


# HOSPITAL TECHNICAL MEMORANDUM NO 63

 Western Cape Government BETTER TOGETHER	<b>WATER CONSERVATION &amp; RECYCLING IN HEALTHCARE FACILITIES</b> <b>DIRECTORATE: INFRASTRUCTURE PLANNING</b>	DOCUMENT	WATER CONSERVATION & RECYCLING
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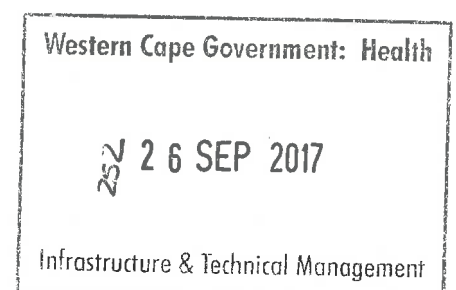
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## 1. BACKGROUND

South Africa is listed as the 30<sup>th</sup> driest country in the world, yet the average water consumption per person per day exceeds that of Europe, surpassing 200 litres per person per day. As water shortages are becoming a harsh reality within South Africa and particularly the Western Cape Province, it is the responsibility of every sector of industry to re-evaluate their uses and overall treatment of this precious resource so that it may be conserved and used responsibly.

Given that the bulk of a healthcare facilities' water consumption lies within the services of the facility not requiring domestic quality water, such as cooling towers constituting over 50%, recycling wastewater for re-use in all areas not requiring potable water will result in a dramatic reduction in water consumption.

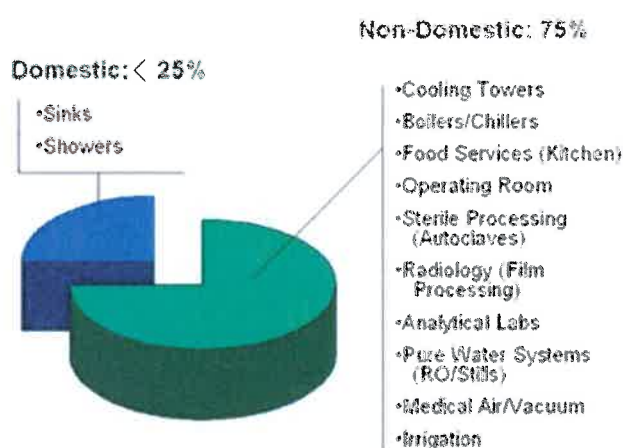


FIGURE 1: WATER REQUIREMENTS AT A HEALTHCARE FACILITY (RICHARD SPEARES (NETCARE), 2017)

## 2. OBJECTIVE

The primary function of this document is to provide terms of reference for consultants who are contacted to engineer systems responsible for the provision of wet building services of state healthcare facilities, with the re-use of rainwater and (treated) grey and black wastewater to be considered. Design consultants are required to investigate systems that are practical and appropriate for the geographic location of the facility and do not necessarily need to use the best available technology.

## 3. GUIDELINES AND REGULATIONS

The guidelines and regulations to be consulted by any designer when undertaking wastewater treatment works include, without limitation, the following:

- Small waste water treatment works, Department of Public Works (DPW) Design Guidelines
- Department of Water Affairs (DWA) Water Quality Guidelines Vol1-8
- National Water Act 1998
- SANS10252 Part 1 - Water Supply Installations for Buildings
- SANS10252 Part 2 – Drainage Installations for Buildings
- SANS 241 Part 1 and 2 – Drinking water quality requirements

- SANS10248 – Management of healthcare waste
- IUSS Health Facility Guides: Building Engineering Services

## 4. WATER CONSUMPTION

### 4.1. HEALTHCARE SERVICES

In the healthcare environment, domestic water is currently used to serve the following purposes (excluding fire-fighting):

- Potable water consumption
- Ablution facilities for staff (including scrub-up for medical personnel) and patients
- Washing, cleaning and sterilisation throughout the facility.
- Heating, Ventilation and Cooling (i.e. hot water and chilled water supply for space heating and cooling, respectively)<sup>1</sup>

On average, water usage for each kind of facility ranges between 20 and 450 litres per capita per day, depending on the size of the facility and its level of water efficiency.

**TABLE 1: VARIOUS TYPES OF HEALTHCARE FACILITIES AND THEIR TYPICAL WATER DEMAND**

Facility	Operating Hours	Total water demand*
Emergency Medical Services (EMS)	24/7	50 Litres/EM staff /day
Forensic Pathology Labs	5 days per week, 8hrs per day	50 Litres/post mortem/day
Clinics	5 days per week, 8hrs per day	20-30 Litres/head count/day
Community Day Centres (CDC)	5 days per week, 8hrs per day	30-40 Litres/head count/day
Community Health Centre (CHC)	24/7	30-40 Litres/head count/day**
District, Regional & Provincial Hospitals	24/7	300-450 Litres/bed/day
Central Hospital	24/7	450 Litres/bed/day

\*Figures obtained through use of SANS10252-1 and experience of existing facilities. Note that, by providing these figures, the intention is not to enable any consultant to size wastewater treatment facilities, but to simply give one an idea of the total water consumption rates that can be expected of a healthcare facility.

\*\* Dependent on size of MOU. If present, 50 L/head count/day

Note: Where a minimum and maximum total water demand is specified in the table above, the target water demand for any facility should be the minimum amount specified.

<sup>1</sup> These systems operate using a closed cycle, in most cases only requiring make up water to compensate for losses through cooling towers.

## 4.2. WASTEWATER CLASSIFICATION

The various wastewater streams (i.e. influents) produced by a facility are classified as belonging to one of three categories, either Hazardous, Black or Grey wastewater.

- Hazardous wastes generally include infectious waste, anatomical (pathological) waste, chemical waste, pharmaceutical waste and radioactive waste.
- Black wastewater includes wastewater produced by the flushing of toilets and from kitchen sinks
- Grey wastewater includes waste produced through the use of basins, baths and showers containing large amounts of soaps, fats, oils and skin cells.

TABLE 2: CLASSES OF WASTEWATER AND THEIR CONSTITUENTS

Class	Constituents of water waste stream	Typical source
Hazardous*	Urine, faeces and vomit from patients, which may contain potentially hazardous amounts of administered cytotoxic drugs or their metabolites and which should be considered genotoxic for at least 48 hours.	Toilets, Radiology, Swimming pool <sup>2</sup>
Black**	Faecal matter and urine	Kitchens, Toilets
Grey**	Fats, oils, soaps, disinfectants and other household cleaning products typically released through baths, showers. This DOES NOT include harsh chemical cleaning products such as drain cleaners etc.	Basins, Showers/Baths, CSSD, Car wash bays, Cooling Towers, Laundry

\*It is assumed that all hazardous waste generated within a facility is defined in accordance with and disposed of as required by SANS 10248. Furthermore, the table above does not cater for toxic chemicals or cleaning products (such as drain cleaners) which may be used intermittently.

\*\*Phosphate free washing powder must be used in healthcare facilities implementing waste water treatment, as it reduces the nutrient load on the system. Phosphate, if not removed, can poison soil when used over the extended periods of time. Also, the use of fabric softeners, Sodium Hypochlorite (i.e. JIK) and anionic surfactants must be avoided as it will have a negative impact on the microbiological processes responsible for treating wastewater. This requirement is aligned with the Green Procurement Strategy.

## 5. WATER CONSERVATION

### 5.1. PRINCIPLES

It must be shown that an investigation by a consultant, for the purposes of water conservation, at a new or existing facility, has gone through each of the stages as indicated in Figure 2, as significant reductions in water consumption can be made with little to no cost.

<sup>2</sup> Although it does not pose any significant risk to human health, it is classified as hazardous waste due to the fact that the presence of Chlorine will detract from the natural biological process (activated sludge) used to remove BOD/COD from a black wastewater stream. It may however, depending on its quality, be redirected for surface (floor) cleaning purposes.



The values given (which are *not* cumulative) indicate the potential saving if each stage is implemented individually. If all stages are implemented, a total reduction of up to 60% in water consumption can be expected.

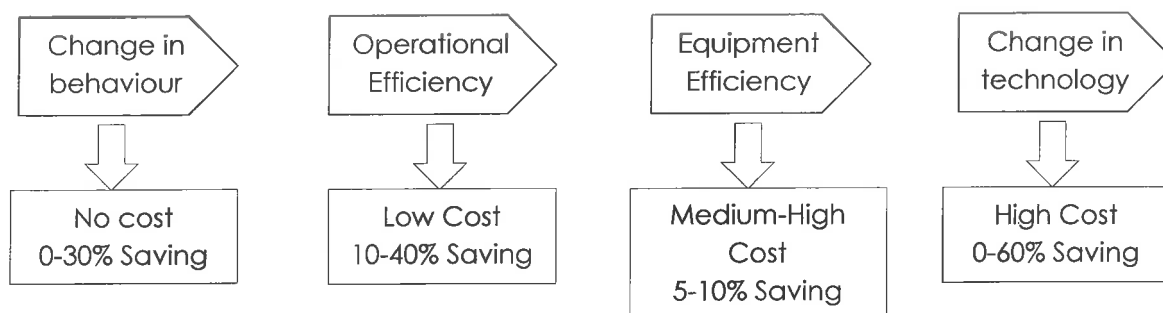


FIGURE 2: STAGES IN ACHIEVING OPTIMUM WATER EFFICIENCY (BESTER, 2017)

Improving of operational efficiencies can include measures such as the following:

- Ensuring air conditioning equipment (i.e. cooling towers) is only operational when the building is occupied
- Irrigating the surrounding vegetation in the early mornings in winter and in the early evenings in summer and doing so with NON-potable water
- Reinstatement of boreholes
- Washing facility floors, tables, counter tops and vehicles (non-EMS) using a bucket
- Bladder bags placed in cisterns of toilets to reduce water usage for flushing
- Regular maintenance and inspection of flush master piston heads and pressure settings
- Placing of screens between urinals to promote their use
- Redirecting CSSD condensate to supply make-up water to cooling towers, which can constitute up to 50% of a facilities water consumption
- Reuse of CSSD condensate within the CSSD, operating in a "closed" cycle (already done at Groote Schuur)
- Use of alcohol rubs at basins

Improving equipment efficiency may include measures such as:

- Making use of high efficiency toilets, such as the passive "vacuum-assisted" type, consuming less than 4 litres per flush. (The needs of any existing sewer reticulation system, in terms of minimum water content required for transport of solid waste, will need to be re-evaluated. Typically, sewerage flow should not fall below 0.75m/s to avoid settling. See Annexure A: Sewerage gravity flow (velocity)
- Making use of waterless urinals with screens
- Using (adjustable) aerators on tap outlets, with a flow range of 2-4 Litres per minute
- Upgrading of valves used for basins and the flushing of toilets and urinals to metered self-closing valves
- Installing water saving shower roses and hand showers (rated at 7L/min)
- Lowering pressure pump settings and installing reducers
- Washing of EMS vehicle interiors and kitchen counter tops using dry steam machines

Changing technologies, requiring significant investments, such as:

- Replacing of evaporative cooling systems with air cooled condensers
- Installing rain harvesting systems

- Drilling of new/additional boreholes
- Installing (grey and black) wastewater recycling and treatment systems
- Installing dual drainage reticulation network
- Installing dual supply reticulation network, defining potable and non-potable water

Note that the generation of water from air has not been mentioned as a possible water conservation mechanism as this is seen as an expensive replacement for municipal water supply. It may however, be considered for production of water strictly assigned for drinking only, for instance through the use of 30L air to water towers to ensure availability of drinking water at all times. Refer to Annexure D for cost estimates pertaining to "air-to-water" technologies.

One other architectural consideration which can have an impact on a facility's ability to conserve water and not mentioned above is landscaping. Gardens in and around the facility using indigenous water-wise plants and trees can not only reduce the amount of water needed to sustain them but can also have an impact on the ambient temperature in and around the healthcare facility, indirectly reducing the heating and ventilation loads of the facility. No grass must be laid at any newly built facilities as this will only increase its water consumption. The above must be considered in the design of any new healthcare facility. Furthermore, a landscape should also allow for sufficient capture and storage of any water runoff, such that the entire footprint of the facility and not only its roofs is used to harvest rainwater.

## 5.2. EFFLUENT CLASSES

Whilst wastewater (i.e. influent) has been classified as belonging to three different classes, the same is done for the treated wastewater (i.e. effluent). To do so, the Department of Water Affairs Water Quality Guidelines (DWA WQG) – Volume 3, was used. Water, for industrial processes (i.e. excluding drinking), can be grouped into four categories. Category 1, is used for industrial applications needing pure, distilled water, as is the case for the washing of electronic components. Category 4, which is "dirty" water, is typically used for surface cleaning, fire-fighting and the wet handling of waste material (such as ash). Below are extracts from the DWA WQG –Vol 3.

