DEPARTMENT OF WATER AFFAIRS & FORESTRY

CODE OF PRACTICE: VOLUME 6

WASTEWATER REUSE

- **Greywater**
- **Reclaimed Domestic Effluent**
- **Industrial Effluents**

(July 2012)

CONTENTS

DEFINITIONS

General:

aquaculture:	Raising of plants or animals in water (water farming);
aquifer:	A water-bearing geological formation from which water can be abstracted;
black water:	Water that contains significant concentrations of excreta;
brine:	Term commonly used to describe effluent (see "effluent");
cyst:	Environmentally resistant infective parasitic life stage (e.g. *Giardia, Taenia*);
dam:	(a) A barrier or structure constructed across or next to a water course that impounds or holds back water flowing in that watercourse; or (b) A specific dam declared by notice under section 129(1)(b) to be a dam with a safety risk;
disinfection:	Inactivation of pathogenic organisms using chemicals, radiation, heat or physical separation processes (e.g. membranes);
domestic use:	The use of water for household purposes, including drinking, cooking, washing, watering a household garden and watering animals for reasonable own use;
drip irrigation:	Irrigation system that delivers drips of water directly to plants through pipes, without contacting plant surfaces that are above ground. Generally uses less water and prevents water contact with crop surfaces and humans;
effluent:	Liquid waste originating from domestic, industrial, agricultural or mining activities that has been treated in a wastewater treatment facility and released into the environment in a dam, an evaporation pond, an aquifer, a river, the sea or onto the surface of the ground;
excreta:	Faeces and urine;
flood irrigation:	Irrigation system that distributes water using gravitational flow of water to wet and infiltrate the soil resulting in flooding. Flood irrigation can be used for irrigation of crops with wastewater only when the flood water level is lower than above ground crop surfaces;
grey water:	Water that has been used for washing, laundering clothes, showering and/or bathing, which does not contain significant concentrations of excreta;
groundwater:	Water - (a) occurring naturally below the surface of the ground; or (b) pumped, diverted or released into a cavity for storage underground;
log unit reduction:	Log unit pathogen reductions are $\log_{10}$ unit reductions defined as $\log_{10}$(initial pathogen concentration/final pathogen concentration). Thus, a 1 log unit reduction = 90% reduction; a

	2 log unit reduction = 99% reduction; a 3 log unit reduction = 99.9% reduction, etc.
meteoric water:	Water that precipitates from the atmosphere;
multi barrier process:	Process that is designed to inherently contain fail-safes and back-up systems to ensure that the specified product quality is achieved at all times;
sewer:	Pipe or conduit which is used for the conveyance of sewage or industrial effluents;
spray irrigation:	Irrigation system that uses overhead high-pressure sprinklers or nozzles to distribute water. Water distributed in this way comes into direct contact with plant surfaces that are above ground;
waste:	Includes sewage and any matter or substance, whether wholly or partly in solid, liquid or gaseous state, which if added to water may cause the water to be polluted;
wastewater:	Water containing waste;
watercourse:	a) A river or spring, including the base flow of an ephemeral river at the time of no visible purpose flow; b) A natural channel in which water flows regularly or intermittently; c) An estuary, wetland, lake or dam into which, or from which, water flows; (d) Any collection or body of water declared under section 5(s)
water resource:	The whole or any part of a watercourse or an aquifer and includes the sea and meteoric water;

<u>Chemical</u>:

BOD:	Biodegradable Oxygen Demand = measurement of oxygen utilised by microorganisms during oxidation of organic material contained in wastewater.
CFU:	Colony Forming Units = measurement of viable bacterial or fungal numbers, usually expressed as cfu/mL.
COD:	Chemical Oxygen Demand = measurement of the amount of oxidisable organic matter, *viz* the amount of oxygen required to convert all organic carbon constituents to CO_2 and H_2O.
TC:	Thermotolerant Coliforms = group of bacteria whose presence in the environment usually indicates faecal contamination, previously called faecal coliforms;
TDS:	Total Dissolved Solids = measurement of the combined content of all dissolved inorganic and organic substances contained in a liquid
TSS:	Total Suspended Solids = measurement of the combined content of all non-dissolved substances contained in a liquid

1. INTRODUCTION

Namibia is an arid country and the Water Resources Management Act, 2004 (Act No. 24 of 2004) therefore also encourages the reuse of suitably treated effluent. Treated wastewater can and should be reused in order to protect valuable natural water resources and this guideline addresses the use of greywater and treated domestic and industrial effluents for reuse in industrial, agricultural and aquacultural applications. However, it is important to realize that there is a certain risk to the general public coupled to wastewater reuse and carelessness can lead to widespread public health hazards, water borne diseases and can even result in epidemics and fatalities.

When dealing with recovered wastewater emphasis must be placed on continuous monitoring and safe use thereof, especially where treated wastewater ultimately comes into direct contact with humans, or plants and animals consumed by humans, in order to guarantee public health and safety at all times. Wastewater irrigation, for example, can present a risk to public health if not carefully controlled and applied as stipulated in this guideline. However, wastewater reuse can be beneficial because it can prevent over-exploitation of natural water resources. Also, wastewater contains valuable nutrients and no fertiliser needs to be added when reusing treated, domestic effluent for agricultural purposes. Thus the advantages and disadvantages of wastewater reuse must be carefully weighed up when determining areas of application for such reuse.

Table 1. Advantages and disadvantages of wastewater reuse

Advantages	**Disadvantages**
Reduction in consumption of natural water resources	Possible health and safety hazard
Reuse of valuable nutrients for plant growth (e.g. increased crop production leading to increased food security)	

Wherever wastewater contributes significantly, or even solely, to food security and nutritional status, the aim is to identify possible risks and hazards and to design and implement measures to reduce these risks. Risks and hazards associated with wastewater reuse include, but are not limited to, the following:

- water-borne diseases caused by helminth, bacterial, viral and/or protozoan infections;
- aesthetic issues like smell nuisance or decreased product sales due to consumers not wanting to buy products that were produced using wastewater;
- environmental issues including ground water contamination, endangering of marine life and pollution of water bodies used for recreational purposes;

For each individual case of wastewater reuse, risks and hazards such as those mentioned above need to be identified and assessed. If the reuse of wastewater is warranted due to water scarcity or increased food security then the reuse process needs to be designed so that the identified risks are reduced to a minimum or even eliminated. Precautions for wastewater reuse are further discussed in Section 3.

