of the water; the character and condition of the in-stream and riparian habitat; and the characteristics, condition and distribution of the aquatic biota.

***Water resource**:* includes a watercourse, surface water, estuary, or an aquifer.

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**_Reserve_**: means the quantity and quality of water required to satisfy basic human needs by securing a basic water supply, as prescribed under the Water Services Act, 1997 (Act No. 108 of 1997), for people who are now or who will, in the reasonably near future, be relying upon; taking water from; or being supplied from the relevant water resource; and protect aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant water resource.

**_Waterwork_**: includes any borehole, structure, earthwork or equipment installed or used for or in connection with water use.

**_Watercourse_**: a river or spring; a natural channel in which water flows regularly or intermittently; a wetland, lake or dam into which, or from which, water flows; and any collection of water which the Minister may, by notice in the *Gazette*, declare to be a watercourse. Reference to a watercourse includes, where relevant, its bed and banks.

*General Authorisation*

General Authorisation (GA) replaces the need for a water use licence where the water use in question will have a minimum impact on a water resource. However, it must be remembered that the GAs still have certain conditions attached to them which need to be adhered to. The types of conditions include:

- Registration of the water use;
- Location of the water use;
- Wastewater limit values;
- Record-keeping and disclosure of information; and
- Precautionary practices.

*Water Use Licence*

Part 7 of the NWA set out sets out the procedures which apply in all cases where individual applications for licences to use water are made. In considering an application, a responsible authority may require additional information from the applicant, and may also require the applicant to undertake an environmental or other assessment which may be subject to independent review. In this respect it is essential that that adequate information is included during the EIA process.

Where it has been determined that an application for a Water Use Licence (WUL) is needed, even though it may be for small volumes, the normal licensing process must be followed and be submitted to Regional Office for recommendation from where it is then submitted to the National Office for signature by the Chief Director: Water Use, until such time as this function is delegated to the Regional office of DWA.

The final application would therefore include the following documents:

- Draft licence with conditions;
- Relevant completed forms;
- An approved copy of the Reserve Determination;
- Section 27 motivation;
- Water Quality Management Report/Technical Report;
- Monitoring requirements; and
- Other Correspondence such as:
    - The RoD from the relevant provincial Environmental Affairs office;
    - Public Participation correspondence; and
    - Health Department correspondence (e.g. with respect to a buffer zone).

### 3.1.3.2 *Installation Approval*

> Municipal by-laws, policies and practices could be very specific to a municipality and therefore the developer/owner or operator must ensure that they understand the specific requirements of the municipality in the area.

Considering the Water Services and Municipal Structures Act requirements on Municipalities it is essential that the WSA ensures that the package plant is correctly installed.

The developer/owner or operator must also be aware that in terms of Municipal by-laws, the Water Services Authority may go into an agreement with another provider to provide water services, however, it usually also states that if the provider causes any pollution then it will not be the Local Municipality who will be responsible but the other service provider. If the Local Municipality has to clean up in terms of any other Act, then they will claim back from the provider.

Municipal by-laws, policies and practices could be very specific to a municipality and therefore the developer/owner or operator must ensure that they understand the specific requirements of the municipality in the area.

*National Building Regulations and Building Standards Act definitions:*

*building* includes-

(a) any other structure, whether of a temporary or permanent nature and irrespective of the materials used in the erection thereof, erected or used for or in connection with-

- (i) the accommodation or convenience of human beings or animals;
- ii) the manufacture, processing, storage, display or sale of any goods;
- [Sub-para (ii) substituted by s. 1 (b) of Act 62 of 1989.]
- (iii) the rendering of any service;
- (iv) the destruction or treatment of refuse or other waste materials;
- (v) the cultivation or growing of any plant or crop;

(b) any wall, swimming bath, swimming pool, reservoir or bridge or any other structure connected therewith;
(c) any fuel pump or any tank used in connection therewith;
(d) any part of a building, including a building as defined in paragraph (a), (b) or (c);
(e) any facilities or system, or part or portion thereof, within or outside but incidental to a building, for the provision of a water supply, drainage, sewerage, stormwater disposal, electricity supply or other similar service in respect of the building;

*drainage installation* means any installation vested in the owner of a site and which is situated on such site and is intended for the reception, conveyance, storage or treatment of sewage, and may include sanitary fixtures, traps, discharge pipes, drains, ventilating pipes, septic tanks, conservancy tanks, sewage treatment works, or mechanical appliances associated therewith.

In addition to the by-laws, policies and practices, in terms of the National Building Regulations and Building Standards Act (Act 103 of 1977 as amended) no person shall, without the prior approval in writing of the local authority in question, erect any building in respect of which plans and specifications are to be drawn and submitted in terms of this Act. Considering the definition of building and drainage installation below, the municipality is therefore required to approve the installation of a package plant.

The responsibility for the approval of a package plant should include, but not be limited to, ensuring that the design and construction supervision has been undertaken by a professional who, at the completion of the work, certifies that the installation is complete in all respects.

In this respect it is important to note that at this stage that the responsibility of the municipality is to ensure that the procedures and processes required by the NBR have been followed; and in particular that there has been the necessary input of a professional engineer and that the relevant certification from such a professional is included in the submission. In addition that the building cannot be recognised as complete until the relevant professional(s) have supervised the construction and its fitness for occupation or purpose. So while there is no responsibility on the municipality to check, for example, the design calculations or to supervise the construction, and the long term correctness of the design remains that of the respective professional; the responsibility for the approval of a package plant should include, inter alia, but not be limited to ensuring that the design and construction supervision has been undertaken by a professional who, at the completion of the work, certifies that the installation is complete in all respects.

### 3.1.4 Step 4: Monitoring and Auditing

Compliance monitoring is the monitoring that will be carried out by the owner in terms of their water use authorisation.

The Water Use Authorisation will include a number of conditions that need to be monitored by the owner. Some of these are included in Section 7 of this document. These must be audited by the regulator, currently the DWA. In addition it is in the interest of the WSA to undertake audits in terms of any specific by-laws that have been put in place.

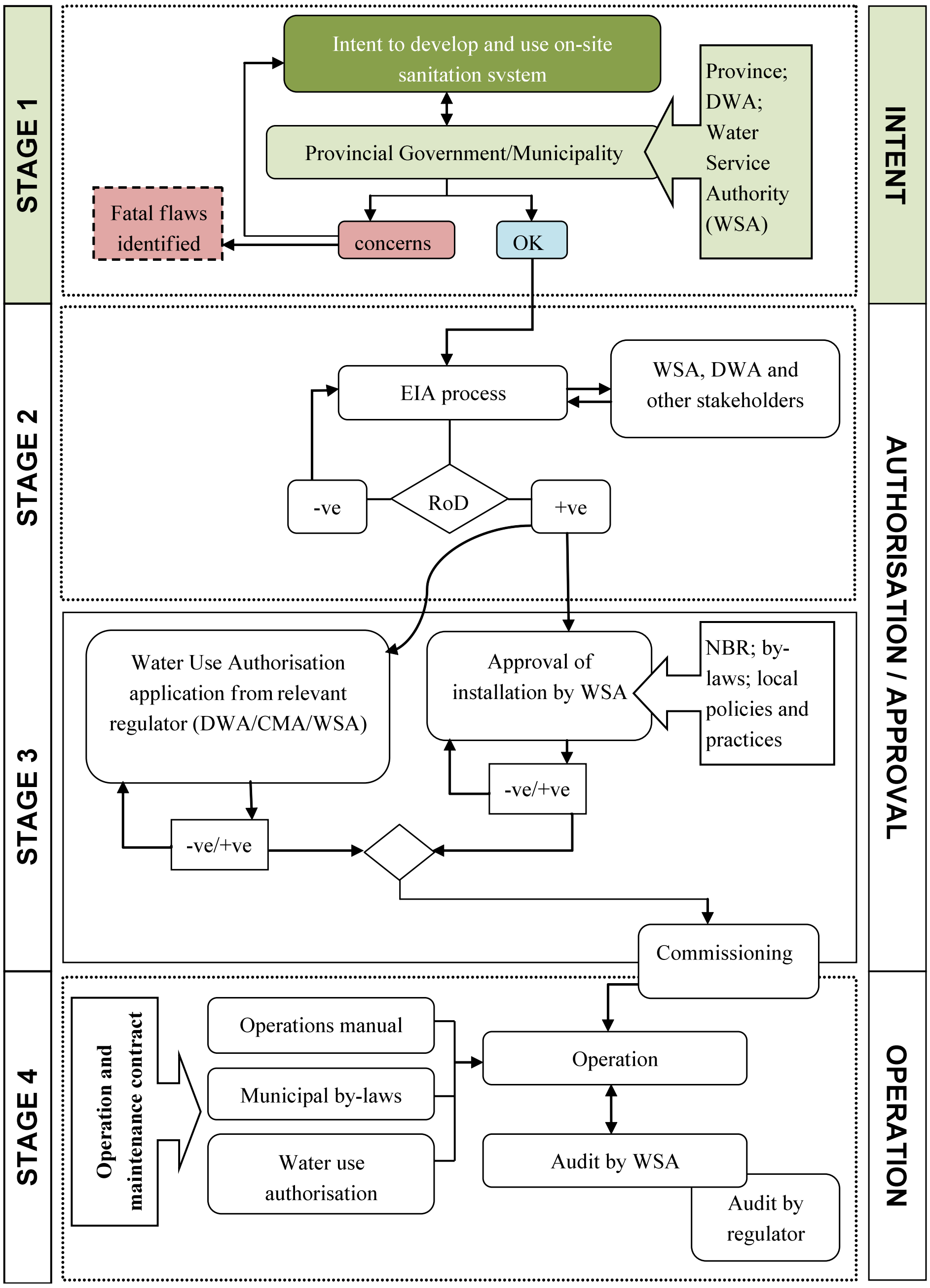
Depending on the type of water use, the regulators involved may come to an agreement where one of the parties would be the lead auditor and the other party would just be kept informed and give input and advice as requested.


This section refers to the minimum that needs to be adhered to. Provincial government, individual municipalities, or WSAs may have additional bylaws, policies and practices that will need to be addressed.

## 4.0 MINIMUM REQUIREMENTS

The following section sets out the minimum requirements (MRs) that must be adhered to when wanting to make use of a package plant with a total capacity less than 2 000 $m^3$/day. In other words, all of the aspects set out in stages 1 to 4 must be adhered to. However, this does not limit the municipal entity from asking for additional requirements in the municipal by-laws and local policies and practices.

## 4.1 Stage 1 Minimum Requirements




The purpose of stage 1 is to ensure that the regulator is made aware of the intend to install a package plant, any fatal flaws identified and addressed upfront and all parties involved are made aware of the process to be followed.


A developer may be defined as an individual or a company that has the intention of developing an area for activities such as a school, a residential development or a recreational facility. The developer may therefore also be the owner.

At this stage the developer is simply making the regulator(s) aware of the intention to develop and use a package plant. No approval will be given at this stage however fatal flaws should be identified. It is important therefore, that all the regulatory authorities (Municipal entity, Province and DWA as relevant) are involved from the start. In addition to this, the developer will be made aware of the process that needs to be followed and the information requirements for the approval; so that all parties are well aware of the process to be followed. Also, if there are any fatal flaws the developer will be made aware of them upfront, and can then abandon the project immediately or consider alternatives.

The minimum requirements for this stage of the process will include those parameters set out in Table 4.

The first aspect that must be discussed is the motivation for installation of the package plant. Typical motivations would include the type of area in which in which the development is proposed. For example, the development may be in a very remote portion of the municipal area where services are not yet supplied or the municipal sewer may not have adequate capacity at the time and an upgrade may not be planned for several years.

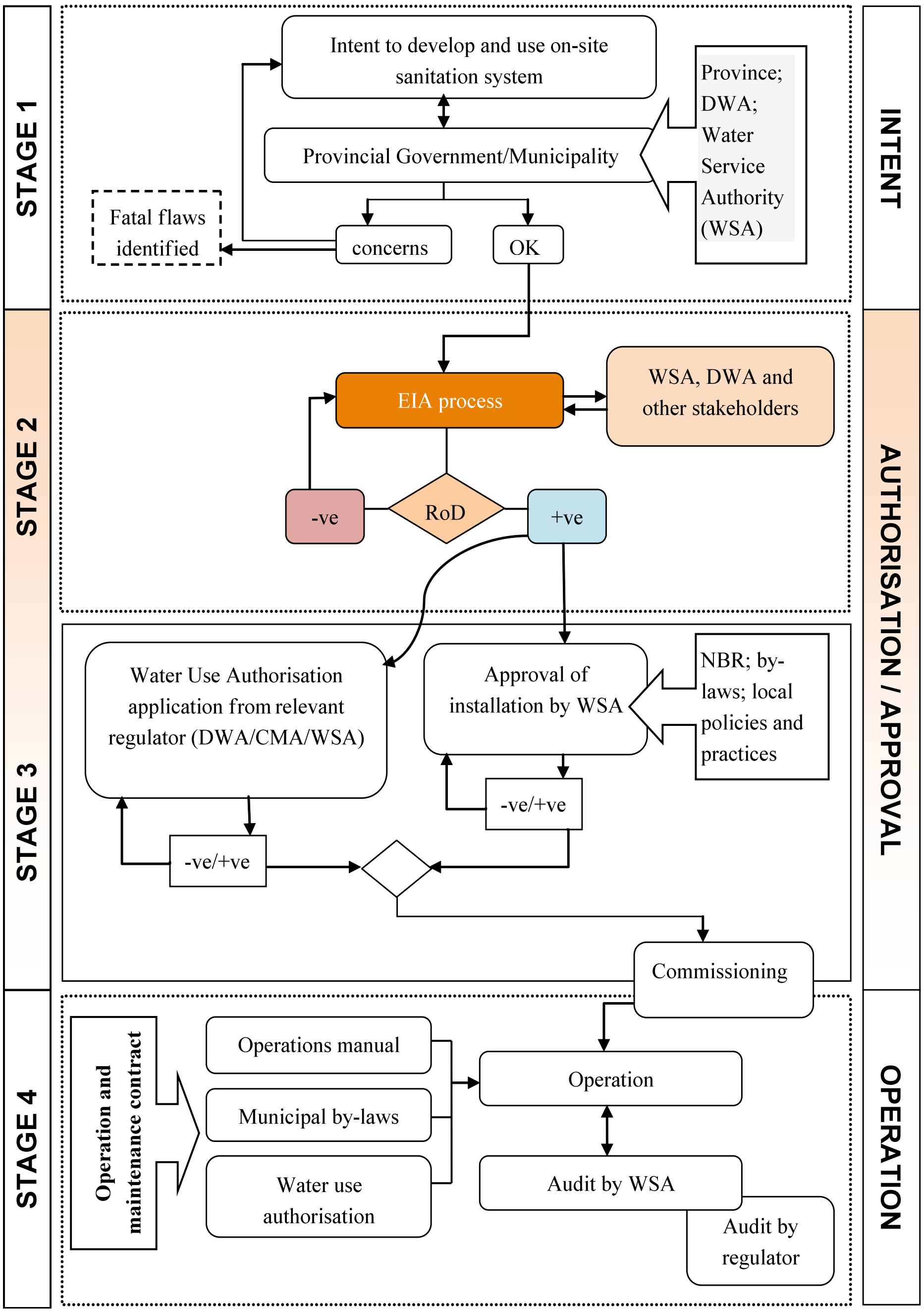
In terms of the location of the development there are certain exclusion areas where package plants will not be allowed, or if they are to be allowed, more stringent conditions will be set. This aspect would therefore be a fatal flaw indicator where alternative options for wastewater treatment would need to be investigated, and if necessary, the development abandoned or moved to a different location. Land use in terms of zoning and ownership should also be discussed this time.