### Examples of Category 1 Industrial Processes

Cooling Water	Steam Generation	Process Water	Wash Water
• Evaporative cooling (high recycle)	• High pressure boilers (demineralisation - plant feed water)	• Phase separation • Petrochemicals • Pharmaceuticals (demineralisation - feed water)	• Washing with no residuals (electronic parts) (demineralisation - water)

### Examples of Category 2 Industrial Processes

Heat Exchange	Steam Generation	Process Water	Product Water
<ul style="list-style-type: none"> <li>• Evaporative cooling (high recycle)</li> <li>• Solution cooling</li> <li>• Water heating</li> </ul>	<ul style="list-style-type: none"> <li>• High pressure boilers (demineralisation - plant feed water)</li> </ul>	<ul style="list-style-type: none"> <li>• Solvent agent</li> <li>• Heat transfer medium</li> <li>• Humidification</li> <li>• Lubrication</li> <li>• Gas cleaning</li> </ul>	<ul style="list-style-type: none"> <li>• Beverages</li> <li>• Dairy</li> <li>• Petrochemical</li> </ul>

### Examples of Category 3 Industrial Processes

Cooling Water	Steam Generation	Process Water	Product Water	Utility Water
<ul style="list-style-type: none"> <li>• Evaporative cooling (once through)</li> <li>• Bearing cooling</li> <li>• Mould cooling</li> </ul>	<ul style="list-style-type: none"> <li>• Low pressure boilers: softening process feed water</li> </ul>	<ul style="list-style-type: none"> <li>• Solvent</li> <li>• Dilution agent</li> <li>• Transport agent</li> <li>• Gland seal</li> <li>• Vacuum seal</li> <li>• Lubrication</li> <li>• Descaling (iron and steel industry)</li> <li>• Gas scrubbing</li> </ul>	<ul style="list-style-type: none"> <li>• Beverages</li> <li>• Food products</li> <li>• Baking and confectionery</li> <li>• Chemicals</li> </ul>	<ul style="list-style-type: none"> <li>• Surface washing (table tops, walls)</li> <li>• Domestic use</li> <li>• Fire fighting</li> </ul>

### Examples of Category 4 Industrial Processes

Cooling Water	Process Water	Utility Water	Wash Water
<ul style="list-style-type: none"> <li>• Ash quenching</li> </ul>	<ul style="list-style-type: none"> <li>• Transport agent</li> </ul>	<ul style="list-style-type: none"> <li>• Dust suppression</li> <li>• Fire fighting</li> <li>• Irrigation</li> </ul>	<ul style="list-style-type: none"> <li>• Rough washing (floors, rough apparatus, trucks, raw materials)</li> </ul>
		(water)	(water)

## 5.3. EFFLUENT QUALITY REQUIREMENT FOR STATE HEALTHCARE

Treated wastewater (whether by primary filtration or through extensive biological and chemical treatment processes) can be used for a variety of purposes. Hence, it is necessary for each healthcare facility (already built or to be constructed) to clearly define what the intended purpose of the treated wastewater (i.e. effluent) is in the facility. Only then can the desired effluent qualities and the necessary treatment processes be determined.

Four broad categories of water use are recognised in the South African Water Act, namely being:

- Domestic (i.e. potable)
- Industrial
- Agricultural
- Recreational

These can further be divided into subcategories as described in the Department of Water Affairs Water Quality Guidelines (DWA WQG), Volumes 1 to 8.

The table below summarises (briefly) the desired qualities of water (or effluent) needed to be fit for use in the various areas of a healthcare facility and is done so such that it corresponds to the categories stipulated within the DWA guidelines for industrial use (vol. 3).

**TABLE 3: EFFLUENT QUALITY REQUIREMENTS FOR USE IN STATE HEALTHCARE FACILITIES**

Use	Effluent Category	DWA WQG Volume No.
Drinking	Potable	Vol. 1 – Domestic Water Use
Showers, wash hand basins, baths	Potable	Vol. 1 – Domestic Water Use
Make up water in cooling towers <sup>3</sup>	3	Vol. 3 – Industrial use
CSSD (autoclaves) <sup>4</sup>	3	Vol. 3 – Industrial use
Laundry	3	Vol. 3 – Industrial use
Evisceration tables	3	Vol. 3 – Industrial use
Kitchen*	3/4	Vol. 3 – Industrial use
Sluice Rooms*	3/4	Vol. 3 – Industrial use
Autopsy floors	4	Vol. 3 – Industrial use
Decontamination areas	4	Vol. 3 – Industrial use
Ablution – Urinals and toilets	4	Vol. 3 – Industrial use
Car wash bays	4	Vol. 3 – Industrial use
Irrigation	4	Vol. 3 – Industrial use, Vol. 4 – Irrigation
Fire-fighting**	4	Vol. 3 – Industrial use

\*Category 3 includes food preparation, cooking, cleaning of surfaces (table tops, walls, cutlery, instruments etc.), whilst category 4 is fit for washing of floors. It does not include human consumption.

\*\*Only acceptable if storage for fire-fighting services is completely separate from domestic supply. A single vessel (used for both fire-fighting and domestic supply) with an internal division will not be regarded as a separate supply. The inner surfaces of fire-fighting tanks and its distribution system using effluent of Category 4 must be treated appropriately to mitigate corrosion and biological proliferation.

<sup>3</sup> It is assumed that cooling towers are provided with the necessary filtration devices to ensure minimum water quality criteria are met when supplied with water of a Category 3 quality.

<sup>4</sup> It is assumed that autoclaves are provided with the necessary filtration devices to ensure minimum water quality criteria are met when supplied with water of a Category 3 quality to prevent the accumulation of dissolved solids.

**TABLE 4: WATER QUALITY REQUIREMENTS. DRINKING WATER EXCLUDING RADIOLOGICAL AND OTHER PHYSICAL/CHEMICAL REQUIREMENTS. MICROBIOLOGICAL REQUIREMENTS CONSIDER INDICATOR ORGANISMS ONLY.**

Parameter	Unit	Target water quality for healthcare facilities		
		Category 4	Category 3	Potable
Alkalinity	mg CaCO <sub>3</sub> / Litre	0-1200	0-300	50-100
COD	mg O <sub>2</sub> / Litre	0-75	0-30	-
Chloride	mg Cl / Litre	0-500	0-100	0-100
Iron	mg Fe / Litre	0-10	0-0.3	0-0.1
Manganese	mg Mn / Litre	0-10	0-0.2	0-0.05
pH		6-10	6.5-8.0	6-9
Silica	mg Si / Litre	0-150	0-50	-
Sulphate	mg SO <sub>4</sub> / Litre	0-500	0-200*	0-200
Suspended Solids	mg / Litre	0-25	0-5*	-
Total Dissolved Solids	mg / Litre	0-1600	0-450 <sup>5</sup>	0-450
Electrical Conductivity	mS/m	0-250	0-70	-
Total Coliform	/100mL	10	10	10
E. Coli	/100mL	0	0	0

\*To be re-evaluated if the facility has reported presence of Sulphur Reducing Bacteria (SRB) and Microbiologically Induced Corrosion (MIC).

Note: Table 4 is based upon Department of Water Affairs and Forestry, 1996, South African Water Quality Guidelines – Vol 3 (Cat. 4 and 3) and Vol 1 (Potable).

<sup>5</sup> May be revised. Between 450 and 1000 mg/Litre, water has noticeable salty taste, but is well tolerated. No effects on plumbing or appliances.

## 6. RAINWATER HARVESTING

Rainwater harvesting systems may consist of seven stages.

- i) Pre-filtration/screening
- ii) First flush diversion
- iii) Storage
- iv) Aeration<sup>6</sup>
- v) Micro filtration
- vi) Ultrafiltration
- vii) Disinfection and pH Correction

For rainwater used as a Category 4 effluent, stages 1 to 4 and stage 7 are necessary. For use as a Category 3 effluent, stages 1 to 5 and stage 7 are necessary. To be used for human consumption (i.e. domestic quality water), all seven stages are necessary. However, this is highly dependent on how the water is captured and stored as leachate through piping, paints and the overall condition of the collecting surface (among other aspects) contribute significantly to the rain water quality.

Prior to the undertaking of rainwater harvesting at any healthcare facility, rain water quality is to be determined through **representative** grab sample analysis.

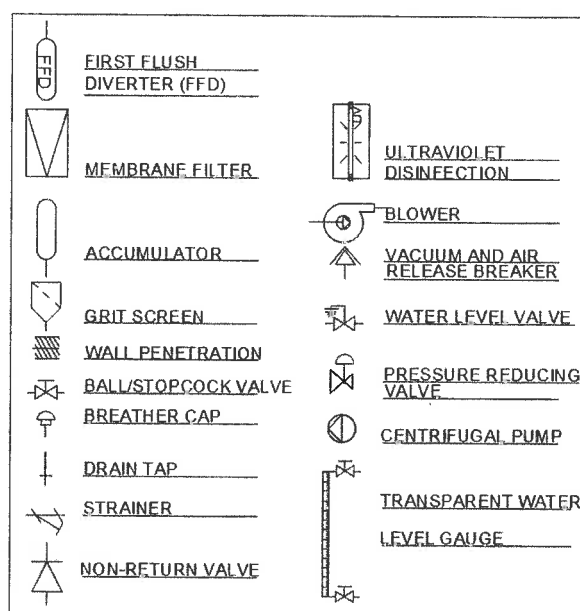


FIGURE 3: LEGEND USED FOR A TYPICAL RAINWATER HARVESTING INSTALLATION

<sup>6</sup> Where continuous aeration or recirculation is not possible (within the primary storage vessel) and it is anticipated that, because of underutilisation of the installation, water entering the tank may remain there for longer than 1 week, temporary provision shall be made for disinfecting the water through chlorination. For clear water, the tank will be dosed with free chlorine at approximately 2mg/l and twice that for turbid water (World Health Organisation, 2011).

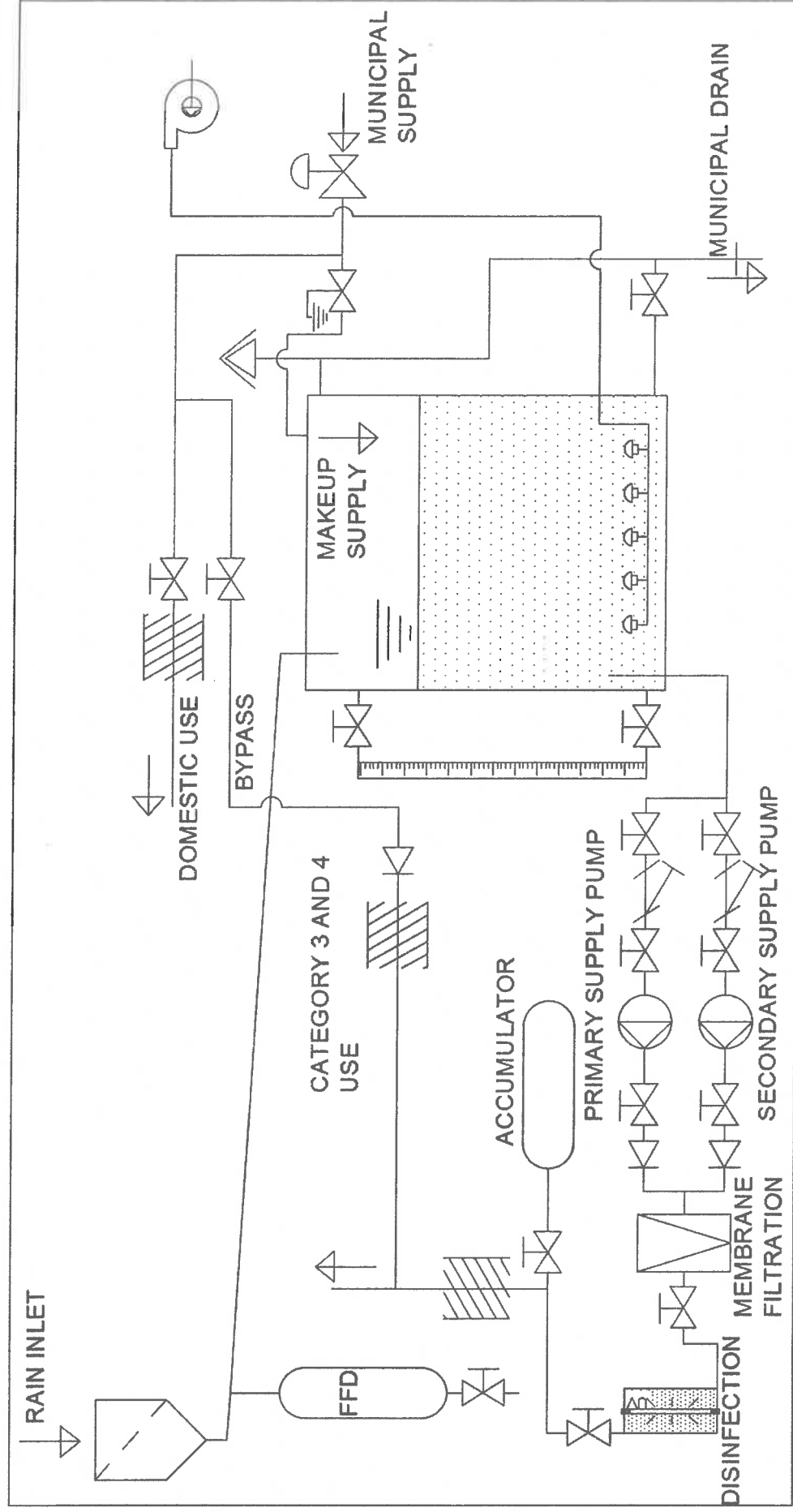


FIGURE 4: TYPICAL RAINWATER HARVESTING INSTALLATION.

## 6.1. PRE-FILTRATION

Pre-filtration must take place where water enters the gutter down comer, by means of a mesh filter (also referred to as a "leaf eater"). All gutters must be maintained, free of leaks, vegetation and birds' nests. Gutters or paints used to coat them must not contain lead as this may leach into the collected rainwater.