2. TREATMENT OF WASTEWATER

Wastewaters can stem from many different sources and vary hugely in quality. Therefore, when considering reuse thereof, each source should be individually considered and a water treatment specialist must be consulted for the possible reuse thereof, treatment processes required to make the final water suitable for reuse and necessary control and monitoring to ensure the final water is safe and suitable for its application at all times.

The safe use of treated wastewater and effluent is dependent on both the type of treatment process(es) employed and the final application thereof. For example, treated wastewater suitable for reuse in industrial applications may not be suitable for agricultural purposes.

2.1 Grey Water

Water that has been used for washing, laundering clothes, showering and/or bathing, which does not contain significant concentrations of solids and/or excreta is called “grey water” and can be reused with minimal treatment (see later) for non-potable applications. Latter include typically, gardening, agricultural applications, toilet flushing, cooling water, process water, mining, dust suppression etc.

Minimal treatment that must be provided before reuse includes filtration and disinfection.

For other than own, domestic reuse, regular sampling and analysing, at intervals of at least once every 12 months, is required to ensure that the grey water does not contain any contaminant that will render final reuse thereof a health risk or unsuitable for its envisaged application. A suitably qualified specialist in water treatment must be consulted to advise the frequency and specific analyses (organic, inorganic and biological) that need to be performed on the effluent and final application of the water to be reused. The suitably qualified specialist shall, periodically (not less than once per year), based on proper final water analyses:

- Explicitly state for what final application this water may be reused – no other reuse application is permitted unless stated so by the suitably qualified specialist in writing;
- State what treatment processes must be incorporated for reclaiming the grey water before reuse;
- Certify that the water will be safe and suitable for its specific reuse application.

Cognisance must be taken in towns or areas where grey water reuse is not allowed by the local authority or other laws or by-laws prohibiting reuse thereof. For example, the City of Windhoek needs all domestic effluent for their reclamation plant and does not allow for any grey water collection and reuse by their inhabitants.

2.2 Domestic Wastewater

Domestic wastewater is regarded as sewage generated by a typical family household and is also known as “black water”. It does not contain significant amounts of oil or other industrial types of contaminants and is generally treated using biological processes.

Treatment of the effluent is usually classified according to the level of treatment applied, *viz* primary, secondary, tertiary or advanced treatment. Whereas different literature may classify latter treatment processes slightly differently, the nomenclature used in this Guideline will be as follows:

2.2.1 Primary Treatment

Primary treatment is a first unit process during which mainly larger solid particles are removed from the wastewater utilising screens, grit removal and sedimentation facilities.

Latter often incorporates an anaerobic digestive process such as a primary pond, septic tank, primary clarifier or an anaerobic reactor. After primary treatment the effluent should not contain larger solid particles but will still have a prominent, pungent smell typically connected with sewage and usually has a greyish colour.

While general pathogen reduction is minimal (<1 log unit), this type of treatment can remove substantial numbers of pathogenic helminth eggs.

2.2.2 Secondary Treatment

The additional removal of dissolved organics and ammonia-nitrogen by biological or physical-chemical processes is generally known as secondary treatment. If only the latter term is used, it is generally understood that secondary treatment also includes primary treatment as described under Section 2.2.1. Secondary treatment processes itself include the processes following primary treatment to additionally remove biodegradable organic matter and convert ammonia-nitrogen to nitrates and nitrites, coupled with a solid/liquid separation unit process to remove settleable solids (predominantly biomass) from the final effluent.

Typical processes include facultative or secondary oxidation ponds, aerobic bioreactors such as trickling filters, biodiscs and different types of activated sludge processes. Organic substrates dissolved or suspended in the wastewater are biologically oxidised in an aerobic microbial reactor, followed by secondary sedimentation tanks to remove and concentrate the biomass produced from the conversion of organic constituents.

Apart from primarily removing BOD, ammonia-nitrogen and suspended solids, secondary treatment systems can reduce bacterial and viral pathogens, as well as helminth eggs, by approximately 2 log units and protozoan (oo)cysts by 0-1 log units.

2.2.3 Tertiary Treatment

Tertiary treatment follows secondary treatment and refers to treatment processes where additional nutrients and other contaminants are removed. Again, if the term “tertiary treatment” is used on its own, it is understood to also include primary and secondary treatment processes. Tertiary treatment could, for example include biological N and P removal processes, additional solids removal by flocculation, coagulation and sedimentation and/or granular media filtration. When tertiary treatment processes are used, the overall treatment process is usually termed “advanced wastewater treatment”.

More recently, membrane processes such as submerged or external ultra filtration membranes have been employed as additional polishing steps. Table 2 shows the minimum treatment levels that must be achieved by a Waterworks to be able to classify for inclusion of tertiary treatment.

2.3 Industrial Effluents

Many industrial effluents contain constituents that are poisonous or render them not suitable for reuse. When considering any industrial effluent for reuse, proper sampling and analyses thereof must be undertaken to ensure all possible contaminants therein contained are properly captured and characterised. Each source should be individually considered and a water treatment specialist must be consulted for the possible reuse thereof, treatment processes required to make the final water suitable for reuse and necessary control and monitoring to ensure the final water is safe and suitable for its application at all times.