**Table 4: Minimum Requirements for Stage 1**

| **Parameters to be considered in Stage 1** | | **Minimum requirements** |
|---|---|---|
| 1. Motivation for installation of a package plant | a. Motivation for use of a package plant | i. Typical reasons for use of a package plant:<br>• Remote area;<br>• No municipal sewer connection planned;<br>• Existing municipal sewer/municipal wastewater treatment works does not have adequate capacity; and<br>• Reuse of treated effluent for water conservation reasons. |

| Parameters to be considered in Stage 1 | | Minimum requirements |
|---|---|---|
| 2. Location | a. Exclusion areas | i. Areas that would indicate a fatal flaw include:<br>• Natural Wetlands;<br>• No discharge to Estuaries;<br>• Below the 100 year flood line, or less than 100 metres from the edge of a water resource;<br>• Land overlying a major aquifer (identification of major aquifers are available from the Department of Water Affairs and Forestry on written request);<br>• Listed water resources as set out in the latest version of the General Authorisations;<br>• A sewer connection is available; and<br>• High density areas where homes are in excess of 40 houses per hectare. |
| | b. Land use | i. Zoning<br>ii. Ownership |

## 4.2 Stage 2 Minimum Requirements




Provisions have been made for DWA and the WSA to comment on the EIA before the RoD is issued. It is important that comments are submitted to the department of environmental affairs to ensure that all concerns are addressed at this stage.

In the second stage the process enters the environmental impact assessment phase which includes the aspects considered under the NEMA, 1998 (Act 107 of 1998). Once the documentation is submitted to the Province, it is essential that both the municipal entity and the DWA give input based on the national water policy and municipal by-laws in place, and request further information regarding the package plant, if it is lacking. At this stage the municipal entity can deny permission to use a package plant if criteria set out are not met.

In this respect Table 5 sets out the minimum requirements that must be included as part of the EIA.

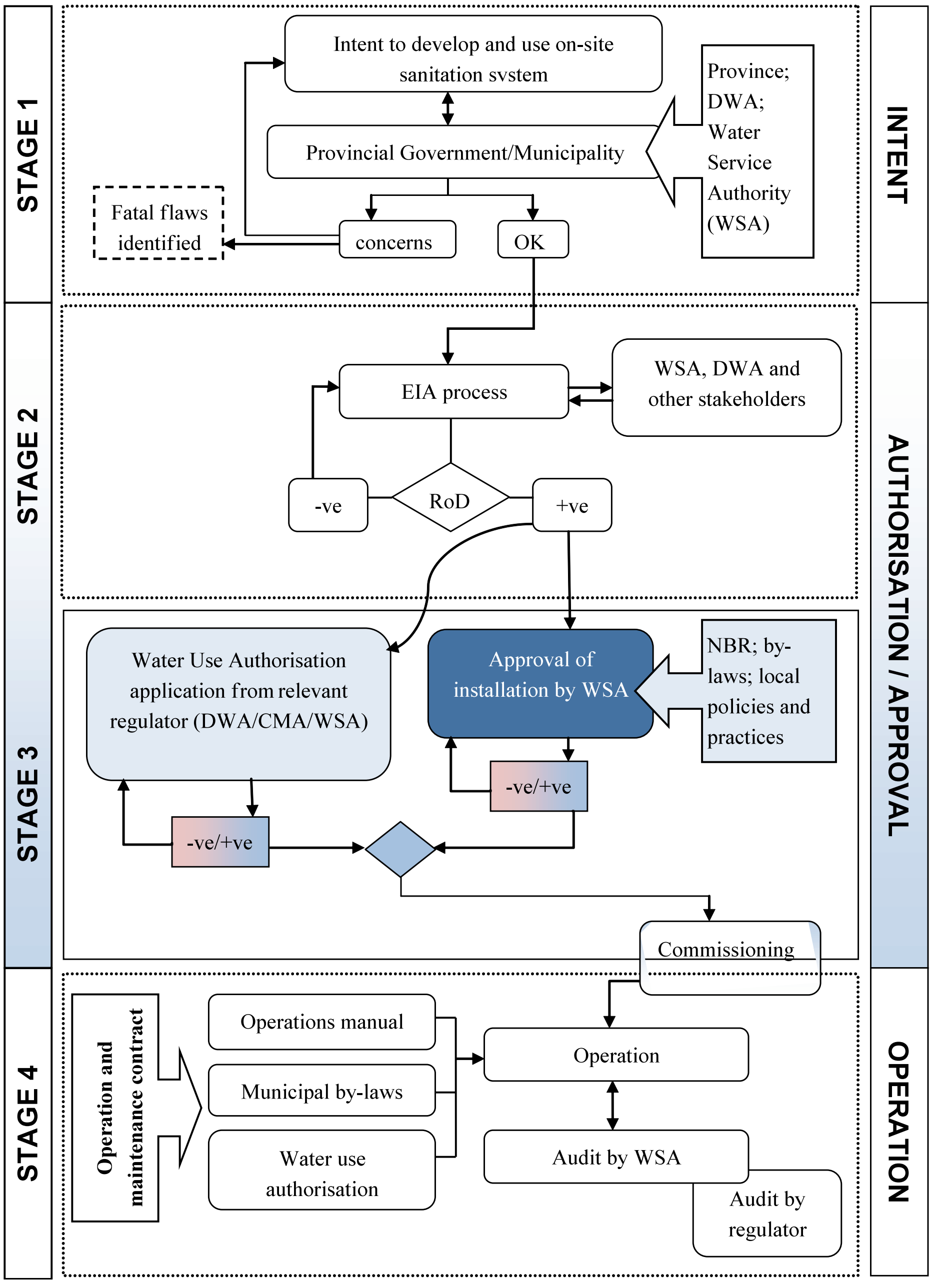
**Table 5: Minimum Requirements that need to be included in the EIA application for Stage 2**

| Parameters to be considered in Stage 2 | | Minimum requirements |
|---|---|---|
| 1. Development | a. Categorisation of the development | i. Categorisation of the development as:<br>• Densely Populated settlement (> 40 houses per hectare);<br>• Upper income development (e.g. golf estate);<br>• School;<br>• Shopping centre (must give an indication of the types of shops expected and what measures will be put in place, e.g. grease/fat traps; chemicals from hairdressers and laundries; increased flows from laundries, etc.)<br>• Fuel station;<br>• Mine/industry/Police camp/prison/hospital residential area;<br>• Holiday resort; |
| | b. Categorisation of package plant | i. Categorisation according to Table 2:<br>• Activated Sludge Plant;<br>• Submerged Bio-Contactors;<br>• Rotating Bio-Contactors;<br>• Trickling Filter Plants;<br>• Membrane bio-reactors<br>ii. At least three package plant alternatives must be presented in the impact assessment. |
| | c. Package plant lifespan | i. Indicate life of plant as per manufacturers specification |

| Parameters to be considered in Stage 2 | | Minimum requirements |
|---|---|---|
| | d. Flow characteristics | ii. Wastewater characterisation in terms of:<br>• Typical loads per person per day (see chapter 6);<br>• Expected diurnal flows;<br>• Expected seasonal flows;<br>• Typical domestic wastewater characteristics (see Table 10) |
| 2. Catchment | a. Catchment specific water quality objectives | i. Water stressed or sensitive catchments;<br>ii. Specific catchment requirements in terms of:<br>• discharge to a resource; or<br>• irrigation of effluent.<br>iii. Cumulative impacts of discharges in the catchment. |
| 3. Disposal | a. Final effluent | i. Storage for reuse; or<br>ii. Irrigation; |
| | b. Sludge | i. Sludge collection by a tanker for disposal to the nearest municipal wastewater treatment works; and<br>ii. Reuse of sludge in accordance with the latest sludge guidelines; especially for beneficial use |
| | c. Disinfection | i. Type of disinfection system in place. |
| 4. Classification | See Appendix A for risk assessment methodology | i. Class of package plant (see tables 8 and 9) |
| 5. Financial guarantee | | i. This will be specific to each WSA and it is up to the owner to get the details of what is required. |

## 4.3 Stage 3 Minimum Requirements

At this stage the developer will have received a positive Record of Decision (RoD). The Municipality must now approve that the installation of the package plant occurs within the required specifications and the conditions set out in the RoD and within the constraints of the National Building Regulations, municipal by-laws, policies and practices.




The WSA will include conditions in the approval. These conditions will include compliance monitoring and reporting requirements on the performance of the package plant


The package plant must have been designed by a suitably qualified and registered person.

**Table 6: Minimum Requirements for Stage 3**

| Parameters to be considered in Stage 3 | | Minimum requirements |
|---|---|---|
| 1. Installation | a. Installation of the package plant | Installation must be according to:<br><br>i. Specifications of the package plant;<br>ii. Conditions of the RoD;<br>iii. National Building Regulations; and<br>iv. Municipal by-laws, policies and practices. |
| 2. Contract | a. Leased/hired with an operation and maintenance contract; or | In all cases the following must be included:<br><br>i. Name of supplier;<br>ii. Name of contractor/sub-contractor;<br>iii. Period (timeframe[2]) of contract; and<br>iv. Conditions of contract that must include that the operation of the plant is in accordance with the RoD, the water use authorisation, the terms and conditions of the Municipal approval and any by-laws, policies or guidelines and relevant provincial ordinances. |
| | b. Purchased by the owner and supplier operates and maintains the plant; or | |
| | c. Purchased by the owner and a sub-contractor undertakes the operation and maintenance; or | |
| | d. Purchased by the owner and the owner undertakes the operation and maintenance, if agreed to by the relevant authority. | |
| 3. Responsibilities | a. Owner[3][4] | i. Get operation and maintenance contract drafted;<br>ii. Understand and sign operation and maintenance contract if 2(a), 2(b) or 2(c); or<br>iii. Employ appropriately |

[2] A 5 year contract is recommended as this will be in line with municipal planning

[3] Owner includes but is not limited to the following: body corporate; school governing body; private owner; shopping complex owner; etc.

[4] It is important that a proper handover is carried out before the developer leaves the property.

| Parameters to be considered in Stage 3 | | Minimum requirements |
|---|---|---|
| | | qualified technician in full-time capacity if 2(d). |
| | b. Supplier | i. Provide training and operational manual;<br>ii. Specifications plate;<br>iii. Sign operation and maintenance contract if 2(a) or 2(b); |
| | c. Contractor/sub-contractor | i. Sign operation and maintenance contract if 2(a) or 2(c); |
| 4. Water use authorisation | a. Water use registration and where required registration and authorisation[5] | i. Contact the relevant DWA Regional Office (or relevant regulator) to discuss which water use authorisation is applicable;<br>ii. Complete relevant water use forms currently available from the web-site: http://www.dwaf.gov.za/Projects/WARMS/default.asp; and<br>iii. Submit application the DWA Regional Office (or relevant regulator). |
| 5. Construction | a. Specification plate<br>b. Controlled access<br>c. Warning signs | i. The specifications plate must contain:<br>• Power usage;<br>• Capacity of plant;<br>ii. The package plant area must have suitable fencing and a lockable gate.<br>iii. Warning signs relating to the hazardous nature of the domestic wastewater must be in several conspicuous places on the fence and gate. |

[5] A water use license will be required if the activity does not fall within the General Authorisations; is a Schedule I activity or is an n Existing Lawful Use (National Water Act, 1998).

| Parameters to be considered in Stage 3 | | Minimum requirements |
|---|---|---|
| 6. Commissioning | a. Calibration<br>b. Testing | i. Calibrate pumps, aerators, disinfection systems<br>ii. Analyse treated water and confirm that discharge limits are achieved<br>iii. Test system for robustness to shock loading |

## 4.4 Stage 4 Minimum Requirements

In this final stage, the main focus is on the operation of the package plant within the conditions/parameters set out in:

- The operations manual;
- The water use authorisation; and
- The municipal by-laws, policies and practices.

Ongoing auditing will be undertaken by the WSA, who in turn will need to furnish the auditing information to the regulator.

The main focus is on the operation of the package plant within the parameters set out in:

- The operations manual;
- The water use authorisation; and
- The municipal by-laws, policies and practices.