FIGURE 5: LEAF EATER

## 6.2. FIRST FLUSH DIVERSION

The holding vessel and leaf eater (i.e. pre-filter) must be placed in such a way as to allow a minimum slope of 1:10 for the interconnecting pipe with first flush diversion. The purpose of the diverter is to ensure dirt and organic matter lying on the roof gets separated from the water contained in the holding vessel. The diverter must be of a polypropylene construction. It must be provided with a ball (i.e. isolation) valve with a drain line directed into the municipal drain. The capacity of the diverter must be sized in accordance with the total (projected) roof area being served, such that the first 10mm of rainfall is captured by the diverter. For example, if the projected roof area is equal to 100m<sup>2</sup>, a diverter of 1 litre is required.

## 6.3. STORAGE

Ideally, this vessel (if it is the primary storage vessel) should be placed such that it is under shaded cover provided by a man-made structure and is not at risk of contamination by bird droppings. For this reason, designs whereby the mesh filter is located on the top and forms a part of the primary storage vessel will not be acceptable. The rain head inlet filter must be placed at the point where the roof gutter connects to the down-comer pipe feeding into the first flush diverter. Vessels smaller than 10 000L and constructed out of metal will not be acceptable. These must be of a polypropylene type material with a smooth black inner lining. Storage tanks larger than 10 000L may be constructed using either a polypropylene type material, a hot-dip galvanised steel plate construction (i.e. "Braithwaite" water storage tank) or from reinforced concrete. All steel fasteners used must also be hot-dipped galvanised. Contrary to polypropylene vessels (serving as primary storage), Braithwaite storage tanks do not need to be housed under a man-made structure. All vessels, whether of metal or non-metallic construction, must be sealed at the top. Municipal storage vessels may not, under any circumstances, be combined with rainwater storage, unless the rainwater has been treated specifically for the purposes of human consumption beforehand and has undergone and continues to undergo the necessary water quality tests as per SANS 241.

Due to the fact that independent roofed structures may occupy several areas on the erf of the healthcare facility, it is more than likely that several small storage vessels (< 750L) will be



needed to collect rainwater from each of these structures. The collected water must be transferred immediately to the primary storage vessel supplied with aeration to prevent degradation in water quality by means of submersible pumps. Pump protection must include dry running and overcurrent protection, along with automatic start/stop functionality. The surrounding landscape, if available, along with other disused storage spaces, such as empty swimming pools or ponds, should also be used as additional water storage. However, modifications should be made to mitigate risk of contamination through infiltration.

Vessel(s) must be located above ground level to allow for periodic scum removal and cleaning with ease. It must also be placed upon on a well-drained site not liable to flooding. Vessel(s) must be clearly marked to identify it as a rain water storage tank and that it is not fit for drinking. A sight glass (i.e. Perspex) with a protective (opaque) cover must be provided on the primary storage tank wall (top and bottom), to allow for visual inspection of water quality at any time. Other equipment to be included on the primary storage tank is a transparent level gauge and vacuum and air release valve. All vessels/tanks must (i) be supplied with an overflow discharge line near the top of the vessel and a drain tap at its base which must feed into the storm water drain; (ii) be sealed on the top with all vents screened to prevent birds and insects from entering the tank; (iii) be anchored at its base to prevent it from being dislodged when empty and experiencing high winds.

Total storage capacity at healthcare facilities, excluding surrounding landscape features (i.e. provided by tanks), should be designed by taking into consideration the following:

- The average amount of rainfall expected per year (example Figure 6)
- The building AND land extent
- The availability of land for rainwater storage
- The landscape design and its suitability for rainwater storage (eg. Slope)
- The water demand of the facility

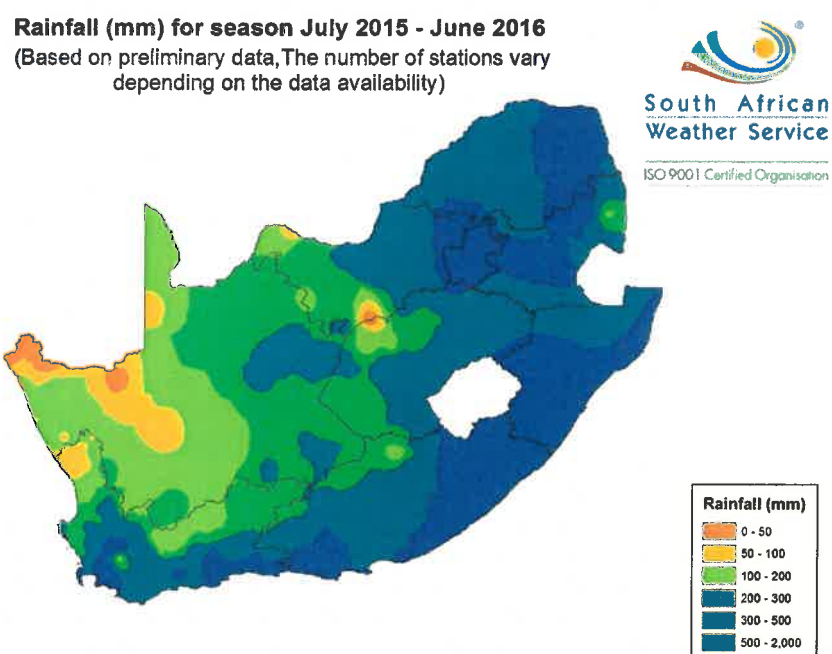


FIGURE 6: HISTORICAL RAIN MAP. SOUTH AFRICAN WEATHER SERVICE

## 6.4. AERATION

Aeration is not applicable to retention ponds or to man-made vessels if underutilisation is not expected. In all other instances, the design must include adequate and continuous aeration of the primary storage vessel, through the use of an air blower, to ensure anaerobic respiration does not take place, preventing the build-up of sludge and unpleasant odours. Using an air blower is seen as a cost effective solution. It is also possible that during times where the centrifugal (booster) pump does not need to provide pressure to the accumulator, it can continue to operate to provide the recirculation and aeration required. However, given that this would be a more energy intensive and complex solution, direct aeration through air injection is seen as a more appropriate solution. Aeration is to be supplied by a diaphragm pump and not centrifugal blowers, as the former is considered more energy efficient.

## 6.5. MEMBRANE FILTRATION

Membrane filtration must take place between the supply pump and accumulator, the degree of which is specified below.

- For Category 4 consumption, no filtration following storage is necessary.
- For Category 3 consumption, microfiltration using two inline strainers of at least 5 micron (connected in series).
- For domestic use (i.e. drinking quality), microfiltration, of at least 5 micron, must precede ultrafiltration. Similarly, reverse osmosis (and polishing) must be preceded by ultrafiltration.

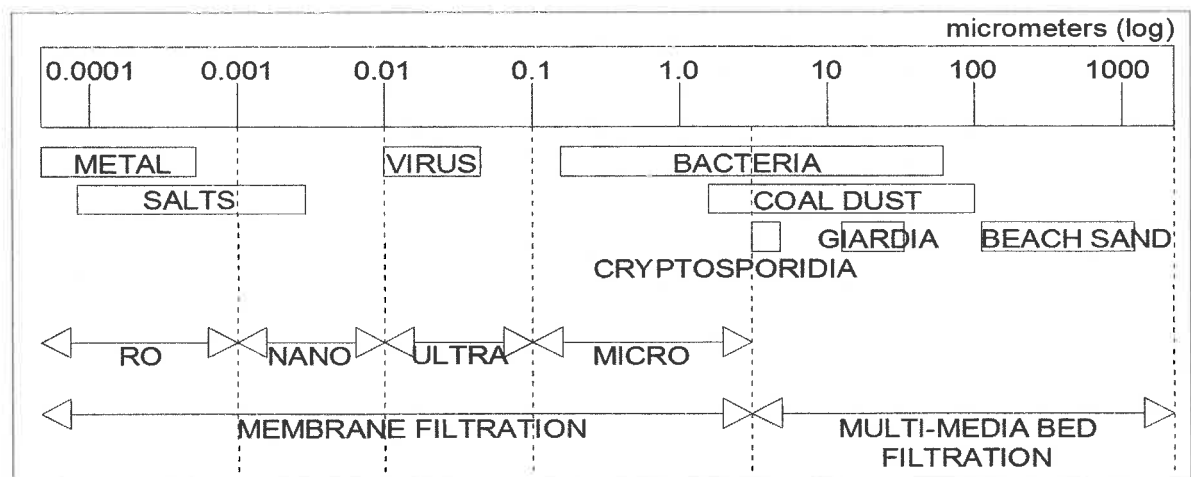


FIGURE 7: FILTRATION LEVELS

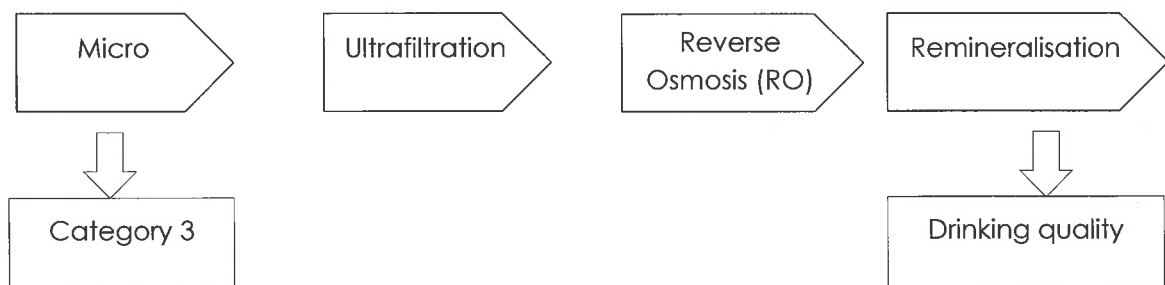


FIGURE 8: STAGES IN FILTRATION, FROM THE PRIMARY STORAGE VESSEL OUTLET, USING CAPTURED RAINWATER TO PRODUCE DESIRED EFFLUENT QUALITY

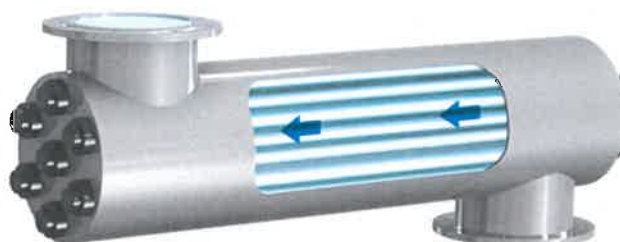
## 6.6. DISINFECTION & PH CONTROL

Acceptable means of disinfection following tertiary filtration are Ultraviolet Irradiation (UV), Chlorination and/or Ozonation. Furthermore, it must take place between the point of (treated) water storage and the point of supply, by means of UV as indicated in Figure 4.

Continuous disinfection through the use of chlorination will not be acceptable, unless it can be shown that (i) this will not have a negative impact on any wastewater treatment process downstream the point of supply (as this treated wastewater may be recycled), and (ii) sufficient hydraulic retention time is available within the water supply system (typically at least 30 minutes). A residual chlorine test kit used for regular monitoring (i.e. daily, weekly) of residual chlorine levels in the primary storage vessel must be included in the scope of supply.

Ultraviolet (UV) irradiation, when properly maintained, should however provide sufficient pathogen sterilisation. Only UV units making use of a grouped longitudinal lamp construction, such as in Figure 9, are acceptable. UV disinfection shall include:

- Microfiltration, upstream of the UV device, by means of an inline 20 micron Y-strainer (or better). Generally this is installed between the pump and the UV unit.
- A second stage pre-filter (1 micron) before the UV unit to reduce parasitic cysts such as *Cryptosporidium* and *Giardia* that are more resistant to UV light than bacteria and viruses. (Note: this filtration level is not required in the case of ultrafiltration provided upstream of the final holding tank and UV disinfection.)
- A built in light sensor that can monitor the UV intensity, connected to an alarm system to alert the user in case of low UV level
- A safety control system that can shut off the water supply in case of a low UV level alarm or loss of power
- A constant power supply of sufficient capacity to suit the system



**FIGURE 9: INLINE UV DEVICE**

In some areas the pH of rainwater may be low enough to promote corrosion in copper piping if left untreated. If the pH is found to lie below the minimum figures specified in Table 4, pH balancing must be performed using Sodium Bicarbonate. For small primary healthcare facilities including EMS, pathology Labs, clinics and CDC's, manual pH correction will be undertaken by maintenance staff. For larger facilities including CHC's and hospitals, an automated dosing system is acceptable.

## 6.7. PUMPING

Water is to be supplied to the facility from the primary storage vessel (i.e. final holding tank) by means of a primary and secondary (single speed) centrifugal booster pump with automatic start/stop functionality and dry running and overcurrent protection. A 20 micron inline strainer must be installed upstream of the primary and secondary supply pump. Tertiary filtration followed by disinfection, as described in section 6.5 and 6.6 respectively, will take place after the pumps and prior to entering the accumulator. The primary supply pump will be sufficient only to top up the accumulator and is not intended to meet peak demand. The capacity of the primary supply pump will not exceed 40% of the peak demand. A secondary, larger, external supply pump, also connected to the accumulator, will be on standby and only come into operation to meet the peak demand of the facility. The pumps must draw water no less than 100mm and no more than 150mm from the bottom of the primary storage vessel.

The capacity of the accumulator tank will not exceed 1.5 times the capacity of the (peak demand) pump (rated in litres per minute). The accumulator is to be maintained at a pressure suitable to the facility being evaluated, but must not exceed 6 bar. The surge tank must be of metal construction and provided with an isolation valve and pressure relief valve. As this tank may be regarded as a pressure vessel, it must conform to all South African pressure equipment regulations.