Table 2. Tertiary treatment levels that must be achieved (95 percentile) using various combinations of unit processes for wastewater reclamation (excluding drinking water)

	Required final effluent quality [mg/L, except turbidity, NTU] after Tertiary Treatment						
Treatment Process	**TSS**	**BOD**	**COD**	**Total N**	**NH3-N**	**PO_4-P**	**Turbidity**
Biological + granular medium filtration	< 10	< 10	< 70	< 35	< 10	< 15	< 5
Biological, granular medium filtration + carbon adsorption	< 5	< 5	< 30	< 30	< 10	< 10	< 3
Biological, nitrification, single stage	< 25	< 15	<75	< 45	< 10	< 15	< 15
Biological, nitrification/denitrification, separate stages	< 25	< 15	<75	< 10	< 5	< 15	< 15
Biological, metal salt addition , nitrification/denitrification + filtration	≤ 5	≤ 5	<40	< 5	< 5	≤ 1	< 3
Biological + granular medium filtration + carbon adsorption + reverse osmosis	≤ 1	≤ 1	<10	< 2	< 5	≤ 0.1	< 0.2
Biological, nitrification/denitrification and phosphorus removal + granular medium filtration + carbon adsorption + reverse osmosis	≤ 1	≤ 1	< 5	≤ 1	≤ 0.1	≤ 0.1	<0.1
Biological, nitrification/denitrification and phosphorus removal + microfiltration + reverse osmosis	≤ 1	≤ 1	< 5	≤ 0.1	≤ 0.1	≤ 0.05	<0.05

3. PRECAUTIONS FOR WASTEWATER REUSE SYSTEMS

The following aspects need to be considered when installing and using wastewater reuse systems:

- Evidence shall to be obtained that the type of soil, the size of the surface as well as the type of crop concerned are suitable for irrigation with the proposed quantity and quality of effluent to be reused;
- In order to prevent accidental cross-coupling of pipes, piping used for effluent shall be distinctly different from piping used for drinking water in respect of colour, construction and type of material. As a suitable color for piping to identify wastewater (for reuse), a purple color such as “jacaranda” should be used;
- Taps, valves and sprayers of the irrigation system shall be designed so that accidental drinking or washing with effluent water is prevented. Only authorized personnel shall be able to operate them;
- Clear and legible notices shall be provided at every water point where persons could possibly drink reclaimed effluent, indicating that it is potentially dangerous to drink the water;
- Wherever the expression “after effective draining and drying” is used in this guideline, the activity concerned shall only be performed once the irrigated area no longer contains evident effluent drops or pools;
- All possible precautions shall be taken to ensure that excessive irrigation is avoided and the irrigation area is protected against storm water runoff with suitable screening walls and contours to avoid contamination of surface or underground water with irrigation water, especially when the latter does not comply with the general standard;
- Spray irrigation shall only be permitted in cases where spray cannot be blown over to adjoining areas for which such irrigation is prohibited. The distance of an adjoining area and its use, as well as the quality of the effluent and prevailing winds shall be considered before spray irrigation is permitted;
- Necessary precautionary measures shall be taken to ensure that effluent is not used for drinking water or domestic purposes;
- If desired, treated wastewater can subsequently be treated further to potable water standards with multi-barrier processes.

3.1 Possible dangers related to Wastewater Reuse

It should be noted that the reuse of wastewater can be very hazardous if not performed correctly. Water samples need to be tested regularly to determine the quality of the treated wastewater to be used. Once the water quality has been determined it is crucial that such water is only used for applications for which it has been recommended by the water treatment specialist/Consultant, as will be discussed in Section 3.3. Also, correct methods need to be used when reusing treated wastewater for a specific application. For instance, wastewater to be used in agriculture is often only permissible if no direct spray irrigation is used (see later - Table 5). Abuse or improper application of the guidelines presented in this text could lead to serious health and safety hazards, which could adversely affect humans and animals as well as the environment.

Table 3 serves as an example of the health risks associated with reuse of wastewater for irrigation purposes.

Table 3. Health risks associated with wastewater irrigation

Exposed group	Helminth infections	Bacterial/viral infections	Protozoan infections
Consumers	Significant risk of *Ascaris* infection for both adults and children with untreated wastewater	Cholera, typhoid and shigellosis outbreaks reported from use of untreated wastewater; seropositive responses for *Heliobacter pylori* (untreated); increase in non-specific diarrhea when water quality exceeds 10^4 TC/100 mL	Evidence of parasitic protozoa found on wastewater-irrigated vegetable surfaces, but no direct evidence of disease transmission
Farm workers and their families	Significant risk of *Ascaris* infection for both adults and children in contact with untreated wastewater; risk remains, especially for children, when wastewater treated to <1 nematode egg per liter; increased risk of hookworm infection in workers	Increased risk of diarrheal disease in young children with wastewater contact if water quality exceeds 10^4 TC/100 mL; elevated risk of *Salmonella* infection in children exposed to untreated wastewater; elevated seroresponse to norovirus in adults exposed to partially treated wastewater	Risk of *Giardia intestinalis* infection was found insignificant on contact with both untreated and treated wastewater; increased risk of amoebiasis observed with contact with untreated wastewater
Nearby communities	*Ascaris* transmission not studied for spray irrigation, but same as above for flood or furrow irrigation with heavy contact	Spray irrigation with poor water quality (10^6 - 10^8 TC/mL) and high aerosol exposure associated with increased rates of infection; use of partially treated water (10^4 - 10^5 TC/100 mL or less) in spray irrigation not found to be associated with increased viral infection rates	No data on transmission of protozoan infections during spray irrigation with wastewater

3.2 Disinfection

Disinfection is an extremely important step in wastewater treatment processes. All wastewater that is discharged must be suitably disinfected to not pose a danger to humans and animals when coming into contact with this water, whether it is for reuse purposes or only discharged into the environment. In very exceptional cases, a permit may be applied for from MAWF for exemption from the obligation to disinfect wastewater. This permit will only be granted if it can be proven beyond reasonable doubt that the wastewater will not come into contact with humans or animals and will not cause any health related hazard.

Wastewater that is not disinfected contains numerous intestinal nematodes (e.g. *Ascaris* and *Trichuris*) and hookworms and bacterial pathogens that are difficult to control. When such wastewater is used for crop irrigation these infectious agents and enteric viruses can damage the health of both farm workers and the general public consuming the crop. Thus, where direct human or edible crop contact is made with the wastewater, intestinal nematodes must be destroyed by disinfection. It should be noted, however, that disinfection does not destroy protozoan (oo)cysts. Therefore, even disinfected wastewater cannot simply be used in applications resulting in direct contact with humans or crops.