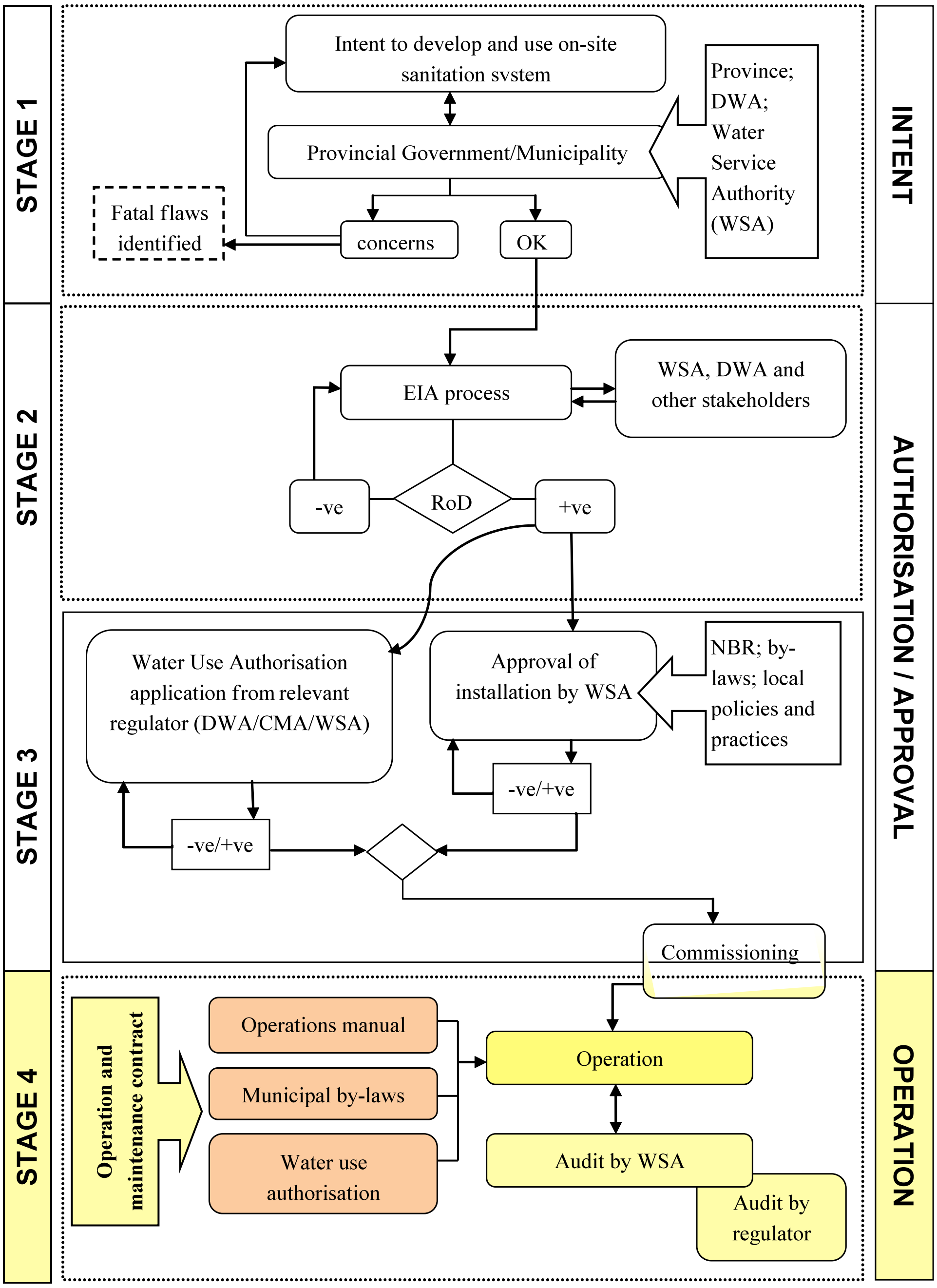

STAGE 1
STAGE 2
STAGE 3
STAGE 4
INTENT
AUTHORISATION / APPROVAL
OPERATION
Intent to develop and use on-site sanitation system
Provincial Government/Municipality
Province; DWA; Water Service Authority (WSA)
Fatal flaws identified
concerns
OK
EIA process
WSA, DWA and other stakeholders
-ve
RoD
+ve
Water Use Authorisation application from relevant regulator (DWA/CMA/WSA)
Approval of installation by WSA
NBR; by-laws; local policies and practices
-ve/+ve
-ve/+ve
Commissioning
Operation and maintenance contract
Operations manual
Municipal by-laws
Water use authorisation
Operation
Audit by WSA
Audit by regulator

**Table 7: Minimum Requirements for Stage 4**

| **Parameters to be considered in Stage 4** | | **Minimum Requirements** |
|---|---|---|
| 1. Operation and maintenance | a. Daily inspection | i. Power is available and is on;<br>ii. Air is flowing (if necessary);<br>iii. Effluent looks and smells clean;<br>iv. Pumps and motors are quiet;<br>v. Pumps and motors are running cool. |
| | b. Maintenance | i. Calibrate equipment every six months<br>ii. Service pumps and aerators as specified in O&M manual.<br>iii. Desludge septic tank as per operation and maintenance manual |
| 2. Compliance monitoring and reporting | a. Monitoring according to water use authorisation and bylaws | i. Qualities;<br>ii. Quantities;<br>iii. Frequency; and<br>iv. Reporting. |

# CHAPTER 5

# 5.0 CLASSIFICATION SYSTEM FOR PACKAGE PLANTS

## 5.1 National Water Act

Section 26 of the National Water Act, 1998 (Act 36 of 1998) allows for the Minister to make regulations that include:

- regulating the design, construction, installation, operation and maintenance of any waterwork[6]; where it is necessary or desirable to monitor any water use to protect a water resource; and
- requiring qualifications for and registration of persons authorised to design, construct, install, operate and maintain any waterwork, in order to protect the public and to safeguard human life and property.

Schedule 3, section 3 of the NWA also makes provision for a Catchment Management Agency to make similar rules to regulate water use.

### 5.1.1 Regulation 2834

Prior to promulgation of the NWA, and in terms of the Water Act, 1956 (Act 54 of 1956) Regulation No. R2834 was promulgated in 1985. These regulations were for the erection, enlargement, operation and registration of water care works. With the promulgation of the National Water Act in August 1998 (Act 36 of 1998) these regulations required updating to comply with both the National Water Act as well as the South African Qualifications Authority (SAQA) Act, 1995 which provides for the implementation of a National Qualifications Framework (NQF). From a legislative perspective however, Regulation No. R2834 is not in contradiction to Section 26 of the NWA and remains in force until such time as the updated regulations are promulgated.

The above-mentioned regulation however, was developed to cater for the municipal owned water and wastewater treatment works and does not necessarily take into account the smaller package plants. In this respect it is recommended that:

- the current update being developed be amended to include package plants; or
- a separate regulation be developed to cater for package plants.

## 5.2 Classification structure

Table 8 sets out the proposed classification structure for package plants and the form in Appendix B can then be used to score a particular package plants. Recognising that domestic wastewater is a potentially harmful substance both to human health and the environment and that the treatment thereof is complex in nature, failure of the treatment process can lead to a severe human health risk as well as an environmental disaster.

In this respect, the parameters listed below need to be taken into account in order to get a good understanding of the type of package plants being installed throughout South Africa and the potential risks associated with their installation and operation. Each parameter is divided into relevant sub-parameters and points are allocated to each sub-parameter based on:

---

[6] Definition of a waterwork i.t.o. the NWA includes *any borehole, structure, earthwork or equipment installed or used for or in connection with water use.*


The risk will increase and hence the classification will be higher if treated effluent is discharged into a sensitive catchment.

- the complexity of operating the sub-parameter;
- the complexity that is introduced because of a parameter (e.g. source of raw domestic wastewater); or
- the potential risk to human health and/or the environment should there be a failure in the system.

The major categories include:

- Site;
- Process parameters; and
- Disposal practice.

The allocation of points is described in Table 8 and the total points scored then places the package plant into a specific Class. Each Class of package plant will then have certain requirements in terms of personnel needed to operate and maintain the package plant.

Points are allocated individually to each sub-parameter based on the potential risk to human and/or environmental health as described below, should there be a failure of the system. Negative points allocated means that measures have been put in place that would reduce the risk to human and/or environmental health and would not have any health or environmental impact should there be a failure of the additional measures put in place.

Table 9 sets out the package plant classification, based on total points scored and the operational requirements.

Appendix A gives details of the points' allocation and the rationale including the various parameters.

Table 8: Classification structure for package plants

| Parameter | | Sub-parameters | Up to 1 000 kℓ/d | 1 001-2 000 kℓ/d |
|---|---|---|---|---|
| ***Site*** | | Residential (including those for mines/industries) | 3 | 4 |
| | | School | 3 | 5 |
| | | Route petrol station | 3 | 4 |
| | | Shopping centre | 3 | 5 |
| | | Lodges/holiday resorts | 3 | 5 |
| | | Mine /Industry Change Houses | 3 | 4 |
| | | Hospitals | 5 | 5 |
| | | Prisons | 4 | 4 |
| ***Process parameters*** | ***Pump station*** | Gravity flow | 1 | 1 |
| | | 1 to 2 pump stations on-site | 3 | 3 |
| | | >2 pump stations on-site | 3 | 3 |
| | ***Preliminary treatment*** | Handraked screens | 1 | 1 |
| | | Automatic screens | 3 | 3 |
| | | Flow balancing | -1 | -1 |
| | | Septic tank (as flow balancing) | 0 | 0 |
| | ***Secondary Treatment*** | | | |
| | *Suspended biomass* | Activated sludge | 3 | 4 |
| | *Fixed film biomass* | Rotating bio-contactors | 3 | 3 |
| | | Submersed bio-contactors | 3 | 3 |
| | | Trickling filters | 3 | 3 |
| | *General* | Anaerobic treatment | 3 | 3 |
| | | Pond systems | 3 | 3 |
| | | Constructed Wetlands | 3 | 3 |
| | ***Tertiary Treatment*** | Maturation ponds | 3 | 3 |
| | | Reedbeds | 3 | 3 |
| | | Sand filters | 3 | 3 |
| | | Disinfection (e.g. Chlorination, ammonium bromide, ozone and UV 1-2) | 4 | 4 |
| | | Desalination/membrane filters | 3 | 3 |
| | ***Solids handling (includes screenings)*** | On-site disposal | 2 | 3 |
| | | Removal by contractor to authorised site | -1 | -1 |

| *Parameter* | | Sub-parameters | Up to 1 000 kℓ/d | 1 001-2 000 kℓ/d |
|---|---|---|---|---|
| | ***Additional Factors*** | Partial to full plant automation | 2 | 4 |
| | | Odour control | -1 | -1 |
| | | Standby power | -1 | -1 |
| | | 24 hour telemetry monitoring | -1 | -1 |
| | | Full time O&M | -2 | -2 |
| ***Disposal practice*** | ***Irrigation*** | Indigenous buffer strips of > 10 m in place | -1 | -1 |
| | | < 10 m or no buffer strips in place | 2 | 3 |
| | ***Disposal/ storage*** | Re-use | -1 | -1 |
| | | Evaporation | 2 | 3 |
| | ***Discharge*** | Listed area | 1 | 4 |
| | | General areas | 1 | 3 |
| ***Total Points*** | | | | |

**Example 2**

A boarding school catering for 200 learners is located in a rural area. Electricity is supplied to the school by the municipality of the small town located approximately 5 kilometres away. However no sewer connection is available so that a package plant was installed. The package plant has a capacity of 50 kℓ and treats approximately 35 kℓ/d. The wastewater flows by gravity to a septic tank before being pumped to the rotating biological contactor (RBC). The effluent from the RBC passes to a small constructed wetland which supports reed growth and two small open water bodies. The school is located in a summer rainfall area where the average rainfall is 562 mm/a and the evaporation rate is 1 351 mm/a. Due to the high evaporation rate and the reed growth, the open water bodies are frequently dry during the winter months. In summer water from the open water bodies is used to irrigate the gardens.

Classification of the package plant:

**Total points scored: 9**

This package plant is classified as a **Class A** meaning that it would have a **low risk** and would require bi-weekly checks on the specifications described in Table 9.

**Table 9: Rating of package plant based on the total number of points scored**

<table>
<tr><th>Total points scored</th><th>Class</th><th>Risk</th><th colspan="3">Minimum Operational requirements i.t.o. staff for operation and maintenance of the package plant</th></tr>
<tr><td>5-15</td><td>A</td><td>Low</td><td rowspan="3">A literate person must do checks on:<br>• power supply[7];<br>• pump stations;<br>• odour and colour of effluent;<br>• solids removal as necessary:<br>- Imhoff cone test/settleable solids primary phase and final effluent; ½ hour test for activated sludge type processes<br>• irrigation system if present;<br>• disinfection system if present;<br>- measure residual chlorine<br>• monthly sludge levels in the septic tank; and<br>• call-out contractor as needed.</td><td>Bi-weekly</td><td rowspan="3">Prior to commissioning a contract for the life of plant or until it is connected to the sewer must be in place for the operation and maintenance of the package plant. The contract must allow for:<br>• monthly inspection of the package plant;<br>• sampling according to Section 6 of this document;<br>• call-out as necessary from the staff member on site; and<br>• maintenance as necessary.<br><br>Daily[8]:<br>• pH;<br>• Electrical conductivity; and<br>• Dissolved oxygen</td></tr>
<tr><td>16-26</td><td>B</td><td>Medium</td><td>Daily</td></tr>
<tr><td>27-36</td><td>C</td><td>High</td><td>Morning and evening</td></tr>
</table>

Notes:

A daily operational checklist is attached as Appendix B and methods for solids determination and residual chlorine measurement is attached as Appendix C.

[7] If power failure is longer than 8 hours then the service provider must be called out to undertake a check on the package plant;

[8] This could be done by the person on site if the owner decides to purchase the equipment

# CHAPTER 6

## 6.0 BEST PRACTICE CRITERIA


The steps outlined below are a guideline on the process to be followed and in no means replaces the need for a detailed design for each individual system.

**It is important that the plant is designed by a suitably qualified person and signed off by a professional engineer.**

The WSA should check the application received against the criteria noted in this section. Since every situation is unique, there will be cases where the application will differ from the criteria. In such cases, the application must include a motivation for change.

It is important that the plant is designed by a suitably qualified person and signed off by a professional engineer.

## 6.1 System location

It is important that the package plant is kept out of the 1:100 year floodline of any water course. Ensure that the plant is easily accessible and can be visited on a daily basis for inspection. In residential estates, it is preferable that the package plant discharges upstream of a water feature in the estate.

It is important that the developer is aware of the local by-laws in terms of building and construction.

## 6.2 System installation

Below ground units, such as septic tanks shall be installed such that:

- The structure is designed to be stable under different groundwater conditions and withstand the uplift forces of a high groundwater level; and
- All inspection covers are above ground and easily accessible.

Above ground units shall be installed such that:

- The plant will be installed on a suitably sized and reinforced concrete slab that will support the weight of the unit when full;
- The plant should have reasonable access to allow operations and maintenance work to be performed;
- The plant should be constructed (supported, jointed, and protected) to avoid the likelihood of damage from superimposed loads or normal ground movement; and
- Access to the site is restricted in order to prevent theft and vandalism.