Non-metallic piping, as per SANS10252-1:2016, must be utilised throughout the wastewater treatment facility. The only exception to this is if pressure requirements of equipment (such as the supply pump and accumulator) dictate the need for metallic piping. This is done to mitigate the risk of theft. It is also recommended that piping between the accumulator and the treated water supply line are flexible.

All equipment installed, particularly expensive components such as the pumps, must be installed in such a way as to mitigate the risk of theft. These same components may also use non-metallic components, such as hardened plastic pump impellers, to decrease their street value.

## 6.8. RETICULATION

Rain water harvesting systems utilised at healthcare facilities must make use of a design similar to that as shown in Figure 4, with sufficient redundancy to allow for the bypassing of the harvesting system if necessary. The design must ensure that cross contamination (of the municipal supply line) is not possible, by means of strategically placed non-return valves.

All equipment and installations must be accessible to allow for easy maintenance. Specific pieces of equipment at risk of theft, such as the pump and control instrumentation, must be safeguarded. Furthermore, all installations exposed to the elements must be weather proof.

## 6.9. METERING

Municipal water supplied to health facilities should include a main isolation valve, strainer with blow down, bulk water meter, pressure gauge, non-return valve and stop valve all mounted above ground. The pressure gauge shall be of good quality with stainless steel body and rated at double the average municipal supply pressure in order to accommodate surges. The gauge shall be fitted with a petcock.

All plumbing appurtenances, as mentioned, shall be mounted on a light mesh reinforced concrete slab, in a prominent position within 3 m of the ERF boundary in close proximity to the facility's entrance gate. The mains isolation valve shall be clearly labelled "Municipal Stop Cock" and shall be easily identified and accessible by staff in cases of emergency. The label shall have letters at least 25mm high and shall be permanently mounted close to the stop cock and shall be made from weather proof, durable and noncorrosive materials i.e. Perspex or chromadek.

The bulk water meter and pressure gauge shall be mounted close together under a pad-lockable, galvanised, vandal proof steel mesh cage and rigidly mounted on the slab with chemical bolts. The cage must include an aperture through which the bulk meter can be read without opening / unlocking the cage.

For water supplies to small facilities such as Satellite Clinics, the municipal water meter should be an Elster V100 (PSM) mounted in a vertical wall mounted meterbox on an external wall near the main entrance to the building, at eye level approximately 1600mm above ground in a position that can easily be read for monitoring / billing purposes. For large bulk water supplies between 40mm and 150mm, the water meter should be an Elster Kent Helix H4000 bulk water meter with Emeris PR7 pulse pickup for automatic meter reading.

For existing facilities, if the mains (i.e. municipal) supply meter is not installed or is not of the kind as described above, then a second meter should be installed conforming to the above.

## 6.10. WATER QUALITY ASSURANCE

Refer to section 7.8 for measures required to ensure sufficient water quality. If (untreated) harvested rainwater is not stored within a man-made structure isolated from the surrounding elements, as is such the case with open retention ponds forming part of the surrounding landscape, water tests on a bi-weekly basis through grab sample analysis at the retention pond must be made (as per SANS 241).

## 7. WATER RECYCLING

### 7.1. SOURCES OF WASTEWATER

The table below provides a summary of the various waste water sources, as described in Table 2, within each kind of healthcare facilities. Figure 10 illustrates the typical wastewater treatment process (for grey and black water).

TABLE 5: CLASSIFICATION OF WASTEWATER SOURCES

Waste Water Source	EMS			Forensic Pathology Lab			Clinic & CDC			CHC & Hospitals		
	Black	Grey	Hazardous	Black	Grey	Hazardous	Black	Grey	Hazardous	Black	Grey	Hazardous
Staff showers / baths	-	X	-	-	X	-	-	X	-	-	X	-
Staff Urinals & Toilets	X	-	-	X	-	-	X	-	-	X	-	-
In-patient showers / baths	-	-	-	-	-	-	-	-	X	-	-	X
Sluice room	-	-	X	-	-	-	-	-	X	-	-	X
Outpatient Urinals & Toilets	-	-	-	-	-	-	X	-	-	X	-	-
Inpatient Urinals & Toilets	-	-	-	-	-	-	-	-	X	-	-	X
Ambulance Wash Bay <sup>7</sup>	-	X	-	-	-	-	-	-	-	-	-	-
Kitchen	X	-	-	X	-	-	X	-	-	X	-	-
Wet (i.e. Autopsy) room	-	-	-	-	-	X	-	-	-	-	-	-
Basins (non-sluice)	-	X	-	-	X	-	-	X	-	-	X	-
Staff room	-	-	-	-	X	-	-	X	-	-	X	-
Laundry	-	-	-	-	-	-	-	-	-	-	X*	-
CSSD (autoclaves)	-	-	-	-	-	-	-	X	-	-	X	-
Renal Dialysis Filt. Plant	-	-	-	-	-	-	X	-	-	X	-	-
Pool backwash	-	-	-	-	-	-	-	-	-	-	-	X

Note: All healthcare facilities implementing wastewater recycling must ensure that all drain points are clearly marked to indicate the type of waste which can be received. All staff must be trained such that they become fully aware of the requirements when disposing of waste products into water streams at the facility.

\*No laundry in CHC

<sup>7</sup> Deemed hazardous if large amounts of blood.



## 7.2. RETICULATION

The supply reticulation network of CDC's, CHC's and hospitals (Figure 11), coming from the main municipal supply, must be split into four supply lines (black, grey, domestic and hazardous) after it enters the erf boundary of the facility and *downstream* of the main municipal meter. These facilities making use of water treatment plants with treated wastewater supplied to parts of the facility for Category 3 or 4 use must still allow for the use of a water supply line connected directly to the municipal mains (with an isolation valve and non-return valve). No possibility for cross contamination between the municipal supply and the water treatment plant discharge must exist. Unless specified otherwise, levered isolation ball valves will be the standard isolation valve used throughout the plant and reticulation network.

Use of grey water and black water recycling systems will require a dual sewerage reticulation network, with a bypass line (and *diaphragm-type* isolation valve) allowing for direct discharge into municipal drains in the event that maintenance works are required on the treatment plant. This isolating valve in the bypass line must be located in such a way as to prevent the settling and build-up of (black or grey) wastewater in the bypass line when it is not in use.

All new facilities should be designed in accordance with this technical memorandum. For existing CDC's, CHC's and hospitals, the municipal supply network and the sewerage reticulation network will need to be retrofitted. For facilities smaller than a CDC, only the splitting of the sewerage reticulation network must be considered, the intention of which is to allow the smaller facilities to make use of buckets and other manual mechanisms for the purposes of recycling grey water for use in ablution facilities and irrigation.

All sewerage piping forming part of the black water system must be painted with black banding. Similarly, piping forming part of the grey water sewerage reticulation network must be painted with grey banding. Directions of flow must be indicated on the pipe and must be clearly visible. Signage must also be strategically placed to ensure that users of the facility are made aware of water which is and is not fit for human consumption, indicated at each tap and what kind of waste can be disposed of at each basin/drain.

Cross contamination (through equipment servicing both systems, such as the aeration system) between the treatment vessel and final storage vessel must not be possible. For instance, where the aeration system is concerned, this can be achieved by aerating through the top of the storage and treatment vessels. This will prevent any partially treated wastewater in the treatment vessel from back feeding through the air lines and into the final storage tank in the event that air pressure is lost in the aeration system.

Reticulation must allow for easy cleaning and flushing of the treatment plant. As healthcare facilities make use of disinfectants more regularly than domestic households, it may occur that disinfectant by-products (such as Trihalomethanes) accumulate in the system. The by-products, along with other non-biodegradable, insoluble constituents, must be flushed out of the system directly into the municipal drains.



### 7.3. PUMPING

Treated water is to be supplied to the facility from the primary storage vessel (i.e. final holding tank) by means of a primary and secondary (single speed) centrifugal booster pump with automatic start/stop functionality and dry running and overcurrent protection. A 20 micron inline strainer must be installed upstream of the primary and secondary supply pump. Both pumps will be connected to a hydropneumatic tank (i.e. accumulator). The primary supply pump will be sufficient only to top up the accumulator and is not intended to meet peak demand. The capacity of the primary supply pump will not exceed 40% of the peak demand. A secondary, larger, external supply pump, also connected to the accumulator, will be on standby and only come into operation either to meet the peak demand of the facility or fire-fighting requirements. The pumps must draw water no less than 100mm and no more than 150mm from the bottom of the vessel.

The capacity of the accumulator tank will not exceed 1.5 times the capacity of the (*peak demand*) pump (rated in litres per minute). The accumulator is to be maintained at a pressure suitable to the facility being evaluated, but must not exceed 6 bar. The accumulator must be of metal construction and provided with an isolation valve and pressure relief valve. As this tank may be regarded as a pressure vessel, it must conform to all South African pressure equipment regulations.

Non-metallic piping, as per SANS10252-1:2016, must be utilised throughout the wastewater treatment facility. The only exception to this is if pressure requirements of equipment (such as the supply pump and accumulator) dictate the need for metallic piping. This is done to mitigate the risk of theft. It is also recommended that piping between the accumulator and the treated water supply line is flexible.

All equipment installed, particularly expensive components such as the pumps, must be installed in such a way as to mitigate the risk of theft. The equipment may also use non-metallic components, such as hardened plastic pump impellers, to decrease their street value.

### 7.4. METERING

Municipal water supplied to health facilities should include a main isolation valve, strainer with blow down, bulk water meter, pressure gauge, non-return valve and stop valve all mounted above ground. The pressure gauge shall be of good quality with stainless steel body and rated at double the average municipal supply pressure in order to accommodate surges. The gauge shall be fitted with a petcock.

All plumbing appurtenances, as mentioned, shall be mounted on a light mesh reinforced concrete slab, in a prominent position within 3 m of the ERF boundary in close proximity to the facility's entrance gate. The mains isolation valve shall be clearly labelled "Municipal Stop Cock" and shall be easily identified and accessible by staff in cases of emergencies. The label shall have letters at least 25mm high and shall be permanently mounted close to the stop cock and shall be made from weather proof, durable and noncorrosive materials i.e. Perspex or chromadek.

The bulk water meter and pressure gauge shall be mounted close together under a pad-lockable, galvanised, vandal proof steel mesh cage and rigidly mounted on the slab with

chemical bolts. The cage must include an aperture through which the bulk meter can be read without opening / unlocking the cage.

For water supplies to small facilities such as Satellite Clinics, the municipal water meter should be an Elster V100 (PSM) mounted in a vertical wall mounted meterbox on an external wall near the main entrance to the building, at eye level approximately 1600mm above ground in a position that can easily be read for monitoring / billing purposes. For large bulk water supplies between 40mm and 150mm, the water meter should be an Elster Kent Helix H4000 bulk water meter with Emeris PR7 pulse pickup for automatic meter reading.

For existing facilities, if the mains (i.e. municipal) supply meter is not installed or is not of the kind as described above, then a second meter should be installed conforming to the above.

To facilitate the installation of any water treatment plants at existing and newly built facilities, conventional metering of Class A in each of the waste streams (i.e. "grey" and "black" metering as in Figure 11) is needed. By assuming a 1:1 supply-waste ratio, the need for robust and expensive flow meters in the sewerage reticulation network to quantify wastewater production (necessary for the sizing of a wastewater treatment plant) is avoided. Furthermore, it makes provision for the future introduction of treated wastewater into the appropriate areas of the healthcare facility.

Flow direction is to be indicated on the water supply lines. Labels, as described above, will be used to indicate the area of the hospital to which water is supplied, whilst banding (painted) will indicate which waste stream it belongs to. "Grey" supply lines will make use of grey banding, "black" supply lines with black banding, "domestic" supply lines with blue banding and "hazardous" supply lines with yellow banding.