Table 4 reflects typical reduction or inactivation of pathogens that can be achieved by selected wastewater treatment processes. From latter table it should be noted that there is no general disinfection method that guarantees absolute reduction or inactivation of helminth eggs. It is for this reason, that caution should be exercised when reusing final effluent to not let it come into contact with food that may be digested directly by humans.

Table 4. Reduction or inactivation of pathogens by selected wastewater treatment processes (all values in log unit reductions)

Treatment process	**Viruses**	**Bacteria**	**Protozoan (oo)cysts**	**Helminth eggs**
Low-rate biological processes				
Waste stabilisation ponds	1-4	1-6	1-4	1-3
Wastewater storage and treatment reservoirs	1-4	1-6	1-4	1-3
Constructed wetlands	1-2	0.5-3	0.5-2	1-3
Primary treatment				
Primary sedimentation	0-1	0-1	0-1	0-<1
Chemically enhanced primary treatment	1-2	1-2	1-2	1-3
Anaerobic upflow sludge blanket reactors	0-1	1-2	0-1	0.5-1
Secondary treatment				
Activated sludge + secondary sedimentation	0-2	1-2	0-1	1-<2
Trickling filters + secondary sedimentation	0-2	1-2	0-1	1-<2
Aerated lagoon or oxidation ditch + settling pond	0-2	1-2	0-1	1-<2
Tertiary treatment				
Coagulation/flocculation	1-3	0-1	1-3	2
High-rate granular or slow-rate sand filtration	1-3	0-3	0-3	1-2
Dual-media filtration	1-3	0-1	1-3	2-3
Membrane bioreactors	2.5->6	3.5->6	>6	>3
Disinfection				
Chlorination (free chlorine)	1-3	2-6	0-1.5	0-1
Ozonation	3-6	2-6	1-2	0-2
Ultraviolet irradiation	1->3	2->4	>3	0

As a final disinfection step, all wastewater must be disinfected. If chlorine is used, residual (=free) chlorine concentrations in the treated wastewater (after the chlorine contact tank) should not be less than 0,5 mg/l and needs to be sampled and analysed daily by the end-user to ensure that sufficient disinfection has taken place.

Due to the inherent health and safety hazards associated with wastewater reuse, the onus lies on the end-user of the treated wastewater (e.g. a farmer that uses treated wastewater for crop irrigation) to regularly test the water to be used, to ensure that proper disinfection has taken place. Only when proper disinfection effectiveness has been confirmed, shall the reuse of treated wastewater for a specific application be allowed to commence, unless it can be proven that the non-disinfected wastewater will not come into contact with any humans or animals.

3.3 Final Water Quality Suitable For Reuse

Where an effluent is treated and reused it shall either adhere to the General or Special Standard, depending on its final application (see Section 4), as per the Water Resources Management Act, 2004 (Act No. 24 of 2004). The General and Special standards are based on the proposed Namibian Water Quality Standards and Guidelines. It should be noted that both the General and the Special standard require a final disinfection step in the treatment process before the water is discharged to the final point of application.

3.4 Effluent Reclamation and Non-Potable Reuse

When a user intends reclaiming his effluent for reuse, he shall employ the services of a suitably qualified wastewater treatment specialist, who shall advise on:

- The proper treatment process(es) to be employed;
- Required quality of final water to be adhered to at all times;
- An allowable final use/application of the reclaimed water;
- Periodic analyses to be conducted on effluent samples;
- Control and monitoring regime to be employed to ensure safe reuse of the water at all times.

The above information shall be given in writing (report/letter) in duplicate to the intended user. Latter shall immediately be forwarded to the responsible person at the Department of Water Affairs and Forestry (Law Administration). A suitably qualified specialist shall give all relevant contact details and personally sign such report/letter.

3.5 Effluent Reclamation and Potable Reuse

Effluent reclamation for drinking purposes is a very specialised field and must be treated with the utmost respect. A suitably qualified specialist must be used when considering such reclamation and under no circumstances may a non-specialised person be used.

4. SPECIFIC APPLICATIONS FOR REUSE OF WASTEWATER

Worldwide, the safe reuse of wastewater is promoted and becoming an increasingly attractive alternative to fresh water use for applications in industry, agriculture, gardening, aquaculture and other areas due the resulting advantages mentioned in Table 1. These specific applications will now be further explored and discussed in this section.

Figure 1 serves as a summarised flowchart to determine allowable reuse applications for different treatment levels. However, the details and special considerations to be taken into account must be obtained from tables 5.1, 5.2, 5.3 and 6 before decisions on reuse options are made.