## 6.3 System specification plate

The system specific plate will ensure that important information such as manufacturer's contact details and design information is easily available if and when required.

Every plant shall have a permanently fixed aluminium plant specification plate (similar to that affixed to electric motors) bearing the following information stamped or printed on it:

- Name and contact details of supplier;
- Year of manufacture;
- Total installed power;
- Power supply requirements (voltage, phase, frequency);
- Design influent flow rate; and
- Design COD and TKN concentrations.

Clearly marked warning sign (e.g. "DO NOT DRINK WATER) must also be included on the equipment and fencing. The warning signs need not be on the system specific plate.

The operational manual will assist the owner in ensuring that the plant continues to meet the requirements that it was design for.

## 6.4 Operation and maintenance manual (O & M)

An O & M manual including at least the following sections must be supplied with the installed plant:

- A system specification sheet containing the following:
  - Date of manufacture;
  - Serial and batch number;
  - Design flow;
  - Power rating;
  - Phase rating;
  - Design influent COD and TKN concentration;
  - Design effluent concentrations in terms of COD, TSS, ammonia, nitrates, phosphorous and faecal coliforms;
  - Disinfection method and dosage instructions;
  - Discharge method for treated water; and
  - Sludge production and disposal.
- A process flow diagram;
- A step-by-step description of how the process operates,
- A description of any limitations the system may have (e.g. what toxic household chemicals should be avoided, exclusion of stormwater from the system);
- A section describing the various operational and maintenance procedures required (e.g. regular checks on pump and blowers, disinfection chemicals, etc.);
- A matrix indicating the frequency of each operational and maintenance procedure;
- A section indicating the monitoring requirements and frequency of sampling/analysis required;
- A table of acceptable discharge limits;
- A "FAQ" (frequently asked questions) section dealing with common questions asked and resolving common misperceptions;
- A troubleshooting matrix;
- Contact details of the supplier;
- A signed copy of the maintenance contract;
- Handover sheets with signed declaration on handover of responsibility; and
- A declaration by the owner that the operational and maintenance procedure was explained and understood.

- Details on mechanical and electrical components of the plant (e.g. pumps, etc.)
- Critical spares list.

> Technologies available at the time of print are presented in this document. New technologies may have become available consequently and must not be ruled out as possible treatment options.

## 6.5 Technology selection

Refer to Section 2.1 for a description of commonly available technologies at the time of print of this guideline.

## 6.6 Capacities

The majority of package plants are designed as modular systems. Each plant will be made-up to the specifications supplied by the consumer. Refer to the best practice design parameters section for criteria for determining the capacity of the plant.

## 6.7 Best practice design parameters

In terms of ease of design, large plants are always much simpler to design than small plants.  There are a number of reasons for this, including:

- The smaller the plant the less likely it will get regular maintenance;
- Components which are small in capacity such as pumps and aerators are more difficult to source, and tend not to be as durable as larger components;
- Piping is difficult to design – a small bore pipe is easily blocked while solids tend to deposit in larger pipes due to low velocities;
- The variance in flows is more acute in a smaller plant – this is one of the most marked problems;
- Disinfection is more difficult for a small flow and it is very difficult to get an accurate dose of disinfectant in a small system; and
- There is less buffering volume in terms of a toxic or inhibitory event.

> The guidelines presented in this document are meant to assist with the design, operation and management of a package plant. Each situation is different and must be designed and approved by a suitably qualified individual.

This document is meant to be a guide to assist with the design of package plants. Each situation will be unique and must be treated as such when proposing a suitable technology.

### 6.7.1 Domestic wastewater quality

It is important to ensure that the quality of the domestic wastewater inflow is properly evaluated. The quality of domestic wastewater is dependent on the source. In the case of office block /supermarket complexes the domestic wastewater quality tends to be stronger than normally expected due to a lack of low COD flows such as bathing and laundry. Total Kjeldahl Nitrogen (TKN) and thus ammonia concentrations are generally very high (100-200 mg N/l) due to the use of "un-flushed" urinals in the toilets.

These high TKNs require special treatment both in terms of process configuration and alkalinity requirements (if the alkalinity is too low, which it generally will be, then the pH will drop below 7 and nitrification will cease, resulting in a high ammonia content effluent).

In most cases the high ammonia domestic wastewater will need to be treated in a two stage aerobic process to achieve full nitrification. The de-nitrification to below 15 mg N/l may well be, without the addition of supplementary COD after nitrification.

The typical flow presented by British and USA guidelines can be useful, but discretion is required when considering lifestyle differences.

It is thus highly recommended that comprehensive sampling be performed at any installation which is not simply a domestic home to check on the COD and TKN concentrations.

Supermarkets and restaurants also tend to have high oils and fats due to the indiscriminate dumping of cooking oil and scrapings down the drains. Experience has shown that if oil/fats enter package plants they will cause serious problems in the process, if not total failure. The grease trap should be specified in terms of the anticipated load and it is the responsibility of the restaurant owner and supermarket owner to install and maintain the fat trap. A three stage septic tank at the head of the package plant would act as a back-up should the grease trap fail. An operational and maintenance manual will be supplied with the grease traps. Copies of this must be included in the operational and maintenance manual for the package plant. The procedures outlined for the maintenance of the grease trap must be adhered to. The accumulated oils and fats will need to be removed from time to time by vacuum tanker for suitable disposal. While the operation and maintenance of the fat trap is the responsibility of the owner of the restaurant, audits on the Package plant should include audits on the fat traps. Agreements must be in place such that if the fat trap is not maintained, the owner is liable for fees incurred for an outside maintenance contract on the fat trap.

In residential estates, a kitchen fat trap is recommended for each household. It is the responsibility of the home owner to maintain this fat trap.

Commercial premises may also suffer from toxicity problems from time to time due to the liberal use of disinfectants in drains to combat odour problems. Adequate balancing upfront of the package plant can help alleviate the problem. All users are to be informed of the risks associated with using toxic detergents.

Typical South African municipal domestic wastewater quality is given in Table 10 below, adapted from Ekama, 1984.

**Table 10: Typical domestic wastewater characteristics for South Africa (DJ Nozaic, 2009)**

| Determinant | Unit | Typical domestic wastewater characteristics |
|---|---|---|
| COD | mg $O_2$/ℓ | 500-700 |
| Suspended solids | mg/ℓ | 200-350 |
| Settleable solids | mℓ /ℓ | 8-10 |
| TKN | mg/ℓ | 35-85 |
| Phosphate | mg/ℓ | 10-13 |
| Ammonia | mg/ℓ | 40-60 |

British Water has prepared a comprehensive table for the sizing of package plants in terms of its Code of Practice document (British Water, 2005).

**Table 11: Typical loads as presented by the British Water**

| Location | Flow (ℓ/pers/d) | BOD (g) | Ammonia as N (g) |
|---|---|---|---|
| **Domestic Dwellings** | | | |
| Standard residential | 200 | 60 | 8 |
| Mobile home type caravans with full services | 180 | 75 | 8 |
| **Industrial** | | | |
| Office/factory without a canteen | 50 | 25 | 5 |
| Office/factory with a canteen | 100 | 38 | 5 |
| Open industrial site, e.g. construction, quarry, without canteen | 60 | 25 | 5 |
| Full time day staff | 90 | 38 | 5 |
| Part-time staff (4 hour shift) | 45 | 25 | 3 |
| **Schools** | | | |
| Non-residential with canteen coking on site | 90 | 38 | 5 |
| Non-residential without canteen | 50 | 25 | 5 |
| Boarding school i) residents | 200 | 75 | 10 |
| ii) day staff | 90 | 38 | 5 |
| **Hotels, Pubs and Clubs** | | | |
| Hotel Guests (Prestige) | 300 | 105 | 12 |
| Hotel Guests (3 and 4 star hotels) | 250 | 94 | 10 |
| Guest (Bedroom only – no meals) | 80 | 50 | 6 |
| Residential Training/conference facilities (including meals) | 350 | 150 | 15 |
| Non-residential conference guest | 60 | 25 | 2.5 |
| Drinkers | 12 | 15 | 5 |
| Holiday camp – chalet residents | 227 | 94 | 10 |
| Resident staff | 180 | 75 | 10 |
| Restaurants – full meals (luxury catering) | 30 | 38 | 4 |
| – full meals (pre-prepared catering) | 25 | 30 | 2.5 |
| – snack bars and bar meals | 15 | 19 | 2.5 |

| Location | Flow (ℓ/pers/d) | BOD (g) | Ammonia as N (g) |
|---|---|---|---|
| – Function rooms including buffets | 15 | 19 | 2.5 |
| – Fast food (roadside restaurants) | 12 | 12 | 2.5 |
| – Fast Food Meal (e.g. burger chain ) | 12 | 15 | 4 |
| Students (Accommodation only) | 100 | 56 | 5 |
| **Amenity sites** | | | |
| Toilet blocks (per use) | 10 | 12 | 2.5 |
| Toilet (WC) (per use) | 10 | 12 | 2.5 |
| Toilet (urinal) (per use) | 5 | 12 | 2.5 |
| Toilet block log stay car parks/lorry parks | 10 | 19 | 4 |
| Shower (per use) | 40 | 19 | 2 |
| Golf club | 20 | 19 | 5 |
| Local community sports clubs | 40 | 25 | 6 |
| Public swimming pools | 10 | 12 | 2.5 |
| Health club | 50 | 19 | 4 |
| Tent sites | 75 | 44 | 8 |
| Caravan sites i) Touring not serviced | 100 | 44 | 8 |
| ii) Static not serviced | 100 | 44 | 8 |
| iii) Static fully serviced | 180 | 75 | 8 |
| **Hospitals and Residential Care Homes** | | | |
| Residential old age homes/nursing | 350 | 110 | 13 |
| Small hospitals | 450 | 140 | Assess |
| Large hospitals | Assess | | |

Where actual sampling is not conducted in a programmed manner, then the domestic wastewater concentration should be taken as the upper limit of the range indicated above. If an unusual domestic wastewater is suspected, it is important to obtain a sample of domestic wastewater from a similar source and evaluate the quality in terms of a minimum of Chemical Oxygen Demand (COD), Total Kjeldahl Nitrogen (TKN) and Total Phosphate (TP). The size of the reactor vessels will then need to be adjusted accordingly.

### 6.7.2 Domestic wastewater flow rates

Any domestic wastewater treatment plant operates optimally under steady flow and load. The smaller the domestic wastewater collection system feeding a plant, the more marked flow spikes and diurnals will be. This is well documented. Where the characteristics of the flow is uncertain, and suspected to be unusual it is imperative to evaluate the flow regime, either of the facility in question, or a similar one.

Measuring actual domestic wastewater flows is a difficult and not particularly pleasant job, and a simpler method is to measure the potable water supply to the facility by means of the water meter supplying the facility. The meter should be read hourly for 24 hours on a typical usage day and the flow per hour calculated. The results can then be evaluated to determine the volume of the balancing or equalisation tank.

As a general rule an equalisation tank of 12 hours holding capacity should be installed. Where a two stage septic tank of total hydraulic retention time of 24 hours precedes the plant, then the second compartment can serve as the holding tank. Three stage tanks are preferred.

In the case of normal domestic accommodation, the minimum volumes of wastewater generated should be calculated as in Table 12.

**Table 12: Typical wastewater flow estimates for full waterborne systems**

| Description | Sewage Flow (ℓ/day)[9] |
|---|---|
| **Low income group:** | |
| Per dwelling unit | 500[10] |
| Per person | 70 |
| **Middle to upper income group:** | |
| Per person | 160 |
| Per dwelling unit | |
| 2 bedrooms | 750 |
| 3 bedrooms | 900 |
| 4 bedrooms | 1 100 |
| 5 bedrooms | 1 400 |
| 6 bedrooms | 1 600 |

For higher volume domestic installations such as boarding schools, hostels or hotels, a per capita volume of 110 l/day has been suggested. However, volumes should be established from similar institutions, and should be validated against water use according to the supply meter (sewer return being in the range of 70-90% depending on the degree of gardening or washing down of driveways, etc. taking place).

If a reduced flow is used in some unusual application, then the flow must be fully substantiated to the applicable authority and documented in the O&M manual.

[9] An allowance of 15% for stormwater infiltration and other contingencies should be incorporated in the design figures used for dwelling houses

[10] 500 have been assigned due to the uncertainty with respect to the number of persons per dwelling.

The following guidelines have been incorporated from the British and USA guidelines. These can be used as a guide, but discretion is required to account for the different lifestyles and per capita consumptions.

**Table 13: Typical flow measurements for units other than households**

| Type of establishment | Unit | Daily sewage flow (ℓ/unit) |
|---|---|---|
| Airports | Passenger | 10 |
| Bar | Customer | 8 |
| Boarding houses | Person | 110 |
| Non-resident guests at boarding houses | Person | 23 |
| Cocktail lounges | Seat | 70 |
| Country clubs | Visitor | 370 |
| Day Schools | Pupils | 37 |
| Department Stores | Employees | 40 |
| Dining halls | Meals served | 30 |
| Drive-in theatres | Car space | 9 |
| Factories | Worker per shift | 140 |
| Hospitals | Bed | 500 |
| | Employee | 40 |
| Hotels without private bathrooms | Person | 110 |
| Hotels with private bathrooms | Person | 140 |
| Motels | Bed | 90 |
| Offices | Employees | 70 |
| Restaurants | Person | 20 |
| Fuel Service Stations | Person | 10 |
| Theatres | Seat | 10 |
| Camp sites or caravan parks with central bathhouse | Person | 90 |
| Shopping centres | Employees | 50 |


Ideally, typical flows must be measured where possible. This guideline serves as a guide for situations where actual measurements are not possible.

### 6.7.3 Flow Equalisation Tank

Since flows are highly variable through the day it is important to install a flow equalization tank. This usually takes the form of a 12 hour retention tank from which the domestic wastewater is fed to the plant at a constant rate using a pump.

The flow equalization tank can often take the form of a three stage septic tank. Refer to section 6.7.5 for sizing of septic tanks. This is ideal in that the first compartment usually retains most of the debris and grit in the domestic wastewater, ensuring that it does not reach the pump that feeds the aerobic treatment section.