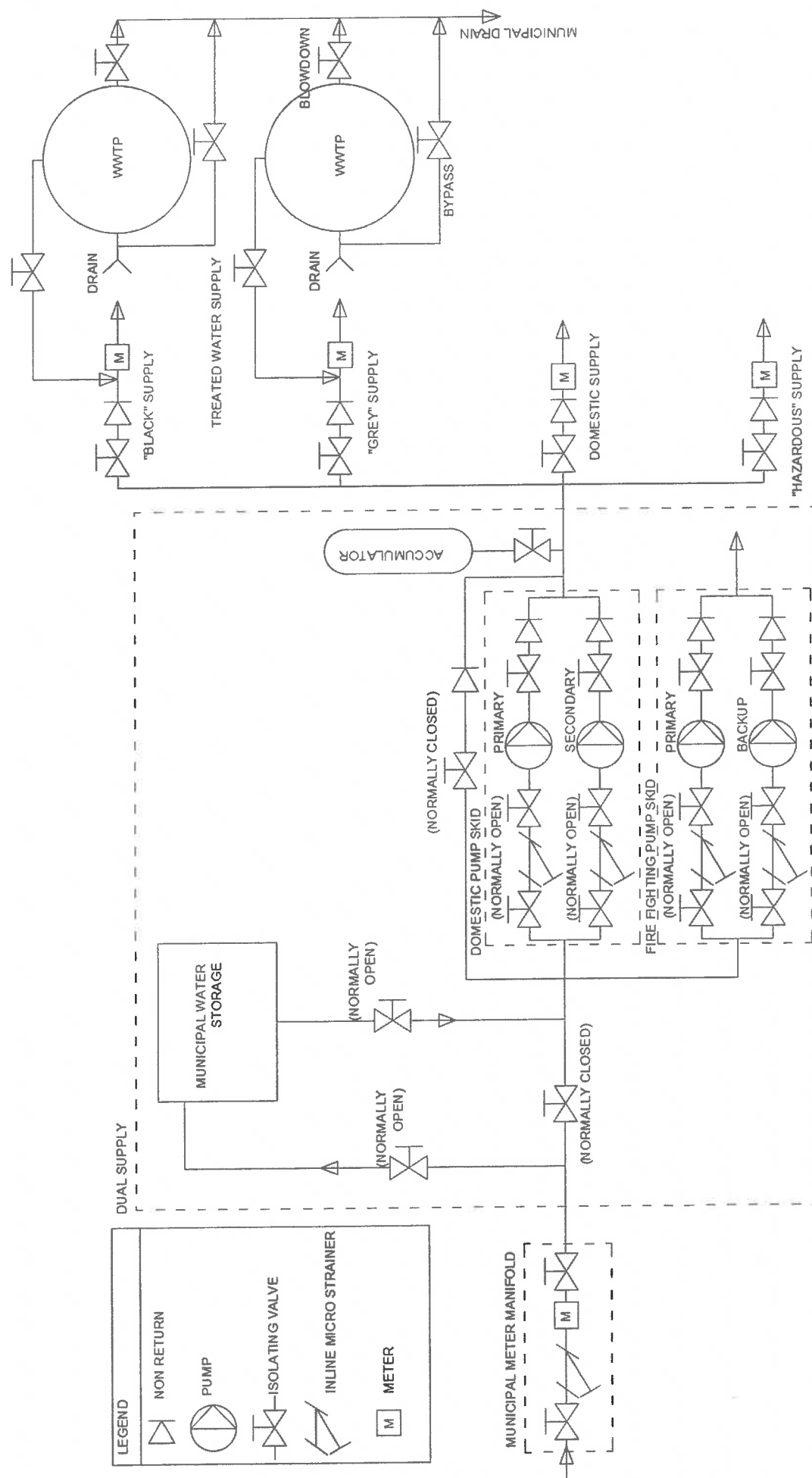


FIGURE 11: REQUIRED STRUCTURE OF THE MUNICIPAL SUPPLY AND DRAINAGE RETICULATION NETWORK TO CATER FOR WASTEWATER TREATMENT FACILITIES

## 7.5. TREATMENT

Wastewater recycling systems may consist of four stages, all of which must be applied for Category 3 and 4 effluent production from grey and black waste water.

- i) Pre-filtration/screening
- ii) BOD / COD reduction
- iii) Filtration
- iv) Disinfection

Due to the significant increase in cost when treating waste water for the purposes of human consumption, repurposing of the wastewater streams for human consumption and bathing will not be considered. The treatment process stages discussed below apply to both black and grey wastewater treatment, which must make use of all treatment processes.

Prior to the undertaking of wastewater treatment at any healthcare facility, wastewater quality is to be determined through **representative** grab sample analysis by the WWTP designer. This must be clearly stated during the tendering process, to ensure that the WCG mitigates risk with regards to wastewater treatment plant performance.

### 7.5.1 PRE-FILTRATION

Filtration will be applied both upstream and downstream the BOD/COD reducing wastewater treatment plant. Acceptable pre-filtration technologies upstream of the reducing plant, are screen and mesh filters, multi-media bed filters and lint shakers which are robust and easily maintained.

For laundry handling facilities dedicated to the washing of dirty linen supplied by primary healthcare facilities, the lint content in the wastewater may pose a challenge and must be considered when selecting filtration devices. In such instances, a lint shaker (i.e. mesh pre-filter), followed by a multi-media filter, must be used to filter the wastewater prior to entering the wastewater treatment plant.

For black water systems receiving wastewater from kitchens, the first level of filtration will take place at the main header pipe into which each grey water (sewerage) pipe (from the various rooms of the facility) feeds, upstream of the BOD/COD reduction vessel. This (primary) filter must consist of a particulate filter and also allow emulsified fats and oils to float to the surface for easy removal. Removal of particulates, fats and oils must be facilitated automatically and should not require manual intervention. The design of the pre-filter must be such that only manual cleaning will be required no more frequently than on a monthly basis.

### 7.5.2 BOD/COD REDUCTION

Treatment processes to be considered for the purposes of wastewater recycling at healthcare facilities will be limited to a predominantly biological treatment process for Biological Oxygen Demand (BOD) or Chemical Oxygen Demand (COD) reduction, such as the Activated Sludge Packaged Treatment Plant (ASPTP) or the Membrane Biological Reactor (MBR), with mechanically assisted aeration. Treatment plants operating only through Reverse Osmosis (RO) or electrodialysis are not acceptable. Treatment processes relying upon a continuous supply of coagulants, flocculants and anti-surfactants are not acceptable.

Removal of BOD/COD must take place in a non-metallic, polypropylene vessel. The design of this vessel must not contain any moving parts and ideally make use of circulation by gravitation. All components located in the interior of the vessel must be non-metallic to mitigate corrosion. Aeration must be provided through the top of the vessel by means of an air blower supplying air into the bottom of the vessel, the aeration injectors of which must be robust enough to not require replacement or cleaning (due to fouling) more than once during the lifetime of the treatment plant. Aeration by means of circulation of waste water within the vessel will not be acceptable as this is regarded as being more energy intensive than an air blower. Routing must also be provided around the vessel in case of inadvertent spilling. Each compartment within the treatment vessel must have drain lines with isolating valves, feeding directly into municipal mains, to allow for blow through of the system (preventing the build-up of inorganic, non-biodegradable and insoluble constituents of the wastewater).

Decentralised wastewater treatment systems harnessing natural biological processes facilitated within a packaged plant<sup>9</sup>, using natural circulation by gravitation through a baffled reactor, are seen as the ideal technology for state healthcare facilities. This type of treatment technology is regarded as consuming small amounts of energy and requires little maintenance. Purpose built wetland type solutions for the (biological) treatment of grey water, such as the Organica FCRTM, may also be an attractive solution for grey water recycling and would not be discounted as a possible solution at healthcare facilities.

All waste water treatment solutions offered must be capable of handling an influent intermittently laden with Phosphates (from non-phosphate free washing powders), Sodium Hypochlorite (i.e. fabric softeners and JIK), anionic surfactants and other substances that could result in toxic shock, *without* the need for reseeded. It must be proven during the design stage and during commissioning that the WWTP can meet this requirement. However, the WWTP must still be designed to allow for any manual reseeded which may be required, which can be performed by existing maintenance staff at the facility (with minimal training for the handling of the wastewater treatment plant) to maintain or restore plant performance.

### 7.5.3 FILTRATION

Downstream the BOD/COD reducing plant, in the case of ASPTP, ultrafiltration (i.e. post-filtration) must be provided upstream of the final holding tank to produce effluent of Category 3 quality. Micro-filtration, using a 20 micron filter, must then precede ultrafiltration (0.1-0.01µm). This applies to both grey water and black water treatment plants and the production of Category 3 effluent. For the production of Category 4 effluent, pre-filtration requirements are the same as for Category 3. However, for tertiary (i.e. post) filtration, a multi-media bed filtration device should suffice (i.e. NO ultrafiltration should not be necessary). Refer to Figure 7 for filtration scale.

Although reverse osmosis (RO) removes a large spectrum of contaminants such as dissolved salts, lead, mercury, Iron, Calcium, Cysts and Asbestos, it does not remove pesticides, solvents or volatile organic chemicals (such as Chlorine, Radon, Trihalomethanes etc). Many manufacturers of RO membranes will state the following:

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<sup>9</sup> 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<sup>3</sup>/day. It typically includes equipment largely constructed and packaged off site and brought onsite for installation.

*"Notice: The use of this product in and of itself does not necessarily guarantee the removal of cysts and pathogens from water. Effective cyst and pathogen reduction is dependent on the complete system design and on the operation and maintenance of the system."*

Hence, considering the use of RO should only be warranted in very specific cases as a premium is usually paid for this technology. In all other instances, no membranes with pore sizes smaller than 0.01  $\mu\text{m}$  will be necessary in any treatment plant, including any tertiary stages, utilised by the WCGH, unless specific wastewater conditions (such as excessively high COD and/or Total Dissolved Solids, i.e. TDS, content,  $>300\text{mgO}_2/\text{l}$  and  $> 2000\text{mg/l}$  respectively) and desired effluent quality warrant its use. For instance, this may be the case in laundry handling facilities, which should then be treated as producing black water.

As the filtration devices will require regular cleaning, these must be placed in areas which are also accessed with ease and provide sufficient space for maintenance or replacement.

#### 7.5.4 DISINFECTION

Acceptable means of disinfection following tertiary filtration are Ultraviolet Irradiation (UV), Chlorination and/or Ozonation. Disinfection must take place immediately following COD/BOD reduction and membrane filtration. Furthermore, it must take place between the point of (treated) water storage and the point of supply, by means of UV as indicated in Figure 10.

Continuous disinfection through the use of chlorination will not be acceptable, unless it can be shown that (i) this will not have a negative impact on the treatment process downstream the point of supply (as this treated wastewater may be recycled once again), and (ii) sufficient hydraulic retention time is available with the water supply system (typically at least 30 minutes). A residual chlorine test kit used for regular monitoring (i.e. daily, weekly) of residual chlorine levels in the final holding tank must be included in the scope of supply.

Ultraviolet (UV) irradiation, when properly maintained, should however provide sufficient pathogen sterilisation. Only UV units making use of a grouped longitudinal lamp construction, such as in Figure 9, are acceptable. UV disinfection shall include:

- Microfiltration, upstream of the UV device, by means of an inline 20 micron Y-strainer (or better). Generally this is installed as indicated in Figure 10
- A second stage pre-filter (1 micron) before the UV unit to reduce parasitic cysts such as *Cryptosporidium* and *Giardia* that are more resistant to UV light than bacteria and viruses. (Note: this filtration level is not required in the case of ultrafiltration provided upstream of the final holding tank and UV disinfection.)
- A built in light sensor that can monitor the UV intensity, connected to an alarm system to alert the user in case of low UV level
- A safety control system that can shut off the water supply in case of a low UV level alarm or loss of power
- A constant power supply of sufficient capacity to suit the system

If the pH of the treated effluent is found to lie below the minimum figures specified in Table 4, pH balancing must be performed using Sodium Bicarbonate. For small primary healthcare including EMS, pathology Labs, clinics and CDC's, manual pH correction will be undertaken by maintenance staff. For larger facilities including CHC's and hospitals, an automated dosing system will be acceptable.

## 7.6. STORAGE

As a minimum, black and grey water treatment plants and storage vessel(s) must be housed above ground within a permanently fenced, roofed and secure structure at the healthcare facility. The area in which it is housed must be well ventilated, not prone to flooding and accessible by road. The burying of packaged treatment plants into the ground may only be considered in extreme circumstances, such as the threat of theft/vandalism and a highly reliable design. In both cases however, attention must be paid to accessibility, for instance in the event of plant failure or routine de-sludging which would require accessibility for sludge/waste removal vehicles.

Water treatment plant vessels must be of a polypropylene type material with a smooth black inner lining, fit for the (short term) containment of water which is of a domestic, grey or black quality containing a medium chemical content. Provision shall be made in the storage tank for the installation of a sampling tap situated at a point not less than 50 mm and not more than 150 mm above the internal floor of the tank.

Vessels may not be used with the sole intention of storing untreated, raw (black or grey) wastewater. They may only be used for the purposes of facilitating the in-situ treatment of the wastewater and for the storage of treated wastewater. Sufficient routing/drainage must be provided around the base of the vessel(s), maintained at atmospheric pressure, in case of inadvertent spilling and to facilitate blow-through of the vessel(s).

Treated wastewater which has gone through all treatment stages described above must be stored in a second storage vessel which is completely separate from the BOD/COD reducing plant. This (primary storage) vessel must be clearly marked to identify it as a treated grey/black water storage tank and that it is not fit for drinking. This vessel should be located such that it is under shaded cover provided by a man-made structure and is not at risk of contamination by bird droppings.

Vessels smaller than 10 000L and constructed out of metal will not be acceptable. These must be of a polypropylene type material with a smooth black inner lining. Storage tanks larger than 10 000L may be constructed using either a polypropylene type material or a hot-dip galvanised steel plate construction (i.e. "Braithwaite" water storage tank). All steel fasteners used must also be hot-dipped galvanised. Contrary to polypropylene vessels (serving as primary storage), Braithwaite storage tanks do not need to be housed under a man-made structure. All vessels, whether of metal or non-metallic construction, must be sealed at the top. Municipal storage vessels may not, under any circumstances, be combined with treated wastewater storage vessels.

Vessel(s) must be clearly marked to identify their function and that the water contained therein is not fit for human consumption. A sight glass (i.e. Perspex) with a protective (opaque) cover must be provided on the primary storage tank wall (top and bottom), to allow for visual inspection of water quality at any time. Other equipment to be included on the primary storage tank is a transparent level gauge and vacuum and air release valve. All vessels/tanks must (i) be supplied with an overflow discharge line near the top of the vessel and a drain tap at its base which must feed into the storm water drain; (ii) be sealed on the top with all vents screened to prevent birds and insects from entering the tank; (iii) be anchored at its base to prevent it from being dislodged when empty and experiencing high winds.