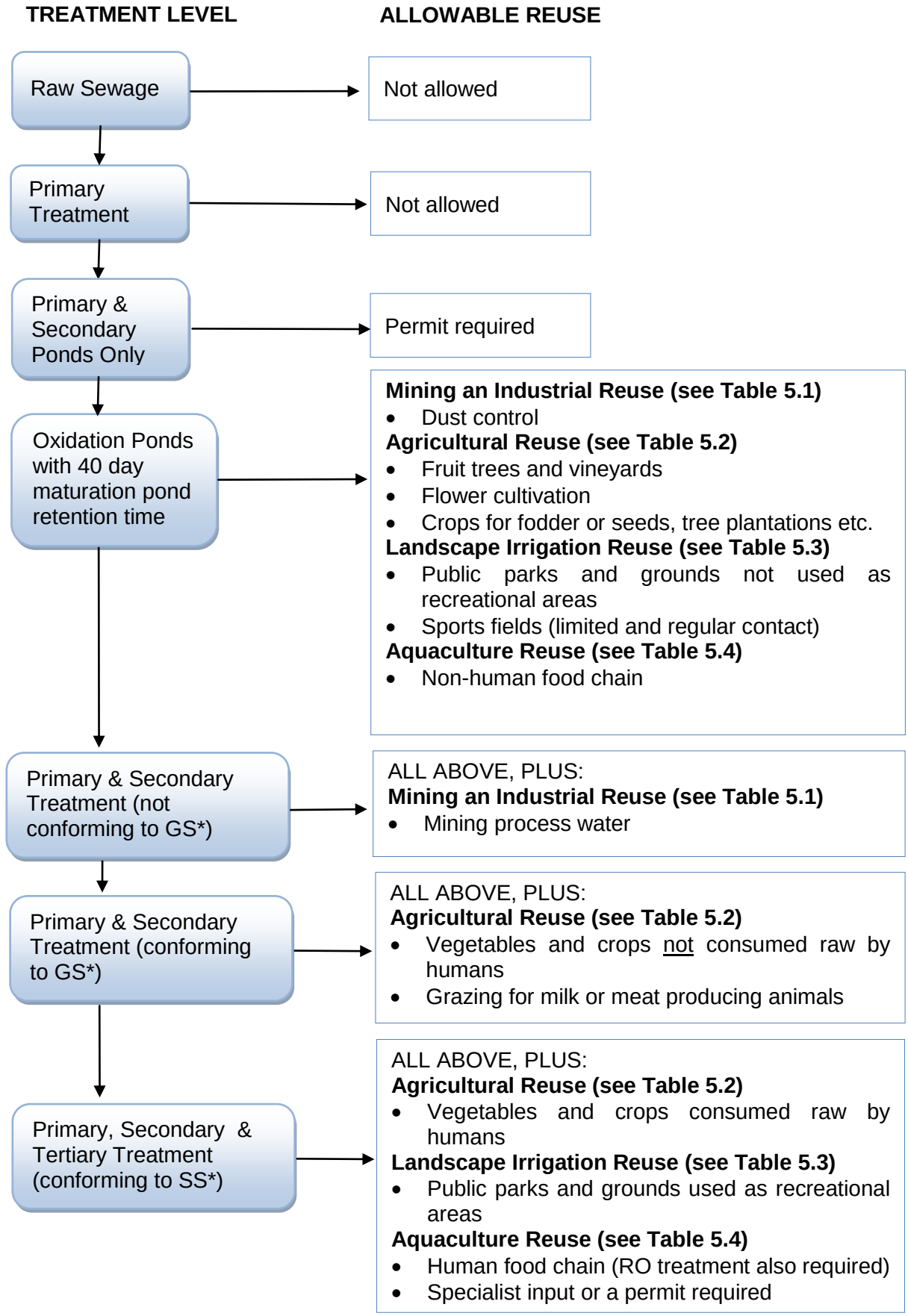

Fig 1: Allowable Reuse Flowchart (*GS = General Standard, SS = Special Standard)

4.1 Mining, Industrial and Food Processing

Industrial and Mining. Industry and especially the mines and power plants (wet cooling systems) are generally large consumers of water, but many unit processes that consume water, do not need water of potable water quality. These include, typically, wet cooling systems in industry and mineral leaching processes and dust suppression at mines. Also, industry often also needs water of a quality better than potable water, e.g. for use in high-pressure boilers and then have to provide additional treatment to obtain the required water quality. In latter case consideration should be given to use water of a lesser quality, such as reclaimed water, as raw water source if additional treatment is anyway required.

Food Processing. Effluent reuse is not permitted in factories where the water is used for food processing, including beverage production. Latter restriction includes reuse in indirect processes not necessarily in contact with the food produced itself, e.g. cooling towers. Reason being, there is always the danger of pipes leaking and the effluent indirectly coming into contact with and contaminating the food being processed. This is further set out in Table 5.1.

4.2 Agricultural Reuse

Wastewater is increasingly used for agricultural purposes in both developing and industrialised countries. This is due to increased water scarcity and degradation of freshwater resources caused by improper disposal of wastewater. Also, the value of nutrients contained in wastewater is now being recognised. Domestic effluent contains all nutrients required for agricultural applications and renders fertiliser addition obsolete. The increase in food demand resulting from population growth, results in increased irrigation water demand. Thus, the safe and efficient use of treated wastewater in agriculture is of environmental and economic importance, as it can help communities to grow more food while conserving natural water and nutrient/fertiliser resources.

Wastewater can be treated using various different combinations of unit operations and processes, leading to various levels of final water quality and suitable for different methods of irrigation, further set out in Table 5.2.

4.3 Gardening and Landscape Reuse

The reuse of treated wastewater for irrigation of landscapes, e.g golf courses, parks and sport fields has similar benefits to those of agricultural wastewater reuse. Firstly, the reuse of wastewater reduces the consumption of scarce natural water resources and secondly, treated wastewater contains valuable nutrients that are necessary for plant growth. Thus, treated wastewater can be used to increase the economic and environmental efficiency of landscape irrigation.

In order to ensure public health and safety, the reuse of treated wastewater for landscape irrigation purposes shall adhere to the guidelines set out in Table 5.3.

TABLE 5. WASTEWATER REUSE APPLICATIONS

Table 5.1. Mining and Industrial Reuse

APPLICATION in	Primary and Secondary Ponds	OD – Oxidation Ponds with 40 day maturation pond retention time	Primary & Secondary Treatment, not adhering to General Standard	Primary & Secondary Treatment, adhering to General Standard	Primary, Secondary & Tertiary Treatment*, adhering to Special Standard
1. Food Processing	Not permissible	Not permissible	Not permissible	Not permissible	Not permissible
2. Mining and industry: • process water; • cooling towers; • Mineral recovery	Not permissible	Not permissible	- Permissible on merit provided human contact is excluded; - All taps and draw-off points shall contain clear notices indicating water not suitable for human consumption	- Permissible provided human contact is excluded; - All taps and draw-off points shall contain clear notices indicating water not suitable for human consumption	- Permissible provided human contact is excluded; - All taps and draw-off points shall contain clear notices indicating water not suitable for human consumption
3. Dust control on roads.	Not permissible	- Permissible; - Human contact to be excluded; - Proper disinfection at all times required; - Excessive spraying and pool forming shall be avoided.	- Permissible; - Human contact to be excluded; - Proper disinfection at all times required; - Excessive spraying and pool forming shall be avoided,	- Permissible; - Human contact to be excluded; - Proper disinfection at all times required.	- Permissible; - Human contact to be excluded; - Proper disinfection at all times required.
		- No smell nuisance; - No excessive spraying or pool forming allowed, because underground water may become contaminated; - Direct human contact with spray shall be avoided as far as possible; - Effluent must be prevented from being used for domestic purposes; - Container(s) used for transportation of effluent shall be effectively cleaned and disinfected immediately after use.			
4. Sundry uses not mentioned in this guideline.	Not permissible	Permissible on merit in exceptional cases only	- Each case will be treated on its merits - The emphasis shall be on the *E.coli* count - The effluent shall be free from parasitic ova, pathogenic organisms, toxic substances, etc.	- Each case will be treated on its merits - The emphasis shall be on the *E.coli* count - The effluent shall be free from parasitic ova, pathogenic organisms, toxic substances, etc.	- Each case will be treated on its merits - The emphasis shall be on the *E.coli* count - The effluent shall be free from parasitic ova, pathogenic organisms, toxic substances, etc.