Aspects such as diurnal flows and plug flow of chemicals (hairdressers or laundries in a shopping complex) must be considered when sizing the flow equalisation tanks. Sufficient dilution is required in the case of a hairdresser or laundry. In the case of peak flows resulting from shift workers, the equalisation tank must be able to accommodate the flow from a single shift (e.g. 12 hour balance tank for 8 hour shift operation)

### 6.7.4 Screening

Screenings are a problem in all domestic wastewater treatment plants with major implications in terms of pipe and pump blockages. As the flows diminish and pipe sizes are reduced the problems become more exaggerated. It is thus important to remove as much debris as possible. The international trend is towards the use of fine screens (5 mm) even in large plants, as the savings in maintenance costs are significant.

Septic tanks appear to provide an excellent form of screening and de-gritting, but where these are not fitted it is essential to provide some form of screening to prevent blockages and pump breakages. This is even more crucial where the system is serving a communal building where unusually large amounts of debris are often deposited into the toilet (e.g. rags and plastic packets). Systems using screens will require high maintenance and a suitable disposal method for the screenings.

Traditional bar screens such as those found on small conventional wastewater works are not particularly suitable in many applications as they require daily cleaning, and may cause odours. Signage and training of people using the ablution facilities and septic tanks upstream of the package plant is recommended.

> It is important to evaluate the package plant system as a whole. A suitable qualified individual may be able to motivate for variations in the volume of septic tank required for a treatment process.

### 6.7.5 Septic Tanks

SANS 52566-1:200 specifies the requirements for pre-fabricated septic tanks for the partial treatment of domestic wastewater for a population not exceeding 50.

The design parameters for septic tanks preceding package plants are simple and can, for the purposes of this report, be condensed to a minimum of one day's hydraulic retention time, split into a minimum of two equal sized chambers. Three chamber septic tanks are preferred.

The volume of the septic tank may be determined as follows (DJ Nozaic, 2009):

> For larger systems, 12 hour flow retention may not be practical. A motivation by a suitably qualified person is required to address such situations.

[illegible]=[illegible] [illegible]+0.1*[illegible]

Where:

V = volume in $m^3$

Q = flow per capita per day in $m^3$

S = years between desludging (maximum of 10 years allowed).

P = contributing population

It is also advisable to consider building a simple anaerobic baffled reactor (ABR) which gives enhanced COD reduction for the same space requirement. Obviously this is highly desirable as the lower the COD reaching the aerobic stage the less the organic load and the better the performance. For cases where balancing is required, a larger final storage chamber will be required for the ABR.

### 6.7.6 Activated Sludge

Activated sludge is an excellent technology for domestic wastewater treatment, providing a good quality effluent if properly designed constructed and operated.

The chief problems incurred with activated sludge are maintaining the correct sludge age; and preventing solids carryover from the secondary clarifiers.

*Activated sludge plant*

Carryover of solids from the clarifier is a big problem in activated sludge and needs to be controlled in two ways. The mixed liquor concentrations must be maintained in the correct range by careful control of sludge wasting, and flow peaks must be eliminated as far as possible. The reason for this is that the solids-liquid separation in the clarifier is a difficult one due to the small density difference between the two phases due to the activated sludge floc comprising mainly water.

Thus settling is slow and upflow rates have to be limited. This is largely achieved by having an equalisation tank upfront, and the feed pump being controlled by a variable speed drive (VSD).

Activated sludge plants can be preceded by a septic tank, the advantage being that screenings are well removed, and the anaerobic process will remove up to 50% of the COD with minimal solids yield, thus lowering the COD entering the activated sludge plant and reducing the sludge wasting. The septic tank also serves to attenuate flows.

Simple design parameters for activated sludge are given in Table 14.

**Table 14: Activated sludge design parameters.**

| Sludge Age (days) | Sludge loading rate (kg COD applied per day per kg MLSS)* | Recommended sludge density (mg MLSS/ℓ) |
|---|---|---|
| **30** | 0.154 | 5 000 |
| **25** | 0.174 | 4 400 |
| **20** | 0.200 | 3 900 |
| **15** | 0.242 | 3 500 |
| **10** | 0.312 | 3 300 |
| **5** | 0.506 | 3 200 |

The reactor volume ($V_r$) in $m^3$ can then be calculated as:

$$V_r = \frac{M_t}{X}$$

Where: $M_t$ = Total mass of sludge required (kg); and

X = Recommended sludge consistency ($kg/m^3$)

The sludge age is usually 20 days or greater in order to ensure the sludge is properly stabilised, and will not cause a fly or odour problem while drying.

The volume of sludge to be wasted on a daily basis is the volume of the reactor divided by the sludge age (when wasting from the reactor). When wasting from the return sludge line, the volume is calculated as follows:

$$Volume\ wasted = \frac{Volume\ of\ reactor * MLSS}{Sludge\ age * RSS}$$

Where: RSS = Concentration of sludge in return sludge

One of the biggest problems in activated sludge is the management of the sludge, which is either dried on drying beds or dewatered by mechanical means. A novel method is the use of Bidem or similar synthetic sacks to pump the sludge into, capturing the solids, but allowing the water to pass through.

A simple means of simplifying the sludge handling problem is to switch off the aeration and feed pump and allow the sludge to settle for say an hour or two. During this time the sludge concentration at the base of the reactor should concentrate approximately five fold, meaning that the wasting volume can be reduced by a factor of 5.

An alternate method would be to add a simple clarifier to the system. Allow the solids to settle and waste the thickened sludge while the supernatant may be recycled in the system.

**Worked example**

Consider an activated sludge system with a reactor dimension of 5 m x 5 m x 4 m and a settler volume of 18 $m^3$. Calculate the volume of:

a) Un-thickened sludge to be wasted per day to achieve a 25 day sludge age

b) Un-thickened sludge to be wasted per week day (i.e. 5 days a week) to achieve a 25 day sludge age

c) Thickened sludge to be wasted per day to achieve a 25 day sludge age

d) Thickened sludge to be wasted per week day (i.e. 5 days a week) to achieve a 25 day sludge age

e) Thickened sludge to be wasted once a week to achieve a 25 day sludge age

*Answer*

Generally the settler contains a negligible amount of sludge which means that it can be neglected in the calculations. The reactor sludge volume is then calculated as:

Reactor volume = length x breadth x depth
= 5 m x 5 m x 4 m
= 100 $m^3$

The sludge volumes to be wasted can then be calculated as follows:

a) *Daily sludge volume to be wasted* = sludge volume of reactor / 25[11]

---

[11] The defined sludge age in days

| | |
|---|---|
| | = 100 $m^3$ / 25 days<br>**= *4 $m^3$ /day*** |
| b) *Weekday sludge volume to be wasted* | = 4 $m^3$/day X 7 / 5<br>***= 5.6 $m^3$/weekday*** |
| c) *Daily thickened sludge volume to be wasted* | = 4 $m^3$ /day / 5[12]<br>***= 0.8 $m^3$ /day*** |
| d) *Weekday thickened sludge to be wasted* | = 0.8 $m^3$ /d x 7 / 5<br>***= 1.12 $m^3$/weekday*** |
| e) *Once weekly thickened sludge to be wasted* | = 0.8 $m^3$ /d x 7<br>***= 5.6 $m^3$/week*** |

The above calculations (a-e) show the advantage to be gained by allowing the sludge to settle before wasting. The example also gives the volumes for wasting for weekdays once a week. The latter is useful in that wasting is probably the most important operating function and can be done by a more skilled person who visits the plant weekly. This is ideal as the aeration must be switched off with the feed pump. The sludge wasting may well be risky in the hands of an un-skilled labourer, particularly when the aeration and feed pump need to be switched off simultaneously.

To determine the exact sludge thickening factor fill a 1 litre volumetric cylinder to the 1 000 mℓ mark with well aerated mixed liquor and leave for 1 hour. Measure the volume of the sludge at the end of the hour and then divide 1 000 by the settled volume.

If the sludge to be wasted above is to be dried on drying beds then a once weekly wasting scenario is also an advantage in that fewer beds are required. A typical scenario would be as follows:

| | |
|---|---|
| Sludge volume to be wasted once weekly | = 5.6 $m^3$/week |
| Initial drying bed depth of sludge | = 0.3 m |
| Required area of bed | = 18.7 $m^3$ |
| Bed dimensions | = 3 m x 6.2 m |

The following guidelines can be used to determine the number of drying beds required:

- In a dry, highveld, climate the bed will take about five days to dry, and can then be cleared and left to "air" for a day or two before the next use – so theoretically one bed may be enough. However if it rains for a number of days or there is a labour problem, then one gets behind in wasting and can't catch up. Thus an extra bed is needed.
- At the coast rain can be experienced daily for a week and the humidity is often high. This can result in a bed taking two weeks to dry in inclement weather and thus two beds will be sufficient. However, if the weather remains wet for a month then capacity may run out so it is advisable to have a third.

[12] The factor by which the sludge generally thickens

- Where it rains frequently it is advisable to have the drying beds under a waterproof shelter to prevent the sludge from re-wetting and smelling.

Greater efficiencies can be obtained in clearing drying beds if they are either paved or the sand covered with shade-cloth. When paving drying beds, the bricks used should have holes through them (e.g. the normal 3-hole type). Reject face-bricks are excellent for this use as they are harder. The holes through the bricks should be in the vertical plane with sand swept into them until they are filled. A little extra sand is then raked over the brick surface. Cement pavers are totally unsuitable for this use as they do not have holes through them and their pores blind rapidly.

Where shade cloth is used to cover the sand the dried sludge can be "shaken" into the centre of the cloth and then dragged to a disposal point.

Drying beds should wherever possible be placed on a north facing slope.

The return sludge flow rate from the clarifier should be the same as the peak inflow rate. Flow equalization will thus decrease the pumping capacity needed.

The oxygen requirement for COD removal and nitrification must be calculated separately. The oxygen requirement for COD removal depends upon the sludge age, and is shown in

**Table 15: Oxygen requirements to achieve nitrification in activated sludge**

| Sludge Age (days) | Sludge loading rate (kg COD applied per day per kg MLSS) | Dissolved oxygen required for COD oxidation (kg $O_2$.kg/COD removed)* |
|---|---|---|
| **30** | 0.154 | 0.84 |
| **25** | 0.174 | 0.82 |
| **20** | 0.2 | 0.79 |
| **15** | 0.242 | 0.73 |
| **10** | 0.312 | 0.65 |
| **5** | 0.506 | 0.53 |

The oxygen requirement for nitrification is simpler to calculate, being 4.5 mg $O_2$ per 1 mg ammonia as N nitrified. It is also important to note that nitrification consumes alkalinity as it generates nitric acid. For every 1 mg as N ammonia that is nitrified 7 mg of alkalinity as $CaCO_3$ is consumed. If de-nitrification takes place half of this is recovered.

It is important to realize that the pH will drop with nitrification, especially in soft waters, and this will inhibit further nitrification. When this occurs slaked lime must be added to compensate for the alkalinity loss. The simplest way of achieving this is to flush a calculated amount of slaked lime down the toilet once or twice a week in the case of small plants. For larger plants slaked lime can be added daily into the reactor.

**Worked example:**

Domestic wastewater from an office block and shopping centre enters an aerobic treatment plant (all technologies have the same alkalinity requirements) with an alkalinity of 200 mg $CaCO_3$/l, a TKN of 155 mg N/l, and an ammonia of 70 mg N/l. A final effluent alkalinity of 80 mg/l is recommended to protect the concrete work and keep the pH stable. Is there sufficient alkalinity in the domestic wastewater, and if not how much slaked lime will need to be added to the influent per day if the flow is 100 $m^3$/day. Assume that total nitrification and de-nitrification takes place.

*Answer*

Ammonia entering a works is only part of the total nitrogen which is given by the TKN – thus one only uses the TKN in calculations. If only ammonia figures are available then double them to get an approximate TKN value.

| | |
|---|---|
| Alkalinity consumed in nitrification | = 155 mg N/l x 7<br>= 1 085 mg $CaCO_3$/l |
| Alkalinity returned by de- nitrification | = 155 mg N/l x 3.5<br>= 542.5 mg $CaCO_3$/l |
| Net requirement for alkalinity | = 1 085-542.5 mg $CaCO_3$/l<br>= 542.5 mg $CaCO_3$/l |
| Alkalinity available in domestic wastewater | = 200 mg/l |
| Alkalinity shortfall | = 542.5-200 mg $CaCO_3$/l<br>= 342.5 mg $CaCO_3$/l |
| Alkalinity required | = 342.5 + 80[13] mg $CaCO_3$/l<br>= 422.5 mg $CaCO_3$/l |
| Slaked lime addition required<br>mg $CaCO_3$/l | = 422.5 x (74/100)[14]<br>= 312.6 mg/l slaked lime |

So far the mass (mg) of slaked lime per litre has been calculated – this now needs to be converted to kilograms per 100 $m^3$ or kilograms per day. This is done as follows:

Slaked lime needed per day (100 $m^3$/d) = 312.6 mg/l x 100 $m^3$/d x 0.001[15]

= 31.3 kg/d

Slaked lime is calcium hydroxide and should be handled with care. Agricultural lime, which is calcium carbonate, cannot be used as it does not readily dissolve. Slaked lime is available at most builders' merchants. The total amount of lime can be added in one daily dose, or a slurry fed into the reactor over a day.

[13] Residual alkalinity required to protect concrete structures and stabilize alkalinity

[14] Conversion from mg$CaCO_3$/l to $Ca(OH)_2$

[15] 0.001 is a conversion factor to give kg/d

Aeration of activated sludge can be achieved through surface aeration, or submerged aeration. Surface aerators tend to be more robust and simple to install and are easily removed for repairs using a crane if necessary on bigger plants. They are also available in floating or fixed configuration – the fixed configuration gives better energy efficiency, but requires extra construction to give a solid mounting point.

Submerged aeration is neater in terms of aesthetics than surface aeration and is also quieter if radial blowers are installed in a sound proof blower room. They require very little maintenance apart from air-filter changes, while surface aerators often require the gearbox oil level to be checked which can be difficult in the case of a floating aerator. Submerged aeration is generally more complicated to install, but the air supply is useful for air-lift pumping operations such as the return activated sludge.

Aeration equipment performance is usually specified in terms of kg $O_2$ /kWh, which allows one to calculate the power of the aeration equipment. There are however adjustments which need to be made for motor efficiency, alpha factor (related to impurities in domestic wastewater such as salts and detergents) and beta factor (related to altitude, temperature and residual dissolved oxygen). Care must also be taken with submerged aeration to consider the path length of the bubbles through the domestic wastewater (i.e. the depth of the domestic wastewater).