Where continuous aeration (through the use of an air blower) is not possible and it is anticipated that, because of underutilisation of the installation, water entering the primary storage tank may remain there for longer than 1 week, temporary provision shall be made for disinfecting the water through chlorination. Water contained within the primary storage vessel, maintained at atmospheric pressure, must be of sufficient quality to be regarded as a Category 3 effluent.

## 7.7. CAPACITY

For existing facilities, sizing of the water treatment systems will be based upon actual flow measurements, taken over a period of 1 year, made within the grey and black water waste streams, as indicated in Figure 11. Hence, the first priority of any existing facility is to retrofit their supply and drainage network.

For new facilities, the consultant will rely upon both field measurement data of existing facilities (if available), along with a statistical analysis based upon the expected daily headcount and the frequency of usage for pieces of equipment in the facility using water (SANS 10252-1) which lie within the black and grey waste streams. This analysis is to be disclosed fully to WCG.

## 7.8. WATER QUALITY ASSURANCE

Prior to the undertaking of wastewater treatment at any healthcare facility, (treated and untreated) wastewater quality is to be determined through representative grab sample analysis. All sample analyses are to be performed in accordance with SANS 241 by an ISO 17025 Accredited Laboratory. For a comprehensive *drinking* water sample analysis, a single representative sample pack must include: 2x40ml vials, 1xHNO<sub>3</sub> preserved 50ml plastic bottle(filtered), 1xH<sub>2</sub>SO<sub>4</sub> preserved 50ml plastic bottle, 1xNaOH preserved 50ml plastic bottle and 1x250ml plastic bottle (unpreserved). For water sample analyses required for non-potable applications (i.e. Category 3 and 4), ordinary plastic containers (unpreserved) shall suffice.

To ensure conformance of treated wastewater quality, tests must be performed using a (manual) grab sample and laboratory analysis, with samples taken from the final storage tank. No online measurement of water quality is required. Visual inspection is to be conducted on a daily basis by the responsible person(s) assigned by the facility. The target water quality for use as a Category 3 effluent is presented in Table 4. This does not consider any chlorination required for underutilised installations (i.e. volume not utilised within 1 week), in which case, for clear water, vessels must be dosed with free chlorine at approximately 2mg/l and twice that for turbid water (World Health Organisation, 2011). Chlorination using chlorine gas will not be acceptable, and must be performed using Chlorine in a solid granulated form.

Grab samples must be taken from the sampling tap provided for in the final storage vessel and sent for laboratory analysis for assessment on a monthly basis. Areas posing any infection risk to in-patients (through aerosolization) and deemed to make use of Category 3 effluent as per Table 3, such as sluice rooms adjacent to operating theatres, shall make use of ultrafine membrane filtration at the tap fittings to ensure effective pathogen removal. Water quality tests from these same fittings must be performed on a monthly basis.



Basins in areas of a healthcare facility housing in-patients must be supplied with water from the "domestic supply" line as indicated in Figure 11, as they may inadvertently use tap water for drinking. In all other areas of the facility, basins are supplied using treated wastewater (Category 3), feeding into the "grey" and "black" supply lines as indicated in Figure 11. Drinking water may be provided by water towers using air-to-water generation technology. (Single 30L/day units vary in price between R25 000.00 and R28 000.00 excl. VAT, with rental options available as well, costing between R800.00 and R1000.00 per month).

If water treatment and re-use with a dual supply (and drainage) reticulation network is to be implemented at a healthcare facility, significant effort should be made to ensure that water consumption of high (potable) quality is kept to an absolute minimum whilst ensuring the health and well-being of patients, staff and the public. This can be done by:

- Strategic placement of drinking water towers,
- Use of chlorination tablets in toilet cisterns
- Membrane filtration in high risk areas, such as ICU's, scrub basins and sluice rooms adjacent to operating theatres
- Signage at each point of supply
- Awareness campaigns

## 8. TECHNOLOGIES

Several technologies exist for the purposes of wastewater treatment. The summary below provides technologies which are seen as being the most applicable to meeting the needs of WCGDOH. Along with the requirements given in the preceding chapters (such as biological treatment), preference is given to technologies which can be manufactured locally.

### 8.1. ACTIVATED SLUDGE PACKAGED TREATMENT PLANT (ASPTP)

This technology utilises a process whereby sewage and industrial wastewater are treated by a biological floc composed of bacteria and protozoa under mechanically assisted aeration.

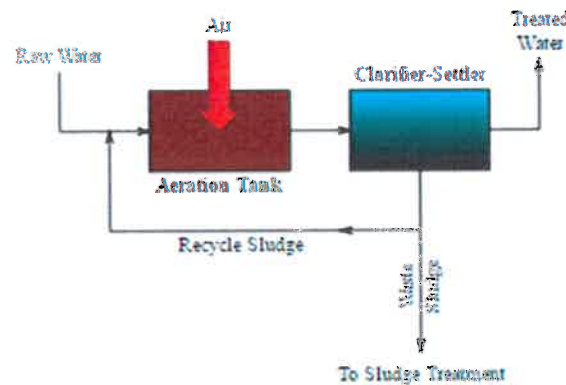


FIGURE 12: BASIC TREATMENT PROCESS INVOLVED IN ACTIVATED SLUDGE TREATMENT PLANTS

Packaged treatment plants, processing less than 2 000 m<sup>3</sup>/day, make use of a centralised treatment processes (aeration, clarification) contained in a single compartmentalised vessel. Unlike the figure above, these may consist of anaerobic, anoxic, aerobic and clarification stages. Sludge, containing the microorganisms which treat the wastewater, is recycled back to the front of the treatment process which would otherwise be low in microbiological content but high in suspended solids. A packaged plant utilising all of these stages is seen as the most effective solution to wastewater treatment. This treatment plant has a large presence in both grey water and black water treatment.

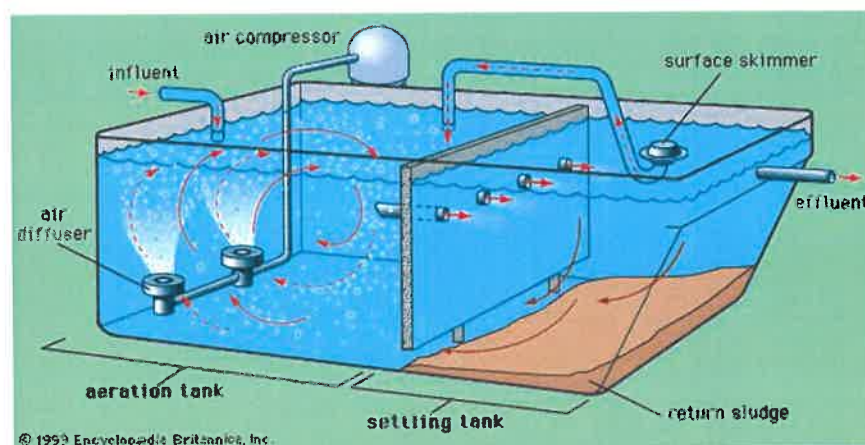


FIGURE 13: TYPICAL PACKAGED WASTE WATER TREATMENT PLANT MAKING USE OF THE ACTIVATED SLUDGE TREATMENT PROCESS

## 8.2. MEMBRANE BIOLOGICAL REACTOR (MBR)

A membrane biological reactor makes use of the same fundamental biological process as an activated sludge treatment plant. However, the difference lies in the replacing of the clarification/sedimentation stage with ultrafiltration (i.e. membrane filtration) either within the aeration tank (referred to as a submerged MBR) or in a side stream separate to the aeration tank. Although, filtration placed directly within the aeration tank is seen as the most economical as it mitigates the scaling and fouling of the membranes more effectively. However, these filters must be purged by reverse flow on a regular basis to maintain their performance. Hence, the advantage of a separate ultrafiltration process is that it would allow for “on-line” cleaning of membrane banks without impacting the wastewater treatment process.

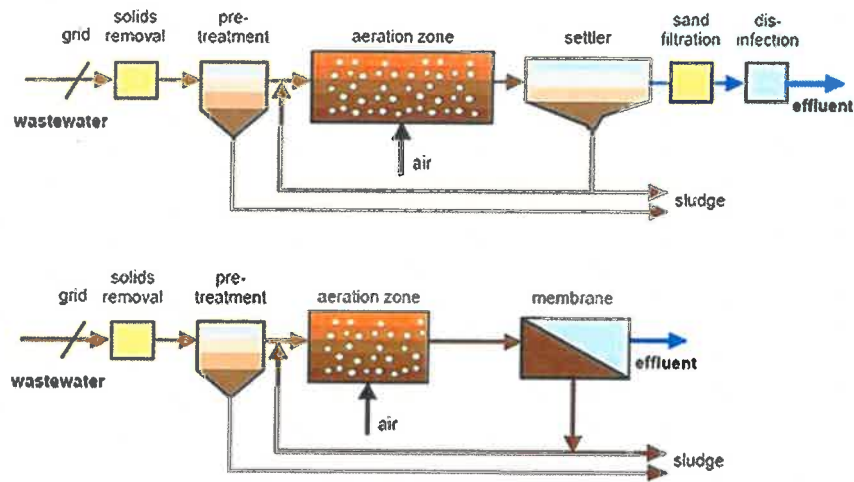


FIGURE 14: (ABOVE) ACTIVATED SLUDGE TREATMENT PLANT. (BELOW) MEMBRANE BIOLOGICAL REACTOR - TREATMENT PROCESS

As the clarification stage is now avoided, a much smaller footprint is required. Also, due to membrane filtration, greater concentrations of suspended solids can be dealt with whilst ensuring a consistent effluent quality. The most economical MBR systems employ membrane filters consisting of hollow fibres, submerged within the aeration tank. Submerging the membranes within the aeration tank not only mitigates fouling but also allows the wastewater to flow through the membranes utilising the hydraulic gradient (i.e. pressure due to depth). This decreases pumping costs, as MBR systems operate either by drawing aerated effluent through flat sheet membrane filters or through hollow fibres. The treated effluent is extracted by vacuum through the centre of the hollow fibre. The level of filtration takes places at the “ultra” level, using a pore size between 0.1 and 0.01  $\mu\text{m}$ . *No membranes with pore sizes smaller than this will be necessary in any MBR treatment plant, including any tertiary stages, utilised by the WCGH.*

This technology is now widely accepted as a wastewater treatment solution and is mostly used for the treatment of black wastewater. However, it may also be applicable to grey water streams with a high suspended solids content and varying loads which would otherwise require a much larger activated sludge treatment plant (such as is the case in hospital laundry handling facilities).

## 9. PROCUREMENT STRATEGY

As rainwater harvesting systems are relatively simple, it will be operated and maintained by maintenance staff at the facility. A Design and Construct by Contractor approach is recommended for the execution of rainwater harvesting projects.

For wastewater treatment plants, it is recommended that the project is executed as a Build, Own, Operate and Transfer ("BOOT") project, where the treated wastewater is sold back to the facility at a predetermined rate (i.e. Rands / kL) under a Goods and Services Contract, for a contract period not exceeding 10 years. A similar approach may also be the implementation of a Shared Savings contract, whereby the Contractor agrees to be reimbursed according to a predetermined percentage of the savings achieved following the implementation of wastewater treatment and reuse. Upon completion of such contracts, ownership of the water treatment plant may be transferred to the WCG. Prior to handover however, WCG employees are to be trained in the operation and maintenance of the plant whilst it is still owned and operated by the Contractor. The various contract options available to the WCG are summarised in Table 6.

TABLE 6: SUMMARY OF CONTRACT OPTIONS AVAILABLE TO WCGH

Contract Strategy	Ownership	Operation	Maintenance
( A – "BOOT")	Contractor	Contractor	Contractor
( B – Shared Savings)	Contractor	Contractor	Contractor
( C )	WCGH	Supplier	Supplier
( D )	WCGH	Sub-contractor	Sub-contractor
( E )	WCGH	WCGH	WCGH

Due to the fact that the WCG department of health does not have the expertise necessary for the maintenance and running of these treatment plants, this type of contract would ensure that the treatment plant is properly maintained and performs optimally, whilst the WCG acquires the necessary skills to manage it in future. The contract under which all wastewater recycling projects will be executed will be NEC3 CONTRACT: TSSC. Given the nature of wastewater treatment and the specialised expertise required, a Design and Construct by Contractor approach is recommended. However, it is important that Contractor(s) prove complete functionality.

Furthermore, the contractor(s) will be required to prove that their design, based upon their own wastewater grab sample analysis, meets the performance criteria set out in the design stage and will do so by means of a performance assessment at the facility, over a period no less than 1 year, as sludge production and denitrification processes are temperature dependent and vary with the winter and summer seasons (with increased sludge production in colder temperatures and, conversely, increased denitrification in warmer temperatures). Performance assessments will include all tests necessary to prove that the treated wastewater produced is of a quality that meets the requirements for use as a Category 3 or 4 effluent (Table 4).

## 10. COST

If the above ("BOOT") option is selected, the price charged *per kilolitre* of treated water (target quality Category 3 of Department of Water Affairs Water Quality Guidelines – Vol 3, or better) should not exceed the going municipal rate + 40%, with a maximum contract period of 10 years and escalation as per inflation. Wastewater treatment plants, if owned and operated by the WCG, must be shown to have a life span of at least 15 years and have a pay-back period not exceeding half of its intended life span. (Some packaged plant designs, such as the ASPTP, have a lifetime of up to 25 years).

Table 7 summarizes the maximum technology cost (i.e. CAPEX) to be expected when planning for wastewater treatment works at healthcare facilities. This cost, given per litre (plant) capacity and categorised according to plant capacity in kilolitres, excludes engineering, installation and running costs. A detailed example is provided in Table 8.