*** Sand and Granular Activated Carbon Filtration and Disinfection must form part of the Tertiary Treatment steps, if conventional treatment processes are used.**

Table 5.2. Agricultural Reuse

Irrigation of	Primary and Secondary Ponds	Oxidation Pond with 40 day maturation pond	Primary & Secondary Treatment, not adhering to General Standard	Primary & Secondary Treatment, adhering to General Standard	Primary, Secondary & Tertiary Treatment*, adhering to Special Standard
1. Vegetables and crops consumed raw by humans (3 excluded)	Not permissible	Not permissible	Not permissible	Not permissible	Any type of irrigation permissible
2. Vegetables and crops not consumed raw by humans	Not permissible	Not permissible	Not permissible	- Flood and drip irrigation permissible provided products are not directly exposed to spray - Effective draining and drying before harvesting; - Fallen produce unsuitable for human consumption	Any type of irrigation permissible
3. Fruit trees and vineyards for the cultivation of fruit which is consumed raw by humans	Not permissible	- Flood and drip irrigation permissible on merit provided fruits are not directly exposed to spray; - Effective draining and drying before harvesting - Fallen fruit is unsuitable for human consumption	- Flood and drip irrigation permissible on merit, provided fruits are not directly exposed to spray - Effective draining and drying before harvesting - Fallen fruit is unsuitable for human consumption	- Flood and drip irrigation permissible on merit provided fruits are not directly exposed to spray - Effective draining and drying before harvesting - Fallen fruit is unsuitable for human consumption	Any type of irrigation permissible
4. Cultivation of cut flowers	Not permissible	- Flood and drip irrigation permissible on merit provided flowers are not directly exposed to spray; - Effective draining and drying before harvesting essential	- Flood and drip irrigation permissible on merit provided flowers are not directly exposed to spray; - Effective draining and drying before harvesting essential	- Any type of irrigation permissible - Effective draining and drying before harvesting essential	Any type of irrigation permissible
5. Grazing for milk or meat producing animals	Not permissible	Not permissible	Not permissible	- Flood and drip irrigation permissible on merit; - Not Permissible as drinking water for animals - Effective draining and drying before consumption	- Any type of irrigation permissible; - Permissible as drinking water for animals.
6. - Crops not for grazing, but utilized as dry fodder; - Crops cultivated for seeds purpose only; - Tree plantations; - Nurseries (cut flower excluded, see 4)	Not permissible	- Any type of irrigation permissible on its merits - No over-irrigating or pool forming - No smell nuisance - Properly fenced (no public allowed) - No meat animals, milk producing animals or poultry permissible	- Any type of irrigation permissible on its merits - No over-irrigating or pool forming - No smell nuisance - Properly fenced (no public allowed) - No meat animals, milk producing animals or poultry permissible	Any type of irrigation permissible	Any type of irrigation permissible

*** Sand and Granular Activated Carbon Filtration and Disinfection must form part of the Tertiary Treatment steps, if conventional treatment processes are used.**

Table 5.3. Landscape Irrigation

Irrigation of	Primary and Secondary Ponds	Oxidation Ponds with 40 day maturation pond	Primary & Secondary Treatment, <u>not</u> adhering to General Standard	Primary & Secondary & Tertiary Treatment, adhering to General Standard	Primary & Secondary & Tertiary Treatment*, to Special Standard
1. Lawns at swimming pools, nursery schools, children's' playgrounds	Not permissible	Not permissible	Not permissible	Not permissible	- Any type of irrigation permissible; - No public allowed during irrigation, only allowed after effective draining/drying.
2. School grounds and public parks (children's' playground excluded, see 1).	Not permissible	- Only flood or drip, no spray irrigation permissible; - No over-irrigation and no pool forming allowed; - No public allowed during irrigation, only allowed after effective draining /drying.	- Only flood or drip, no spray irrigation permissible; - No over-irrigation and no pool forming allowed; - No public allowed during irrigation, only allowed after effective draining/drying.	- Any type of irrigation permissible; - No public allowed during irrigation, only allowed after effective draining/drying.	- Any type of irrigation permissible; - No public allowed during irrigation, only allowed after effective draining/ drying.
3. Parks - only for beautifying flowerbeds, traffic islands etc. (not recreation areas)	- Not permissible	- Only flood or drip, no spray irrigation permissible; - No public allowed during irrigation.	- Only flood or drip, no spray irrigation permissible; - No public allowed during irrigation.	- Any type of irrigation permissible; - No public allowed during irrigation.	Any type of irrigation permissible.
4. Sports fields were limited contact is made with the surface (golf course, cricket and hockey fields)	Not permissible	- Only flood or drip, no spray irrigation permissible; - No over-irrigation and no pool forming allowed; - No players or public during irrigation; - Players and public allowed only after effective draining and drying.	- Only flood or drip, no spray irrigation permissible; - No over-irrigation and no pool forming allowed; - No players or public during irrigation; - Players and public allowed only after effective draining and drying.	- Any type of irrigation permissible - No over-irrigation and no pool forming allowed; - No players or public during irrigation.	- Any type of irrigation permissible; - No players or public during irrigation.
5. Sport fields where regular contact is made with the surface (athletic tracks, rugby and soccer fields)	Not permissible	- Only flood or drip, no spray irrigation permissible; - No over-irrigation and no pool forming allowed; - No players or public during irrigation; - Players and public allowed only after effective draining and drying.	- Only flood or drip, no spray irrigation permissible; - No over-irrigation and no pool forming allowed; - No players or public during irrigation; - Players and public allowed only after effective draining and drying.	- Any type of irrigation permissible - No over-irrigation and no pool forming allowed; - No players or public during irrigation; - Players and public allowed only after effective draining and drying.	- Any type of irrigation permissible; - No players or public during irrigation; - Players and public allowed only after effective draining and drying.