Clarifier design must be carried out with much care, and a conservative attitude should be adopted as carryover of solids is detrimental to the quality of the final effluent, giving high suspended solids and COD. Problems will also be experienced in disinfection as the result of increased chlorine demand from the organics and the shielding of bacteria within flocs.

Few package plant clarifiers will have motorized sludge scrapers. In view of this, the walls must not be less than 60 degrees to the horizontal for the sludge to slide/fall to the bottom of the clarifier. The walls should also be as smooth as possible, with concrete structures being painted, after thorough sanding with a carborundum block, with epoxy type paint to reduce the roughness.

The inlet to the clarifier must be carefully designed to prevent short circuiting of the sludge to the weir. It is usual to have a stilling chamber in the centre of the clarifier which reduces the turbulence of the mixed liquor being fed into the clarifier. This stilling chamber should extend below the surface of the water in the tank to approximately one third of the total depth of the tank. It is important to minimise turbulence in the clarifier to ensure good settling.

Care should be taken in designing the weir to ensure that it can be properly levelled to prevent short circuiting. Where an annular ring pipe is used always have the holes on the outside of the pipe in order to capture debris on the inside of the ring and thus prevent blocking.

The most important design parameter for clarifier design is not to exceed 1 m/h upflow rate at peak dry weather flow. Solids flux loadings should not exceed 8 kg.$m^2$/h. Should either of these two parameters be exceeded it is likely that clarification will fail, solids carryover will occur and the effluent quality will fail.

Submersible pumps or airlift pumps can be used for the recycling of the return activated sludge.

### 6.7.7 Rotating Bio-contactors

These are plants in which the aerobic treatment takes place on disks arranged on a central shaft which rotates in a bath of domestic wastewater. The shaft remains above the surface of the domestic wastewater, and thus only about 40% of the disk surface is in the domestic wastewater at any one time. The disks vary in diameter between 1 and 3.5 m and rotate at 1 to 5 rpm.

A bio-film is formed on the disk as it rotates and this contains the organisms required to treat the domestic wastewater. As the disk rotates through the domestic wastewater it picks up a film of domestic wastewater and aerates it as it passes through the air. When the bio-film growths too thick the inner layer dies off due to a lack of nutrients and it "sloughs" off. The bio-film has an aerobic layer on the outside, but this becomes anoxic as one goes deeper into the layer due to a lack of dissolved oxygen. The disks are usually made of fibreglass or polyethylene. Some contemporary designs comprise a large cylindrical cage filled with packing as found in bio-towers.

With proper design rotating bio-contactors can remove COD, ammonia and denitrify. They usually have some kind of fibreglass or plastic cover which is prone to damage from veld fires, so it is wise to surround the plant with a few meters of stone chips to prevent it going up in smoke. It must also be ensured that the cover is well ventilated to ensure that sufficient oxygen is present.

The wetted area is shown as a function of influent and effluent COD in Figure 8.

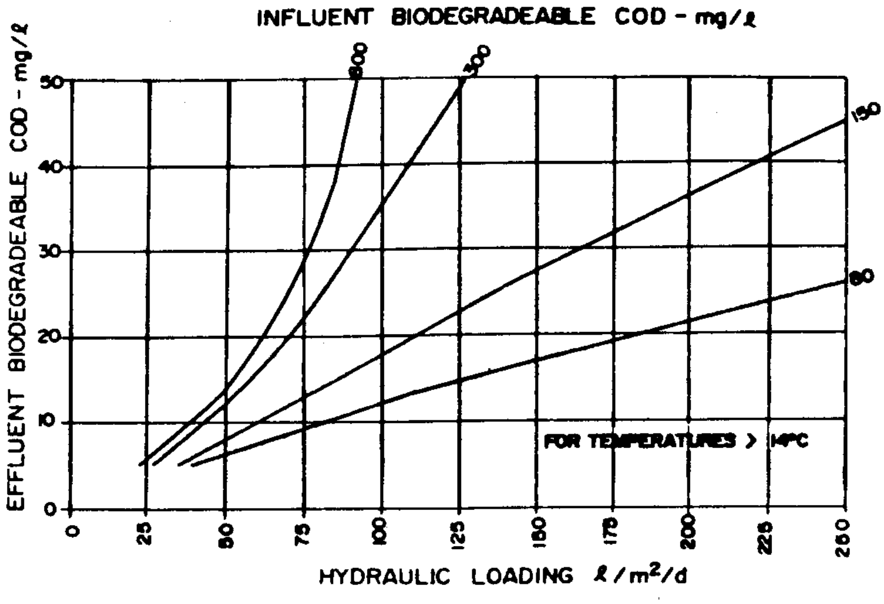



Figure 8: COD removal curves

*Rotating bio-contactor*

Rotating bio-contactors have been shown to perform significantly better when staged in series, i.e. one after the other. If more than 2 stages are used then the wetted surface area can be reduced, as shown in Table 16.

**Table 16: Correction factor for staging**

| No. of stages | Correction Factor |
|---|---|
| 3 | 0.95 |
| 4 | 0.90 |
| > 4 | 0.86 |

When using staging, the load on the initial stages can become very high, causing odours. Due to this an organic loading of 100g biodegradable COD/m$^2$/day should not be exceeded.

Nitrification will only take place once the COD of the domestic wastewater has been reduced to 25 mg/l. If sufficient alkalinity is present to ensure that the pH does not go lower than 7 (for alkalinity requirement see the relevant discussion under activated sludge) then **Figure 9** can be used for design to remove ammonia.

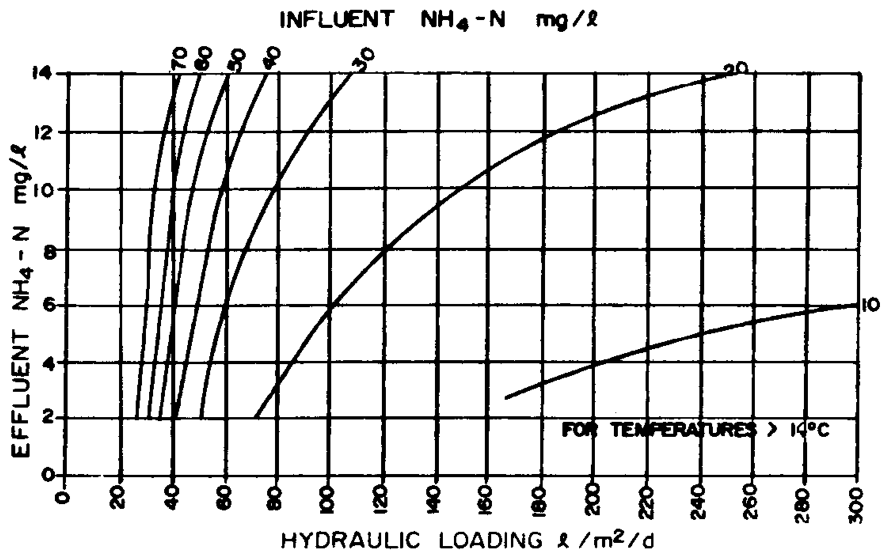



**Figure 9: Nitrification parameters in rotating bio-contactors.**

The above design criteria are for a steady state system, i.e. constant flows. In view of the diurnal flow of domestic wastewater the following correction factors should be adopted.

**Table 17: Correction factor for diurnal**

| Population | Correction factor |
|---|---|
| 400 | 1.3 |
| 400-1500 | 1.3-1.1 |
| 1500-5000 | 1.1-1.0 |

The above design parameters work well in the temperature range of 14-30 °C. If colder temperatures are experienced then the correction factors provided in Table 18 should be adopted.

**Table 18: Correction factors for low temperature**

| Temperature (°C) | Correction factor |
|---|---|
| 14 | 1.00 |
| 12 | 1.05 |
| 10 | 1.15 |
| 8 | 1.30 |
| 6 | 1.40 |

Rotational speed of the disks is usually between 1 and 5 rpm. Little improvement in treatment has been observed at higher speeds, but the power consumption is somewhat higher.

The settling tank after the bio-contactor is designed using criteria for a humus tank. Where a Dortmund type tank (no mechanical scraper) is used then the design parameters in Table 19 should be adopted.

**Table 19: Dortmund tank design parameters**

| **Upward velocity at average dry weather flow** | **≤ 1 $m.h^{-1}$** | **Use whichever gives the larger surface area** |
|---|---|---|
| Average velocity at peak dry weather flow | ≤ 1.5 $m.h^{-1}$ | |

Table 19 data was formulated assuming that any recycle will take place from the bio-contactor trough back to the septic tank, or from the bottom of the clarifier to the septic tank. If the recycle is from after the settling tank then the recycle must be added to the normal flow. Recycling from the settling tank to the septic tank means that drying beds and conventional desludging of the settling tank is not needed as the solids are removed to the septic tank where they are treated anaerobically. Such a recycle is imperative for de-nitrification.

For a flat-bottomed scraped settling tank the design parameters are provided in Table 20. Recommendations are made assuming that any recycle will take place from the bio-contactor trough back to the septic tank, or from the bottom of the clarifier to the septic tank. If the recycle is from after the settling tank then the recycle must be added to the normal flow. Recycling from the settling tank to the septic tank means that drying beds and conventional desludging of the settling tank is not needed as the solids are removed to the septic tank where they are treated anaerobically. Such a recycle is necessary for denitrification.

**Table 20: Flat bottomed scraped settling tank parameters**

| **Retention period of peak dry weather flow plus recirculated flow** | **≤ 1.5 m/h** | |
|---|---|---|
| Upward velocity at average dry weather flow plus recirculated flow | ≤ 1 m/h | Use whichever gives the larger surface area |
| Average velocity at peak dry weather flow plus recirculated flow | ≤ 1.5 m/h | |

The recycle needed for denitrification should be in a ratio of 3:1 to the average dry weather flow. Denitrification halves the alkalinity requirement for nitrification which is desirable. Where necessary, slaked lime should be added to boost the alkalinity.

### 6.7.8 Submerged bio-contactors

Submerged bio-contactors are normally preceded by a septic tank which provides a screening and degritting role, as well as lowering the COD markedly while producing little biomass due to the nature of anaerobic digestion. The final chamber of the septic tank can also be used as an anoxic reactor for nitrification.

# CHAPTER 6

*Submerged bio-contactor*

Few design criteria are available in the references commonly used by the authors. These include the "Manual on the design of Small Domestic wastewater Works" and Metcalf and Eddy (Tchobanoglous & Burton, 1979). This paucity of "recognized" design criteria makes it difficult to design these plants on anything other than empirical data. It also makes it difficult to check the design if a plant does not operate satisfactorily.

There are advantages of using submerged bio-contactors over trickling filters, especially for small scale plants. These are:

- Distribution of the influent is not a problem as it is in trickling filters;
- The media always remains submerged thus eliminating the problem of "drying out" under no flow or low flow conditions; and
- Forced aeration makes it simple to ensure that sufficient oxygen is supplied.

In activated sludge it is well known that for nitrification to occur the dissolved oxygen concentration must be maintained above 2 mg/l. In submerged bio-contactors this alone does not produce nitrification. The efficiency of nitrification depends on the organic loading. When a bio-film forms there are both heterotrophs (COD removers) and nitrifiers (ammonia removers), the nitrifiers tend to attach themselves onto the heterotrophic biofilm, because the heterotrophs grow much faster at higher COD loading rates the nitrifiers become overgrown and nitrification ceases (EPA Technology Fact Sheet 9, USEPA, 2000a).

This is fairly well documented in the literature, and was confirmed with Ekama (1984).

The EPA in their Technical Fact Sheet for trickling filter nitrification (USEPA, 2000b) give a range of organic loadings for plastic media biofilters which will provide 75 to 85% nitrification. These are summarized in Table 21.

**Table 21: Organic loading rates to ensure nitrification**

| Loading rate basis | Loading rate requirement |
|---|---|
| Loading rate based on BOD | 192-288 g BOD/m$^3$/day |
| Loading rate based on COD | 295-443 g COD/m$^3$/day |

* based on BOD = 0.65 x COD

A critical assumption which needs to be made here is that the specific area (m$^2$/m$^3$) of the packing quoted in the EPA document is the same as that used by the local manufacturers. This is considered to be a valid assumption in that the most commonly used packing in the local SBCs would be ideal for use in trickling filters.

As nitrification is temperature dependant, the more conservative loading rates should be used in cooler climates (minimum monthly average domestic wastewater temperature <18°C) to ensure nitrification.

The pH is also extremely important, and should be maintained above 7. A pH level under 6.5 can result in nitrification failure. Since nitrification causes the pH to drop it must be carefully monitored. Slaked lime is used to maintain a suitable pH and can be added once or twice a week, either by flushing it down the toilet, or into the septic tank, depending on the size of the plant and thus the amount of lime (see the discussion on lime addition in the activated sludge section).

Where the effluent is to be discharged to a water body a recycle from the outlet of the aeration tank (or the base of the settling tank – where fitted) back to the final compartment of the septic tank must be instituted to achieve de-nitrification. This has the added advantage of recovering half the alkalinity lost in nitrification, and hence halving the addition of slaked lime. The recycle ratio should be 1:1 with the average dry weather flow.

Where high TKN domestic wastewaters are to be treated the SBC should be designed with two tanks in series to enhance nitrification in the second tank due to the lower COD loading in the that reactor.

The SBC systems all use submerged aeration, or air entrainment via a pumped venturi, which is essentially the same. The air supply for submerged aeration can have a number of forms, e.g. diaphragm pump, vein pump, or a blower radial or rotating lobe.

Of great importance with submerged aeration systems, both for SBCs and activated sludge, is the depth of submersion of the aerator panel, sock, or venturi return. The deeper the reactor the greater the depth of liquid through which the oxygen bubbles pass and the lower the amount of air required. Conversely, the shallower the liquid the shorter the bubble path, and the more the air required.

It is thus advantageous in these systems to have reactors with the maximum possible depth.

When bio-film breaks off the packing material there are one of two routes it can go. The one route is to settle to the base of the reactor where it will continue to digest both aerobically (and thus increasing oxygen demand) and, depending on the reactor design, anaerobically (where a thicker layer forms the underneath sludge will turn anaerobic). The other route is that the solids can leave the reactor with the effluent. Which particular route a particle takes will depend on its size: large particles will tend to settle, while smaller particles will tend to be lifted upwards by the bubble stream and leave the reactor in the final effluent.