**TABLE 7: TECHNOLOGY COSTS FOR WASTEWATER TREATMENT, EXCL. ENGINEERING, INSTALLATION & COMMISSIONING. COSTING BASE DATE 2017, ESCALATION PER ANNUM AS PER INFLATION.**

Plant Capacity, kL/day	100-200kL		50-100kL		30-50kL		10-30kL		0-10kL	
Effluent quality	Cat 4	Cat 3	Cat 4	Cat 3	Cat 4	Cat 3	Cat 4	Cat 3	Cat 4	Cat 3
Black	R 25.00 / L/day plant capacity	R 45.00 / L/day plant capacity	R 30.00 / L/day plant capacity	R 60.00 / L/day plant capacity	R 38.00 / L/day plant capacity	R 75.00 / L/day plant capacity	R 55.00 / L/day plant capacity	R 110.00 / L/day plant capacity	R 76.00 / L/day plant capacity	R 250.00 / L/day plant capacity
Grey	R 15.00 / L/day plant capacity	R 36.00 / L/day plant capacity	R 20.00 / L/day plant capacity	R 45.00 / L/day plant capacity	R 28.00 / L/day plant capacity	R 90.00 / L/day plant capacity	R 45.00 / L/day plant capacity	R 90.00 / L/day plant capacity	R 55.00 / L/day plant capacity	R 100.00 / L/day plant capacity

Running costs include electricity, water discharge fees, chemical fees, sludge transport and disposal, replacement cost (yearly, x% total construction cost, where x is dependent on plant lifetime), staff costs and administration costs. A flat rate of R20 per kilolitre of treated water (base date 2017, escalation 6% per annum) can be taken as encompassing total running costs, for ASPTP and MBR, excluding waste water disposal fees, to produce Category 3 effluent.

To illustrate how the above tables (and Table 9 defining storage costs) can be used, assume that a project budget needs to be assigned for the installation of a wastewater treatment plant at a CDC, with a monthly head count (HC) of 6800. It is assumed that 25% of water consumed is used for domestic consumption (i.e. potable), with 75% entering the drains (see Figure 1) as a mixture of grey and black water (i.e. no split sewerage system). The calculation procedure is shown in Table 8 (below).

**TABLE 8: SAMPLE CALCULATION FOR DETERMINING PROJECT BUDGET INCORPORATING WASTEWATER RECYCLING**

Parameter	Value	Unit	Source
Facility	CDC	-	
Monthly HC	6,800	HC/Mnth	User Asset Management Plan
Daily HC	227	H/Day	HC/Mnth ÷ 30 days/month
Consumption per HC per day	40	L/HC/day	Table 1
Total consumption	9.08	kL /day	
Potable water consumption	2.27	kL /day	25% of total consumption
Waste water production	6.81	kL /day	75% of total consumption
Influent category	Black	-	Table 2
Effluent category	3	-	Table 3/4
WWTP plant capacity	6.81	kL/day	75% of total consumption
Technology cost rate	250	R/L	Table 6
Technology cost	1,702.50	R 000's	R/L X treatment plant capacity
Overheads	425.63	R 000's	25% of Tech cost
<b>Total Technology Cost</b>	<b>2,128.13</b>	<b>R 000's</b>	
Storage volume needed	6.81	kL	Equal to WWTP capacity
Type of storage	Polyprop	-	Table 8
Storage rate	2.00	R/L	Table 8
Storage cost	13.62	R 000's	
Overheads	3.41	R 000's	25% of Storage cost
<b>Total Storage Cost</b>	<b>17.03</b>	<b>R 000's</b>	
<b>Total Capital Investment</b>	<b>2,145.15</b>	<b>R 000's</b>	Tech cost + Storage cost
<b>Expected running costs</b>	<b>136.20</b>	<b>R / day</b>	Flat rate, R20/kL treated

Wastewater treatment plants make use of treatment processes specifically suited to the needs of the facility and the chemical make-up of its wastewater. It is not possible to standardise the cost of wastewater treatment for all healthcare facilities. Each facility, along with its support services (such as laundry, CSSD) makes each installation unique and entirely site dependent. Hence, in each instance, a complete lifecycle cost analysis must be performed. Refer to Annexure B: Economic analysis of laundry facility.

With regards to rainwater harvesting, treatment can constitute a large cost. This too however, is largely dependent on landscape and architecture, which is entirely site specific. It is for this reason that a thorough site investigation be undertaken by any contractor appointed to implement rain water harvesting.

For the purposes of infrastructure planning, Table 9 summarizes the maximum technology cost, excluding installation, to be expected when planning for rainwater harvesting works at healthcare facilities. For example, a 30kL rain water storage and reuse facility, for drinking purposes, utilising a concrete vessel, will require a minimum project budget of R435 000.00 (R180 000.00 for storage + R255 000.00 for treatment technology).

**TABLE 9: STORAGE AND TREATMENT COSTS, PER KILOLITRE PLANT CAPACITY, EXCL. ENGINEERING, INSTALLATION & COMMISSIONING OF RAINWATER HARVESTING SYSTEMS. COSTING BASE DATE 2017, ESCALATION 6% PER ANNUM**

<b>Capacity (kL, treated per day)</b>	<b>1-20</b>	<b>20-100</b>	<b>100-500</b>	<b>500-2000</b>
Storage Cost – Polypropylene	R2.00 / L	NA	NA	NA
– Brathwaite	R3.00 / L	R3.00 / L	R3.00 / L	R3.00 / L
– Corrugated Steel	R1.00 / L	R0.30 / L	R0.25 / L	R0.25 / L
– Concrete	R9.00 / L	R6.00 / L	R5.00 / L	R5.00 / L
Treatment Cost*	R10.50 / L	R8.50 / L	R6.90 / L	R5.40 / L

\*To produce water of drinking quality

One critical component to all water treatment processes mentioned above is the analysis of water quality. In all instances, representative grab samples will be required, for both untreated and treated water. For comprehensive analysis of water samples, as per SANS 241, a cost of R4500 – R4900 per sample is to be expected. Analysis must be performed by an ISO 17025 accredited laboratory, a list of which is provided in Annexure C: ISO17025 Accredited Laboratories.

***Prior to the undertaking of wastewater treatment at any healthcare facility, wastewater quality is to be determined through representative grab sample analysis, by the WWTP designer. This must be clearly stated during the tendering process, to ensure that the WCG mitigates risk with regards to wastewater treatment plant performance.***



## 11. PRIORITIES

Given that black water treatment plants require a continuous supply of influent to sustain the bacteria culture responsible for the degradation of organic matter and that these systems are expensive to install, it is only feasible for large facilities operating on a 24/7 basis (i.e. CHC's and hospitals) to make use of a black water treatment process to produce effluent of Category 3 or 4. For similar reasons, grey water treatment plants will be limited to CDC's, CHC's and hospitals to produce effluent of Category 3 or 4. If it is decided that a CHC or hospital will implement black water treatment, also designed to produce effluent of Category 3 or 4, the treatment plant must be designed for treating both grey and black water combined, as treating the grey water independently will result in a greater capital expenditure and operational cost.

In the event of water restrictions being implemented at a healthcare facility, water supply to the various areas of the facility is to be prioritised as described in the WCGDOH "Water Supply Preparedness Plan". As part of ensuring the water security of each healthcare facility in the future, the urgency for the implementation of the various water conservation mechanisms and technologies is described below. *As a minimum, all facilities identified as "Gold Command" in the WCGDOH Water Preparedness Plan must implement these conservation mechanisms with the prescribed level of urgency.*

Note: It is recommended that for key healthcare operations, such as laundry handling facilities (eg. Lentegour Laundry, Mitchell's Plain, servicing 34 hospitals, CHC's and CDC's etc.), grey water treatment and reuse is implemented as per urgency level 1. The lead time expected for large packaged wastewater treatment plants is approximately 4 to 8 months, depending on the size and complexity.

**Level 0** – Not applicable for that facility

**Level 1** – To be implemented within the next 12 months (following the release of this technical memo)

**Level 2** – To be implemented within the next 36 months

**Level 3** – To be implemented in the next 60 months

Facility	EMS	Path Lab	Clinics	CDC	CHC	Hospital	Laundry	CSSD
Conservation mechanism	Urgency Level							
Improving operation efficiencies as per section 5.1	1	1	1	1	1	1	1	1
Improving equipment efficiencies as per section 5.1	1	1	1	1	1	1	1	1
Municipal storage (24 hour supply)	1	1	1	1	1	1	1	1
Boreholes	1	1	1	1	1	1	1	1
Rain Water harvesting	1	1	1	1	1	1	1	1
Grey water treatment	0	0	0	2	2*	2*	0	0
Black water treatment	0	0	0	0	3	3	2	0

\*Grey water treatment only implemented if it is decided to do without black water treatment.



## 12. LAWS AND REGULATIONS

In accordance with the by-laws, policies and practices, in terms of the National Building Regulations and Building Standards Act (Act 103 of 1977 as amended), the municipality is required to approve the installation of a package plant.

In respect of the aforementioned approval, there is no responsibility on the municipality to confirm the fitness or completeness of the package plant. 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 ensure 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.

Refer to "Guideline Document: Package Plants for the Treatment of Domestic Wastewater", by A van Niekerk, A Seetal & P Dama-Fakir et. al. of the Department of Water Affairs, December 2009.

## 13. CONCLUDING COMMENTS

Healthcare facilities consume large amounts of water for use in various parts of the facility. Most of these uses do not require water of a potable quality. Hence, in light of the ever increasing water shortages within South Africa and the Western Cape province, due consideration for water recycling and conservation must be given when designing and/or upgrading a healthcare facility and must be seen as a directive for any designer working within the healthcare industry. The water conservation and recycling mechanisms described herein are immediately applicable to all WCGDOH projects which have not yet completed the concept and viability stage (i.e. G4).

## ANNEXURE A: SEWERAGE GRAVITY FLOW (VELOCITY)

To calculate the revised flow velocity through the sewerage handling pipeline, use the calculation procedure below.

1. Determine the revised total water flow,  $Q$  ( $\text{m}^3/\text{s}$ ), expected once improving operational and equipment efficiencies at the facility.
2. Determine the slope of the sewerage pipeline,  $S$  ( $\text{m}/\text{m}$ )
3. Note the pipe inner Diameter,  $D$  ( $\text{m}$ )
4. Calculate pipe inner radius,  $r$  ( $\text{m}$ )
5. Take the roughness coefficient,  $n$  (dimensionless), as 0.02
6. Solve for angle  $\Theta$  (defined implicitly), through iteration, to satisfy Manning's equation

$$Q = \frac{1.49}{n} \cdot A \cdot R^{\frac{2}{3}} \cdot S^{\frac{1}{2}}$$

Where

$$A = \pi r^2 - \frac{r^2(\theta - \sin \theta)}{2}$$

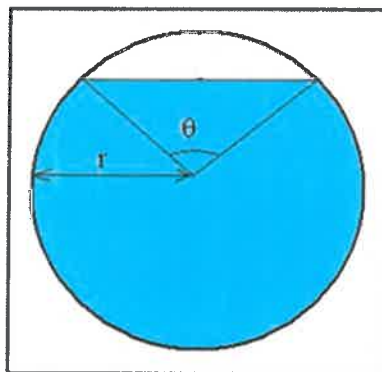
$$R = \frac{A}{P}$$

With wetted perimeter,  $P$  ( $\text{m}$ )

$$P = 2\pi r - r\theta$$

7. Calculate,  $A$ , cross sectional flow area ( $\text{m}^2$ ).
8. Determine flow velocity,  $V$  ( $\text{m}/\text{s}$ )