*** Sand <u>and</u> Granular Activated Carbon Filtration <u>and</u> Disinfection <u>must</u> form part of the Tertiary Treatment steps, if conventional treatment processes are used.**

4.4 Aquaculture Reuse

The use of treated wastewater for farming of plants or animals in water is becoming increasingly popular due to an increase in natural fresh water scarcity. In addition, the nutrients inherently contained in treated wastewater are advantageous to plant growth. However, as with wastewater use for agricultural purposes, extreme care must be taken to minimize or eliminate the potential safety and health hazards associated with wastewater reuse.

Distinction is made between aquacultural products for human and non-human consumption. Wastewater and excreta can be used to raise aquatic plants and fish to be used as high-protein animal feed in societies in which production for human consumption is socially unacceptable. However, fish directly consumed (even if cooked) by humans is not allowed to be grown utilizing reclaimed wastewater unless latter is again passed through a reverse osmosis (RO) process step. This is summarised in Table 6 below.

Table 6. - Effluent reuse for aquacultural purposes

Type of Reuse	Suggested Minimum Level of Treatment	Reclaimed Water Quality
Non-human food chain	Secondary + maturation ponds of at least 45 days retention	- < 10^4 thermotolerant coliforms per 100 mL
Human food chain	Tertiary treatment, including sand and carbon filtration + RO membrane filtration and final disinfection	- Thermotolerant coliforms < 10 cfu/100mL median value, with four of five samples containing less than 40 cfu/100mL - ≥ 1 mg/L chlorine residue after 30 mins or equivalent level of pathogen reduction

4.5 Other Uses

Treated wastewater can be used for various other purposes not mentioned in this guideline. However, every precaution necessary must be taken to ensure that such water is not used for human consumption or domestic purposes. Also, care must be taken to ensure that the use of wastewater does not lead to groundwater contamination.

Reclaimed water can be used for the following non-potable purposes:

- Commercial uses such as vehicle washing facilities, window washing, and mixing water for pesticides, herbicides and liquid fertilizers. However, utmost care must be taken that human contact with the reclaimed water is avoided;
- Ornamental and decorative water features such as waterfalls, reflecting pools and fountains;
- Dust control and concrete production for construction projects;
- Fire protection through reclaimed water fire hydrants;
- Toilet and urinal flushing in commercial and industrial buildings

It is emphasized again that each application of reclaimed wastewater shall be considered on merit after thorough investigation of potential health and safety hazards caused by the use of

such water. Final reuse water quality and a defined application must be certified by a suitably qualified and experienced specialist in water treatment as described in Section 3.4.

Alternatively, treated wastewater can be further treated to potable water standards using multiple barrier processes. These processes are designed to inherently contain back-up systems to ensure that the quality of the product water always achieves the specified standards.

5. DISPOSAL AND DISCHARGE OF TREATED EFFLUENT INTO NATURE

Discharge of treated effluent into water bodies like rivers or the sea should be performed with extreme caution and only following thorough investigations and an elaborate environmental impact assessment into the effects of such discharge. Effluent discharge shall not be permitted if it poses a potential safety and health risk to human or marine life.

In most cases the influence of the above mentioned discharge is not directly predictable. Thorough investigations shall thus be performed prior to discharge to determine such influence to a reasonable degree of certainty. Only when this investigation establishes that effluent discharge poses no health and safety hazards shall such discharge be allowed. Table 7 summarises the permitted methods of disposal for different qualities of treated wastewater.

Table 7. Methods of disposal and discharge of effluents

Method of disposal or discharge	Primary and Secondary Ponds	Oxidation Ponds with 40 day maturation pond	Primary & Secondary Treatment, <u>not</u> adhering to General Standard	Primary & Secondary Treatment, adhering to General Standard	Primary, Secondary and Tertiary Treatment*, adhering to Special Standard
1. Discharge into dry rivers and dry watercourses, excluding estuaries, dams, lagoons and reed beds (artificial or natural wetlands)	Not permissible	Not permissible	- Not permissible	- Permissible under the condition that the effluent contains no harmful substances in concentrations dangerous to health; - No surface water/ponds allowed;	Permissible
2. Discharge into running rivers estuaries, dams, lakes, lagoons or other masses of water (sea excluded - see 3)	Not permissible	Not permissible	- Not permissible	- Not permissible	- Permissible; - Clear warning signs at point of discharge; - Discharge not closer than 250 m from public bathing area.
3. Discharge into the sea	Not Permissible	- Permissible only beyond the surf zone; - Discharge point shall be determined with due regard to quantity, quality, distribution and dilution of effluent, as well as sea currents and proximity of present and future bathing areas		- Permissible; - Discharge not closer than 500 m from public bathing area; - Discharge into surf zone shall be determined with due regard to the proximity of present and future bathing areas and the effect on the seawater quality.	- Permissible; - Discharge not closer than 250 m from public bathing area.
		- Effluent shall not cause any nuisance or have any adverse effect on marine life; - No coastal area shall be contaminated with effluents containing harmful substances in concentrations dangerous to health			