The “stray” solids give rise to two important design elements:

- An outlet should be fitted to the base of the aerobic reactor to allow the accumulated solids to be drained out from time to time, and returned to the septic tank inlet; and
- The treated solids exiting the aerobic reactor need to pass through a settling tank in the case of larger flows, while that exiting smaller units should pass through a sieve type screen which will retain the solids (1-2 mm mesh). This sieve will need to be cleaned on a weekly basis. If the sieve is housed in the chlorine contact tank it should not make contact with the chlorinated effluent in the tank. Any solids in a chlorine contact tank will exert a high chlorine demand which will result in no chlorine being available for disinfection (an analogous situation occurs when the leaf catcher in a swimming pool is left full of leaves – the organics absorb all the chlorine, and the algae thrive, turning the pool green much to the owners astonishment as he adds more and more chlorine).

# CHAPTER 7

## 7.0 OPERATIONAL REQUIREMENTS

This section sets out the minimum requirements for operating a package plant. Should the WSA in your area have by-laws for package plants, it is important to note that the stricter of the two must be complied with.


A **water quality monitoring programme** must include at least:

- Treated waste water at the point it leaves the package plant;
- Up and downstream of any discharge to a water resource; and
- At points up and downstream of an irrigation area if irrigation takes place within 100 m of a water resource.

## 7.1 Monitoring

A water quality monitoring programme needs to be set up and should include at least the following monitoring points:

- Treated waste water at the point it leaves the package plant;
- Up and downstream of any discharge to a water resource; and
- At points up and downstream of an irrigation area if irrigation takes place within 100 m of a water resource.

### 7.1.1 Water quality monitoring

Proposed water quality monitoring requirements for the disposal of the treated wastewater as irrigation; or discharge to a water resource are set out in Table 22 and include specific volumes.

Column 2 of Table 22 sets out the requirements for irrigation volumes of less than 2 000 $m^3$/d. The ammonia value of 6 mg/ℓ ammonia is greater than the 3 mg/ℓ set out in Section 2.7 (a)(i)(d) of the General Authorisations gazetted on the 26 March 2004 (Gazette No 26187) or amendments thereof. The reason for the 3 mg/ℓ in the General Authorisations is not understood as the amounts of nitrate and ammonia added through the application of irrigation water are usually small compared to that which is applied as fertilizer or released by the mineralisation of organic matter. Being an anion, nitrate is only very weakly absorbed by the soil exchange complex (which is mainly a cation exchanger) and its movement in the soil is considered to be unaffected by exchange reactions. Therefore, nitrates leach freely while ammonia takes part in normal cation exchange reactions. Its movement in the soil profile is largely determined by exchange reactions, and leaching of the ammonium ion occurs very seldom under normal conditions. It is therefore recommended, that the value of 6 mg/ℓ be adopted.

### 7.1.2 Sample analysis

Sample analysis must be conducted by an accredited laboratory or a laboratory that uses standard methods[16] and has adequate quality control.

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[16] ***Note:*** *Analyses must be carried out in accordance with methods prescribed by and obtainable from the South African Bureau of Standards in terms of the Standards Act. Act 30 of 1982, or an accepted method prescribed by standard methods of the American Water Works Association, or the Environmental Protection Agency or by other standard methods of comparable accuracy related to the above methods.*

### 7.1.3 Frequency of monitoring

Grab samples must be taken monthly in all cases.

### 7.1.4 Quantities disposed

The quantity of the treated wastewater disposed of must be metered daily and the daily totals recoded weekly in all cases.

### 7.1.5 Record keeping

All sampling analysis records must be kept and a 6-monthly report containing details of the following must be submitted to the responsible authority:

- quantity of treated wastewater disposed of;
- quality of treated wastewater disposed of; and
- failures or malfunctions in the system and details of actions taken to rectify the problem.
- Daily logs as per Table 9 must be kept and condensed in a monthly format.


**Record keeping** must include at least:

- *quantity* of treated wastewater disposed of;
- *quality* of treated wastewater disposed of; and
- *failures or malfunctions* in the system and details of actions taken to rectify the problem.

**Table 22: Treated wastewater quality monitoring requirements**

| Constituent (mg/ℓ unless stated) | Irrigation volumes ($m^3$/d)# | | | Additional requirements** | | Discharge to a water resource ($m^3$/d) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **<2 000** | **<500** | **<50** | **1** | **2** | **Not listed** | **Listed** | **Not listed** | **Listed** | **Not listed** | **Listed** |
| | | | | | | **10-100** | | **100-1 000** | | **1 000-2 000** | |
| Faecal coliforms (FCU/100 mℓ) | <1 000 | <100 000 | <100 000 | 1 000 | 0 | <1 000 | 0 | <1 000 | 0 | <1 000 | 0 |
| Chemical Oxygen Demand (COD) | <75 | <400 | < 5 000 | 75* | 30* | - | - | < 75 | <30 | < 75 | <30 |
| pH (pH units) | 5.5-9.5 | 6-9 | 6-9 | 5,5-9,5 | 5,5-7,5 | 5.5-9.5 | 5.5-7.5 | 5.5-9.5 | 5.5-7.5 | 5.5-9.5 | 5.5-7.5 |
| Ammonia (as N) | 6[17] | - | - | 6 | 6 | - | - | <6 | <2 | <6 | <2 |
| Nitrate/Nitrite as N | 15 | - | - | 15 | 1,5 | - | - | - | - | 15 | 1.5 |
| Chlorine as free chlorine | 0.25 | - | - | 0,25 | 0.25 | - | - | - | - | 0.25 | 0 |
| Suspended solids | 25 | - | - | 25 | 25 | - | - | 25 | 10 | 25 | 10 |
| Electrical conductivity (mS/m) | <70 above intake to a max of 150 | <200 | <200 | 70 mS/m above intake to a maximum of 150 mS/m | 50 mS/m above background receiving water, to a maximum of 100 mS/m | <70 above intake to a max of 150 | <50 above background receiving water to a max of 100 | <70 above intake to a max of 150 | <50 above background receiving water to a max of 100 | <70 above intake to a max of 150 | <50 above background receiving water to a max of 100 |
| Ortho-phosphate as P | 10 | - | - | 10 | 10 | - | - | - | - | 10 | 1 (med)<br>2.5 (max) |
| Fluoride | 1 | - | - | 1 | 1 | - | - | - | - | - | - |
| Soap, oil or grease | 2.5 | - | - | 2,5 | 0 | - | - | - | - | - | - |
| SAR for biodegradable industrial wastewater | - | 5 | 5 | | | - | - | - | - | - | - |

*after removal of algae;
# crop production and includes the cultivation of pasture; Crops not for grazing, but utilised as dry fodder; Crop cultivated for seed purposes only; Tree plantations ; Any park or sportsfield only during development; Parks, only for beautifying flowerbeds, traffic islands, etc., i.e. not a recreation area; sports fields where limited contact is made with the surface, e.g. golf courses, cricket, hockey and soccer fields, etc.
** 1: refers to crops not eaten raw, cultivation of cut flowers; fruit trees (flood irrigation); crops not for grazing; crops for milk producing animals;
2: refers to crops consumed raw; school gardens/lawns; childrens playgrounds;

[17] Refer to section 7.1.1 for recommendation regarding change from 3 mg/l to 6 mg/l

# CHAPTER 8

## 8.0 CHECKLISTS

The objective of the checklists is to ensure that the MRs described in Tables 3, 4, 5 and 6 are adhered to. Three checklists have been developed:

- Regulators checklist;
- Operational checklist; and
- Handover of package plant checklist.

## 8.1 Regulators Checklist

Even though the Water Use Authorisation may fall within the mandate of the National Water Act, since all developments fall within a municipal area it is important that the WSA takes ownership of the process to ensure that the final product has limited impact on both human health and the environment within its jurisdiction. The checklist set out in Table 23 sets out questions that the regulator should ask at the different stages.

**Table 23: Regulators checklist**

| Questions to be asked at each stage | Y/N |
|---|---|
| **Stage 1: Permission/zoning** | |
| Has an adequate motivation for the use of a package plant been given? | |
| Is the property correctly zoned? | |
| Is the proposed development within an exclusion area? | |
| **Stage 2: Environmental Impact Assessment** | |
| Has the development been categorized? (for example school, residential, etc.) | |
| Has the package plant been categorised? | |
| Are the flow characteristics clearly stated? | |
| Are the catchment specific water quality objectives stated? | |
| Are the disposal methods for the treated wastewater and sludge clearly described in terms of volumes, quality and re-use options? | |
| Has the package plant been classified in terms of Appendix A? | |
| Has the design been signed off by a professional engineer? | |

| Questions to be asked at each stage | Y/N |
|---|---|
| Is the financial guarantee adequate? | |
| **Stage 3: Installation** | |
| Is the package plant being installed to specifications; | |
| Is a specifications plate visible and does it contain adequate information? | |
| Have all RoD conditions been met? | |
| Is an operation and maintenance contract in place? | |
| Is there an operational manual in place? | |
| Does the Operator* have adequately trained technicians? | |
| Is the relevant water use authorisation in place and does the Operator* understand the volume and quality requirements that must be met? | |
| Is there controlled access? | |
| Are there adequate warning signs? | |
| Were the mechanical equipment calibrated? | |
| Was the installation signed off by a professional engineer? | |
| **Stage 4: Operational** | |
| Is the Operator* taking adequate samples to test whether the system is working to specifications and is achieving water quality specified? | |
| Has the regulator taken samples to check compliance? | |
| Has the WSA taken samples for auditing purposes, i.e. in accordance with by-laws? | |

*Operator in this case does not refer to an individual but rather the contractor/company/individual in place to undertake the operation and maintenance for the package plant.

## 8.2 Operational Checklist

The operational checklist is for use by the Operator of the package plant and should be undertaken with the operational specifications for the package plant. This checklist could also be used by the regulator for auditing purposes.

| Performance Area | | Aspects to consider | **Notes** (use a separate page if necessary) |
|---|---|---|---|
| 1 | **Mechanical assessment** | • mechanical equipment<br>• maintenance schedule and implementation | |
| 2 | **Final effluent** | • looks and smells good<br>• results are recorded<br><br>*Note:* take a final effluent sample at this time and send to an independent laboratory for analysis; do field tests as appropriate (e.g. residual chlorine using DPD tablets) and interpret the results once received; | |
| 3 | **Biological systems** | • attached growth media (e.g. stones, disks) is in good condition and does not have a bad smell; dissolved oxygen<br><br>• activated sludge – mixed liquor looks good and smells earthy; dissolved oxygen | |
| 4 | **Good house-keeping** | • areas around unit processes are kept clean and tidy;<br><br>• the plant area, including chemical storage areas, is bunded | |
| 5 | **Disposal of solids** | • screenings, detritus and sludge are correctly disposed of in accordance with relevant authorisation | |
| 6 | **Paper work** | • water use authorisation is in place and conditions stipulated are implemented;<br>• contracts for sludge disposal are in place; | |
| 7 | **Safety issues** | • apply common sense, such as, covers to couplings are in place and the power supply is in a secure box | |

## 8.3 Handover of Responsibility Checklist

It is important to note that the package plant owner is ultimately responsible for ensuring that the conditions of the Water Use Authorisation and Record of Decision in terms of the operation of the package plant are met. It is therefore important to ensure that a proper handover of information takes place during a change of ownership. This may not necessarily form part of a purchase and sale agreement, for example, in the case of a development, the developer will transfer ownership to the responsible entity (e.g. Home Owners Association, Body Corporate) once the construction of the development is completed and a home owner association has been formed.

| **Aspects to consider during handover** | | **Yes/No** |
|---|---|---|
| Approval from the WSA | Has the package plant been authorised by a WSA? | |
| | Have the conditions set out by the WSA been met? | |
| Design integrity | Was the design signed off by a professional engineer? | |
| | Was the installation signed off by a professional engineer? | |
| Operations manual | Is there an operations manual available? | |
| | Are the instructions in the operations manual clear? | |
| Record of results | Has the previous owner saved a record of results? | |
| | Is the package plant meeting the specified discharge standards? | |
| Operation and maintenance contract | Is there an operation and maintenance contract in place? | |
| | What is the period of the contract? | |
| Declaration of ownership | Has the declaration of ownership been signed by the package plant owner? | |
| | Is the package plant owner aware of the responsibilities in terms of the RoD; Water Use Authorisation and relevant by-laws? | |

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# APPENDIX A

## Risk Assessment Methodology for Package Plant Classification

# APPENDIX A

## *Process of points' allocation*

Risk is a concept that denotes the precise probability of specific eventualities. Technically, the notion of risk is independent from the notion of value; and as such, eventualities may have both beneficial and adverse consequences. However, in general usage, the convention is to focus only on potential negative impact to some characteristic of value that may arise from a future event.

Risk assessment is the evaluation and ranking of potential hazards based on estimated frequency and intensity, and then determining a margin of safety. In other words risk assessment must include:

- An event;
- The probability that the event will occur; and
- The impact it will have if it happens.

In terms of a quantitative risk assessment, the assessment could be based on probability of occurrence; consequence of occurrence; intensity of the impact; and significance level of the risk posed.

*Probability of occurrence* describes the likelihood of the impact actually occurring and may be indicated as:

- Improbable, i.e. the likelihood of the impact is very low;
- Probable, i.e. there is a definite possibility of the impact occurring;
- Highly probable, i.e. it is very likely that the impact will occur; and
- Definite, i.e. where the impact will occur regardless of any management measure.

Consequence of occurrence describes:

- The nature of the impact;
- The extent of the impact; such as whether the impact will be local, regional, national or across international borders; as well as on the sensitivity of the receiving environment;
- The duration of the impact, i.e. whether the impact will be:

  - short term (<5 years);
  - medium term (6-15 years);
  - long-term (the impact will cease after the operational life of the activity); or
  - permanent; where mitigation measures by natural processes or human intervention will not occur.

*Intensity of the impact* describes the magnitude of the impact on the natural, cultural and social functions and processes.

*Significance level of the risk posed* then signifies the combination of these factors. It is determined through a combination of the probability of occurrence and consequence of occurrence. Significance points (SP) can be determined by using the formula below and the ranking scales set out below.

| ***SP = [magnitude (M) + duration (D) + scale (S)] x probability*** |
| --- |

where the maximum value of significance points (SP) is 100.