*** Sand <u>and</u> Granular Activated Carbon Filtration <u>must</u> form part of the Tertiary Treatment steps**

REFERENCES

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APPENDIX A

Water Quality Standards for Effluent

Effluent to be discharged or disposed of in areas with potential for drinking water source contamination; international rivers and dams and in water management and other areas				
			Special Standard	**General Standard**
DETERMINANTS	**UNIT**	**FORMAT**	**95 percentile requirements**	
PHYSICAL REQUIREMENTS				
Temperature	° C		Not more than 10^0C higher than the recipient water body	
Turbidity	NTU		< 5	< 12
pH			6.5-9.5	6.5-9.5
Colour	mg/litre Pt		< 10	< 15
Smell			No offensive smell	
Electric conductivity 25 °C	mS/m		< 75 mS/m above the intake potable water quality	
Total Dissolved Solids	mg/litre		< 500 mg/litre above the intake potable water quality	
Total Suspended Solids	mg/litre		< 40	< 100
Dissolved oxygen	% saturation		>75	>75
Radioactivity	units		below ambient water quality of the recipient water body	
ORGANIC REQUIREMENTS				
Biological Oxygen Demand	mg/litre	BOD	< 10	< 30
Chemical Oxygen Demand	mg/litre	COD	< 55	< 100
Detergents (soap)	mg/litre		< 0.2	< 3
Fat, oil & grease, individual	mg/litre	FOG	< 1.0	< 3.0
Phenolic compounds	mg/litre	as phenol	< 0.01	< 0.10
Aldehyde	µg/litre		< 50	< 100
Adsorbable Organic Halogen	µg/litre	AOX	< 50	< 100
INORGANIC MACRO DETERMINANTS				
Ammonia (NH_4 – N)	mg/litre	N	< 1	< 10
Nitrate (NO_3 - N)	mg/litre	N	< 15	< 20
Nitrite (NO_2 - N)	mg/litre	N	< 2	< 3
Total Kjeldahl Nitrogen (TKN)	mg/litre	N	< 5.0	< 33
Chloride	mg/litre	Cl	< 40 mg/litre above the intake potable water quality	< 70 mg/litre above the intake potable water quality
Sodium	mg/litre	N	< 50 mg/litre above the intake potable water quality	<90 mg/litre above the intake potable water quality
Sulphate	mg/litre	SO_4	< 20 mg/litre above the intake potable water quality	< 40 mg/litre above the intake potable water quality
Sulphide	mg/litre	S	< 0.05	< 0.5
Fluoride	mg/litre	F	1.0	2.0

Effluent to be discharged or disposed of in areas with potential for drinking water source contamination; international rivers and dams and in water management and other areas				
			Special Standard	General Standard
DETERMINANTS	**UNIT**	**FORMAT**	**95 percentile requirements**	
Cyanide (Free)	μg/litre	CN	< 30	< 100
Cyanide (recoverable)	μg/litre	CN	< 70	< 200
Soluble Ortho phosphate	mg/litre	P	< 1.0	< 15
Zinc*	mg/litre	Zn	1	5

Effluent to be discharged or disposed of in areas with potential for drinking water source contamination; international rivers and dams and in water management and other areas				
			Special Standard	**General Standard**
DETERMINANTS	**UNIT**	**FORMAT**	**95 percentile requirements**	
INORGANIC MICRO DETERMINANTS				
Aluminium	µg/litre	Al	< 25	< 200
Antimony	µg/litre	Sb	< 5	< 50
Arsenic	µg/litre	As	< 50	< 150
Barium	µg/litre	Ba	< 50	< 200
Boron	µg/litre	B	< 500	< 1000
Cadmium*	µg/litre	Cd	< 5	< 50
Chromium, (hexavalent)	µg/litre	Cr	< 10	< 50
Chromium, Total*	µg/litre	Cr	< 50	< 1000
Copper*	µg/litre	Cu	< 500	< 2000
Iron	µg/litre	Fe	< 200	< 1000
Lead*	µg/litre	Pb	< 10	< 100
Manganese	µg/litre	Mn	< 100	< 400
Mercury*	µg/litre	Hg	< 1	< 2
Nickel	µg/litre	Ni	< 100	< 300
Selenium	µg/litre	Se	< 10	< 50
Strontium*	µg/litre	Sr	< 100	< 100
Thallium	µg/litre	Ti	< 5	< 10
Tin*	µg/litre	Sn	< 100	< 400
Titanium	µg/litre	Ti	< 100	< 300
Uranium*	µg/litre	U	< 15	< 500
*Total for Heavy Metals (Sum of Cd,Cr,Cu,Hg,Pb	µg/litre	Cd,Cr,Cu, H g & Pb	< 200	< 500
UNSPECIFIED COMPOUNDS FROM ANTHROPOGENIC ACTIVITIES				
Agricultural chemical compounds	µg/litre		Any in-/organic compound recognized as an agro-chemical is to be avoided or reduced as far as possible. Maximum acceptable contaminant levels will be site specific, dependent on chemical usage and based the water quality of the recipient water body	
Industrial and mining chemical compounds, including unlisted metals and persistent organic pollutants	µg/litre		Any in-/ organic compound recognized as an industrial chemical including unlisted metals is to be avoided or reduced as far as possible. Maximum acceptable contaminant levels will be site specific dependent on chemical usage and based the water quality of the recipient water body	
Endocrine Disruptive Compounds (EDC)	µg/litre		Any chemical compound that is suspected of having endocrine disruptive effects is to be avoided as far as is possible. Maximum acceptable contaminant levels will be site specific dependent on chemical usage and based the water quality of the recipient water body.	

Hydrocarbons (Benzene, Ethyl Benzene, Toluene and Xylene	μg/litre		Below detection level	Below detection level
Organo-metallic compounds: methyl mercury, tributyl tin (TBT), etc.	μg/litre		Below detection level	Below detection level
DISINFECTION				
Residual chlorine	mg/litre		1 Dependent on recipient water body (at retention time 3 hours)	3 Dependent on recipient water body (at retention time 5 hours)

Effluent to be discharged or disposed of in areas with potential for drinking water source contamination; international rivers and dams and in water management and other areas				
			Special Standard	**General Standard**
DETERMINANTS	**UNIT**	**FORMAT**		
BIOLOGICAL REQUIREMENTS (Algae and parasites)				
Further treatment of the effluent dependent on: 1. the water quality of the recipient water body if any 2. the distance from any point of potable water abstraction 3. an acceptable maximum contaminant level downstream of the point of discharge 4. the exposure to human and animal consumption downstream of the point of discharge 5. any reuse option that may be implemented.				
MICROBIOLOGY				
Further treatment of the effluent are dependent on: 1. the water quality of the recipient water body if any 2. the distance from any point of potable water abstraction 3. an acceptable maximum contaminant level downstream of the point of discharge 4. the exposure to human and animal consumption downstream of the point of discharge 5 any water reuse option that may be implemented.				