**Risk ranking scales**

| PROBABILITY = P | DURATION = D |
|---|---|
| 5 – Definite / don't know<br>4 – High probable<br>3 – Medium probability<br>2 – Low probability<br>1 – Improbable<br>0 – None | 5 – Permanent<br>4 – Long-term (ceases with operational life)<br>3 – Medium-term (6-15 years)<br>2 – Short-term (0-5 years)<br>1 – Immediate |
| **SCALE = S** | **MAGNITUDE = M** |
| 5 – International<br>4 – National<br>3 – Regional<br>2 – Local<br>1 – Specific to the site<br>0 – None | 10 – Very high / Don't know<br>8 – High<br>6 – Moderate<br>4 – Low<br>2 – Minor |

This will then aid in the prioritisation of risks and the implementation of risk management.
Risk can therefore be rated as either high (H), moderate (M), or low (L) on the following basis:

| Point scored | Risk description | Points allocated for classification |
|---|---|---|
| > 80 | Extreme | 6 |
| 61-80 | high | 5 |
| 51-60 | Medium to high risk | 4 |
| 31-50 | medium | 3 |
| 20-30 | Medium to low risk | 2 |
| <20 | low | 1 |

## Rationale for including classification parameters

In all cases the classification of the package plant was based on consequence of failure in terms of both human and environmental health.

The sensitivity of the environment into which the treated wastewater will be disposed includes:

- Low sensitivity – such as where treated wastewater is irrigated; discharge to evaporation ponds;
- Medium sensitivity – such as a discharges to a water resource where special standards[18] are not required; and
- High sensitivity areas – such as special standard areas or where a receiving water quality standard is prescribed; and estuaries.

[18] Special standard refers to the special limit values set out in General Authorisations, Gazette No 26187, 26 March 2004

# APPENDIX A

It is often erroneously thought that because the package plant is small, treating small volumes of domestic wastewater, the risk to human health is small. However, it is very important to note that domestic wastewater is potentially hazardous to human health and the risk increases where a wastewater treatment works is in close proximity to a residential development.

Appendix B sets out the risk matrix that was used to determine the allocation of points.

## Site

Sites will vary; from a residential estate to a prison or hospital. Complete failure of the package plant on the particular site, in relation to the potential human health impacts due to spillage of raw domestic wastewater on the site will therefore also vary. It is important to understand the risk associated with failure at each site.

## Process parameters

The process parameters include those aspects that are important in the actual physical infrastructure used in the treatment of the raw domestic wastewater.

## Pump station

Pump stations are vital where domestic wastewater has to be pumped from one area to the package plant or from the package plant to a collection facility. Pump stations are high risk areas that are often not adequately designed to contain spills in the event of a power failure or pipeline blockage.

Where gravity flow is used the points allocated are based on the low likelihood of gravity flow failure.

Where  or more pump stations are included, points allocated are based on the assumption that there is a possibility/probability of failure when pump stations are in place, and depending on the site, will have a low, moderate or severe impact on human and environmental health.

### *Preliminary Treatment*

Preliminary treatment may include processes such as screens which may be automated or hand raked and flow balancing. This stage may therefore also include the removal and disposal of screenings in a responsible manner that will not cause odours and fly breeding or encourage other pests such as rodents.

Where hand raked screens are in place, points are allocated on the assumption that there would be a low likelihood of failure and even if failure did occur then the consequence of failure would be low.

Where automatic screens are in place, points are allocated on the assumption that there is the possibility of failure (e.g. due to power cuts) and that the consequence of failure would be low to moderate.

Flow balancing is especially important in these small systems as the flows are extremely variable. If some form of flow balancing is not included then the loading to the package plant will also be variable and cause the system to fail or work sub-optimally. Points are allocated according to the complexity of the primary treatment.

### *Secondary Treatment*

Secondary treatment will be classified according to types of package plants indicated below:

- Suspended biomass;
- Activated sludge;
- Fixed film biomass;
- Rotating bio-contactors;
- Submersed bio-contactors;
- Trickling filters;
- General;
- Anaerobic treatment;
- Pond systems; and
- Constructed Wetlands.

Points are allocated based on the possibility/probability that failure will occur at some stage for various reasons such as a power failure. However, this failure is only of the secondary process and not the complete plant.

### *Tertiary Treatment*

Depending on the method of disposal, tertiary treatment may be needed and the following methods are included in the classification system:

- Maturation ponds;
- Reedbeds;
- Sand filters;
- Disinfection (e.g. Chlorination, ammonium bromide, ozone and UV 1-2); and
- De-salination/Membrane filters.

Points are allocated based on the assumption that the primary and tertiary processes are still in working order, so that failure of the disinfection process will have a limited impact.

### *Solids handling (includes screenings)*

As mentioned above, screenings generated by the inlet works of the package plant will need to be disposed of responsibly to prevent human health, aesthetic and environmental impacts. Disposal may be either on-site disposal or removal by contractor to an authorised site.

Sludge disposal is limited at these small works however, where sludge is produced and needs to be disposed of, it is important that it is disposed of according to the current sludge guidelines or that a contract is in place with a service provider to collect and dispose of the sludge to an authorised wastewater treatment works. Failure to do this could result in a low to moderate impact on the community.

### *Additional Factors*

Additional factors that may make the process more complex include but are not limited to:

- Partial to full plant automation;
- Odour control;

- Standby power; and
- 24 hour telemetry monitoring.

Automation requires additional skills, especially where the whole plant is automated. Failure therefore, could result in low to severe impacts depending on the volume being treated.

Additional measures put in place to reduce the potential risk of failure therefore also reduce the impacts on the community and are therefore allocated negative points.

## Disposal practices

Where irrigation is practiced it is important to have buffer strips in place. Vegetated buffer strips containing, especially indigenous vegetation, absorb run-off from the irrigated areas therefore preventing run-off entering surface water resources.

Treated wastewater should be seen as beneficial and not a waste and should reused as possible and not necessarily only for irrigation but also for example as process water in industry; especially in areas where the evaporation rate is high.

Listed areas are those areas in which stricter receiving water quality objectives have been set and in which the special standards or stricter standards would apply whereas the general areas are those areas in which the general standard may apply. Table 22 sets out the standards applicable to the various uses.

# APPENDIX B

## Daily operational checklist

# APPENDIX B

**DAILY OPERATIONAL REQUIREMENTS CHECKLIST**

| Day | Flow meter reading | Daily volume | Odours | Visual (colour of final effluent) | Power supply | Settleable solids | 1/2 Hour test for activated sludge type processes | pH (pH units) | Electrical Conductivity (mS/m) | Dissolved oxygen (mg/) | Residual chlorine (mg/l) | Pump station/(s) are working | Irrigation system (in working order) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | |
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| Day | Flow meter reading | Daily volume | Odours | Visual (colour of final effluent) | Power supply | Settleable solids | 1/2 Hour test for activated sludge type processes | pH (pH units) | Electrical Conductivity (mS/m) | Dissolved oxygen (mg/) | Residual chlorine (mg/l) | Pump station/(s) are working | Irrigation system (in working order) |
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# APPENDIX C

## Methods

# APPENDIX C

| Test | You will need | Method | Notes/precautions |
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| **pH** | • Portable pH meter with glass electrode;<br>• Temperature compensation probe;<br>• Buffers: pH 7 and pH 10;<br>• mℓ beaker / 250 mℓ honey jar; and<br>• Distilled water in a wash bottle. | • Remove the cap from the pH electrode and rinse the electrode thoroughly with distilled water;<br>• Give one gentle shake to dislodge water droplets and dab dry;<br>• Place both probes in the buffer 7 solution;<br>• Standardise and calibrate to pH 7 according to the meter instructions;<br>• Rinse electrode with distilled water;<br>• Place in pH 10 buffer solution and standardize to 10 according to meter instructions;<br>• When the reading stabilises again remove the probes, rinse and dab dry;<br>• Rinse the beaker at least 3 times and fill with sample;<br>• Insert the electrodes and read pH, allowing reading to stabilize;<br>• Rinse and dab dry the electrode, rinse the electrode cap and put in a few drops of buffer 7 solution before replacing the cap on the electrode. | • Keep buffers at or near room temperature for accurate calibration;<br>• Be careful not to contaminate buffer solution;<br>• Rinse electrode well before and after readings and gently dab dry with a clean paper towel; and<br>• NEVER touch the electrode bulb. |
| **Dissolved Oxygen** | • Dissolved oxygen meter; and<br>• Water for washing. | The procedure and control settings may vary for different makes of instrument. The general principles are as follows:<br>• Switch on the meter and check that batteries are in good condition;<br>• Keep probe moving gently in air and read temperature;<br>• From temperature and barometric pressure (some instruments have a barometer built in, others require a separate barometer) read off the saturated (equilibrium) concentration in mg/ℓ of oxygen in water;<br>• Calibrate the instrument in air to the equilibrium concentration;<br>• Place probe in effluent and ensure that there is a gentle flow past it or keep it moving gently;<br>• Read off the DO in the effluent once the reading has stabilized; and<br>• Rinse probe with clean water and store according to instructions. | Dissolved oxygen is a useful indicator of the adequacy of aeration in the activated sludge process. Less than 0.5 mg/ℓ indicates inadequate aeration; 1.0-2.5 mg/ℓ normally indicates that aeration is suitable; and greater than 3 mg/ℓ indicates excessive aeration. |
| **Conductivity** | • Conductivity meter; | **Preparation of standard:** (*Reference Solution 0.01 M Potassium* | The conductivity of an effluent is a |

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| | • Potassium chloride (KCl) (AR grade); and<br>• Distilled water. | *Chloride)*<br><br>Dissolve 0.7456 g of anhydrous potassium chloride in water, making up to 1 litre with distilled water. Store in a glass-stoppered borosilicate glass bottle. This solution has a conductivity of 141.2 mS/m at 25°C.<br><br>• Place electrode probe into the reference solution in a beaker. Adjust calibration to the correct reading of 141.2 mS/m. If necessary, when meter uses µs/cm on its scale, convert as described below;<br>• Rinse electrodes thoroughly with distilled water;<br>• Immerse the cell in the sample. Allow to stabilise and record the result;<br>• Rinse the cell in distilled water between samples to avoid contamination. Shake to remove internal droplets and wipe outside prior to immersion in the next sample.<br><br>For short-term storage, immerse cell in distilled water to keep the plate wetted. For long-term storage, rinse cell in deionised water, wipe exterior and store dry.<br><br>To correct the reading to mS/m the following factors should be applied:<br><br>• *µS range – divide by 10 for mS/m; and*<br>• *mS range – multiply by 100 for mS/m.* | measure of its ability to conduct an electric current and is defined as the reciprocal of the resistance of the solution. This ability depends on the ions in solution, their concentrations (total and relative), mobility, valence and temperature of measurement. Measurements are made using a conductivity meter.<br><br>Conductivity increases as temperature increases and, strictly speaking, should be measured at 25°C. However, for our purposes the errors are not significant. The normal unit of conductivity in SI units is millisiemens/metre (mS/m). |
| **Settleable Solids** | • Imhoff cone (plastic with stopper);<br>• Glass rod; and<br>• Stand. | An Imhoff cone is filled to the litre mark with a well-mixed sample, placed in a suitable stand, and left for approximately 45 minutes. At the end of this period, any deposit on the sides of the glass is dislodged as gently as possible, either by spinning the cone or using a glass rod, so that it settles into the apex of the cone. After a total of one hour the volume of sludge in the apex is read off in mℓ. The result can be expressed as mℓ settleable solids per ℓ of sample. | The term *settleable solids* refers to the amount of solid matter that will settle in a given time. The determination is a simple test and indicates how much sludge will settle out in the primary sedimentation tanks. It is carried out in Imhoff cones. |
| **Sludge volume** | • 1000 mℓ measuring cylinder | The SVI is the volume occupied by 1 g of activated sludge after settling for 30 minutes in a 1 000 mℓ measuring cylinder. | The sludge volume index (SVI) provides the information on both |

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| **index (SVI) for activated sludge** | | SVI = V/X (mℓ/g)<br>Where:<br>V = settled sludge volume in mℓ in a 1 000 mℓ measuring cylinder; and<br>X = mixed liquor concentration (g/ℓ). | the settling and thickening properties of the sludge.<br><br>A good settling sludge will have an SVI of about 100 mℓ/g or less. SVIs in the 200 to 300 mℓ /g levels can cause settling problems in clarifiers. Adequate oxygen supply is one of the important factors in ensuring a good settling sludge. |
| **Free, Combined and Total Chlorine** | • Lovibond 2000 Comparator;<br>• 2 x 10 mℓ moulded cells<br>• Comparator discs (340/A 0.1-1.0 ppm; and 340/S 1.0-4.0 ppm);<br>• Glass rod<br>• DPD No. 1 tablets for free chlorine;<br>• DPD No. 3 tablets for combined chlorine;<br>• DPD No. 4 tablets for total chlorine (free + combined); and<br>• Distilled water. | • Ensure the cell walls are clean and free from dust or grease;<br>• Place one cell, containing the sample into the left hand compartment of the comparator. This is the sample blank;<br>• Rinse out the other cell twice with distilled water and then 3 times with the sample;<br>• Fill cell with 10 mℓ of the sample and add one DPD tablet to the cell by popping it straight from the foil. DO NOT touch the tablet. (Use No.1 for free chlorine, No. 3 for combined or No. 4 for total chlorine);<br>• Rinse off the glass rod with pure water and shake off excess droplets before crushing the tablet;<br>• Take care not to break the bottom of the cell (support it on a flat surface during crushing of the tablet and stir with rod);<br>• Swirl to mix and allow to stand for 2 minutes;<br>• Shield the comparator away from any direct light, i.e. no sun behind you and face north or south and read immediately; and<br>• Use the comparator discs provided (Lovibond 340/A and 340/S) to read the correct colour match.<br><br>This is recorded as free, combined or total chlorine depending on which tablet was used. | This test has been described using Lovibond equipment. There are other kits available such as HACH, which produce equally good results.<br><br>• Always rinse the cells and glass rod well with distilled water and sample, before and after testing, to avoid contamination;<br>• Keep a fresh supply of distilled water for this purpose;<br>• DO NOT handle the tablets at all; and<br>• DO NOT leave the sample standing before or during the procedure except where developing colour. |