$$V = \frac{Q}{A}$$

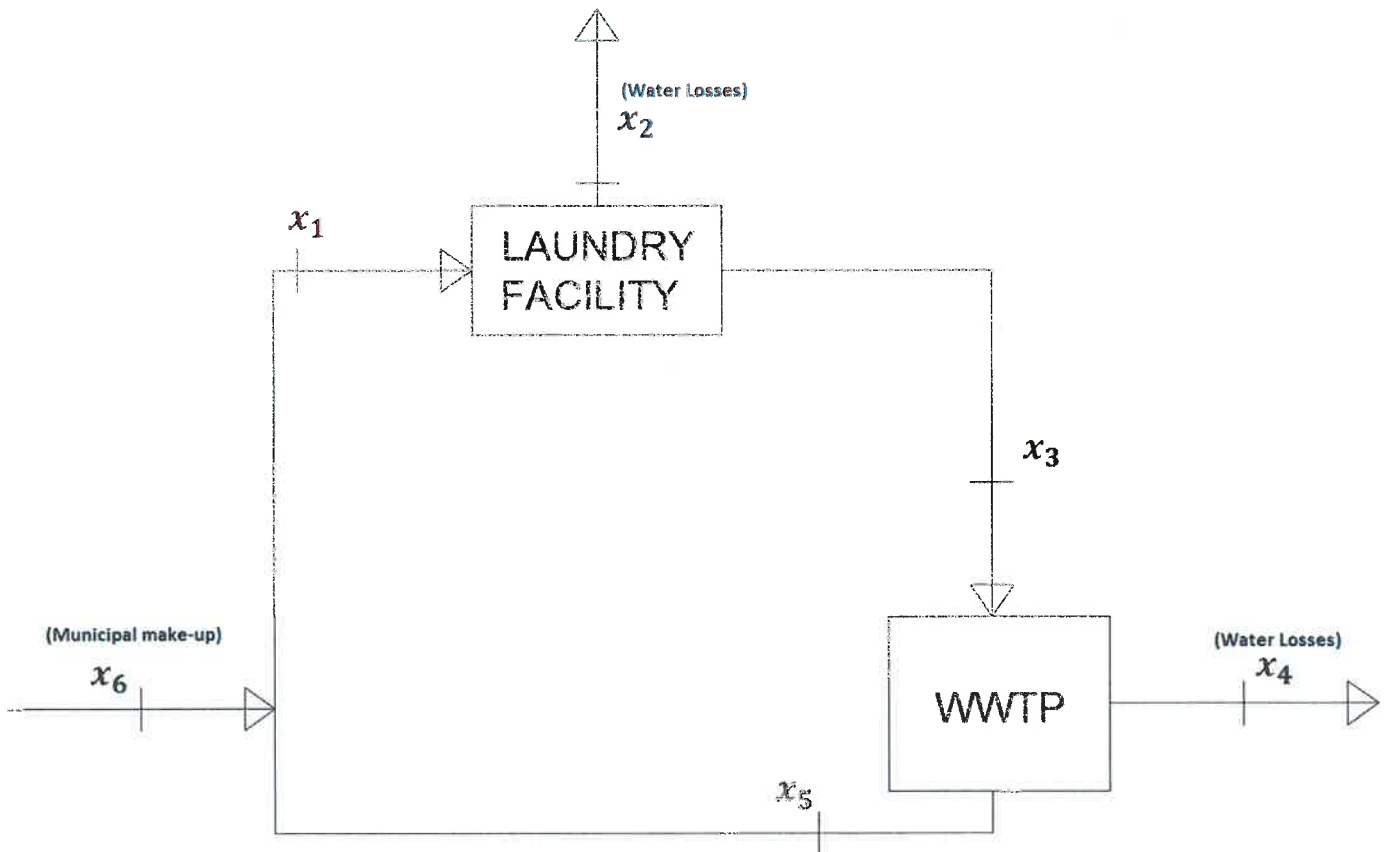


**Partially Full Pipe Flow Parameters  
(More Than Half Full)**

## ANNEXURE B: ECONOMIC ANALYSIS OF LAUNDRY FACILITY

The input data needed for any preliminary economic feasibility study is tabulated below. An example in which three scenarios are considered is presented, for the recycling of waste water from tunnel washers at a laundry handling facility such that the treated water can be re-used by the washing machine (i.e. Category 3 effluent). To determine the municipal demand with a wastewater recycling plant installed, one must consider the efficiencies/losses of the facility and the water treatment plant.

This laundry facility in particular loses 45 % of its water which remains in the linen after it is pressed and removed from the washer. Furthermore, the WWTP operates with a water efficiency of 70% (i.e. 30% of the water is lost).



In the above figure, the flows are described, through conservation of mass, as follows:

$$x_1 = x_2 + x_3 = \text{facility demand}$$

$$x_2 = 0.45x_1$$

$$x_3 = 0.55x_1 = x_4 + x_5$$

$$x_4 = 0.3x_3$$

$$x_5 = 0.7x_3$$

$$x_6 = x_1 - x_5$$

Considering three scenarios:

- **Option A** – The technology is purchased by the WCG and installed and commissioned by an appointed contractor. The WCG continues to operate the plant during its lifetime.
- **Option B** – The WWTP is installed and commissioned by the contractor. It remains under the ownership of the contractor. Hence, maintenance and operation costs are carried by the contractor. Treated water is then sold back to the WCG facility, at R30/kL with escalation as per inflation.
- **Option C** – Continue operations as normal with no WWTP being installed.

			Option		
Parameter	Sym.	Unit	A	B	C
Waste Water Treatment Plant (WWTP)					
Technology Cost	$T$	Rands	7,400,000.00	0.00	0.00
Plant (recycling) efficiency*	$e$	[-]	0.70	0.70	0.00
Installation	$I$	Rands	1,000,000.00	0.00	0.00
Commissioning	$C$	Rands	1,500,000.00	0.00	0.00
Running Cost**	$RC$	Rands / kL	20.00	0.00	0.00
Treated Water Cost	$T_{sc}$	Rands / kL	0.00	30.00	0.00
Contract Escalation	$i$	[-]	0.00	0.07	0.00
Contract Period / Plant lifetime	$P$	Years	15.00	15.00	0.00
Existing Municipal Rates					
Water Cost	$M_{sc}$	Rands / kL	24.07	24.07	24.07
Sewerage Cost 2017 ***	$M_{dc}$	Rands / kL	19.48	0.00	19.48
Operations					
Days operating per year	$d$	Days	365.00	365.00	365.00
Washing process efficiency	$f$	[-]	0.55	0.55	0.55
Water consumption	$M_s$	L / h	21,000.00	21,000.00	21,000.00
Consumption/Discharge Amounts					
Treated Water Consumption	$x_5$	kL / day	64.68	64.68	0.00
Municipal Water Consumption	$x_6$	kL / day	103.32	103.32	168.00
Sewerage discharge entering municipal drain	$x_4$	kL / day	27.72	27.72	92.40
Calculated parameters					
Facility demand	$X_1$	kL / day	168.00	168.00	168.00
Water loss of facility (retained in linen)	$X_2$	kL / day	75.60	75.60	75.60
Facility waste / WWTP influent flow	$X_3$	kL / day	92.40	92.40	92.40
WWTP waste***	$X_4$	kL / day	27.72	27.72	92.40
WWTP effluent flow	$X_5$	kL / day	64.68	64.68	0.00
Municipal make-up	$X_6$	kL / day	103.32	103.32	168.00

\*Assumed 70% water recycling efficiency of WWTP. This must ordinarily be specified by the supplier of the WWTP technology.

\*\*Estimate only. It is imperative that these costs are defined by the supplier upfront.

\*\*\*Waste handled by WWTP owner.

Note: Base date for Running Costs (RC), Municipal Water ( $M_{sc}$ ) and Sewerage ( $M_{dc}$ ) is 2017. Escalation 6% per annum (i.e. inflation).

Using the above information, the total cost for the contract period is calculated using the formula below. The same formula is used to generate a graph, with Cost vs Time, comparing the three options, to estimate the pay-back period. Note that for each year that passes, under Option B, the price of water per kL escalates at 7% per annum (i.e.  $T_{sc} = f(P)$ ).

$$Total\ Cost_{per\ year} = CAPEX + OPEX_{per\ year}$$

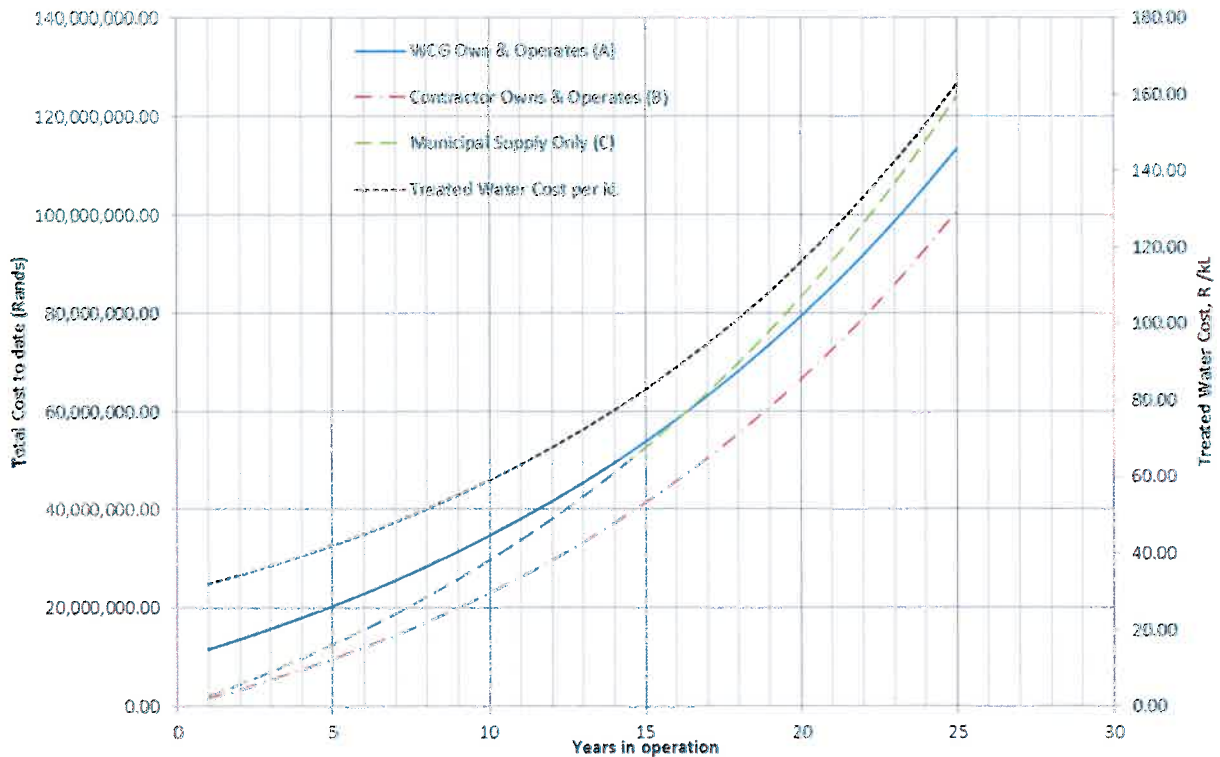
Where

$$CAPEX\ (i.e.\ fixed\ cost) = Technology + Installation + Commissioning$$

$$OPEX_{per\ year} = x_3 \cdot RC \cdot d + x_5 \cdot T_{sc} \cdot d + x_6 \cdot M_{sc} \cdot d + x_4 \cdot M_{dc} \cdot d$$

$$Total\ OPEX = \sum OPEX_{per\ year}$$

The total cost over the plant life time is then calculated by adding the CAPEX to the total OPEX. The calculation results for the above are provided by a graphical representation below. The calculated results for each year are tabulated at the end of this annexure.



**FIGURE 15: GRAPH DEPICTING A COMPARISON BETWEEN TWO WASTEWATER TREATMENT PLANT PROCUREMENT OPTIONS FOR A LAUNDRY HANDLING FACILITY**

For this case study, when selecting option A, the pay-back period is approximately 17 years. Typically, the payback period of wastewater treatment plants is between 6 and 10 years. The main reason for the extensive payback period for this laundry facility is due to the fact that 45% of the municipal water supplied to the machine is lost to the linen. Losses in the WWTP increase the reliance upon an external (municipal) supply and decrease the benefit of having a wastewater treatment plant.

It is interesting to note that although option B would result in a greater cost for water supplied to the facility, because of the fact that less wastewater is discharged by the facility into the

municipal drain, Option B allows for an overall reduction in water costs (assuming the cost of disposing of the wastewater from the WWTP is carried by the contractor). Furthermore, because the amount charged for the treated water (R30/kL) is less than 1.5 times the municipal rate, it remains more appealing than having the WCG own and operate the plant.

## Conclusion

Option B, offered by the contractor, is the most attractive solution for a 10 year period, as it is competitive with municipal rates. Furthermore, it should be noted that the payback period of a WWTP is heavily dependent upon the running costs of the plant.

**TABLE 10: ECONOMIC ANALYSIS FOR LAUNDRY FACILITY. CALCULATED COSTS PER YEAR – OPTION A**

	RC	T <sub>sc</sub>	M <sub>sc</sub>	M <sub>dc</sub>	<b>WCG Own &amp; Operates (A)</b>		
<b>Year</b>	<b>R/kL</b>	<b>R/kL</b>	<b>R/kL</b>	<b>R/kL</b>	<b>CAPEX</b>	<b>OPEX</b>	<b>TOTAL</b>
1	21.20	0.00	25.51	20.65	9,900,000.00	1,886,098.04	11,786,098.04
2	22.47	0.00	27.05	21.89	9,900,000.00	1,999,263.92	13,785,361.95
3	23.82	0.00	28.67	23.20	9,900,000.00	2,119,219.75	15,904,581.71
4	25.25	0.00	30.39	24.59	9,900,000.00	2,246,372.94	18,150,954.65
5	26.76	0.00	32.21	26.07	9,900,000.00	2,381,155.32	20,532,109.96
6	28.37	0.00	34.14	27.63	9,900,000.00	2,524,024.63	23,056,134.60
7	30.07	0.00	36.19	29.29	9,900,000.00	2,675,466.11	25,731,600.71
8	31.88	0.00	38.36	31.05	9,900,000.00	2,835,994.08	28,567,594.79
9	33.79	0.00	40.67	32.91	9,900,000.00	3,006,153.72	31,573,748.51
10	35.82	0.00	43.11	34.89	9,900,000.00	3,186,522.95	34,760,271.46
11	37.97	0.00	45.69	36.98	9,900,000.00	3,377,714.32	38,137,985.78
12	40.24	0.00	48.43	39.20	9,900,000.00	3,580,377.18	41,718,362.96
13	42.66	0.00	51.34	41.55	9,900,000.00	3,795,199.81	45,513,562.78
14	45.22	0.00	54.42	44.04	9,900,000.00	4,022,911.80	49,536,474.58
15	47.93	0.00	57.69	46.68	9,900,000.00	4,264,286.51	53,800,761.09
16	50.81	0.00	61.15	49.49	9,900,000.00	4,520,143.70	58,320,904.79
17	53.86	0.00	64.82	52.46	9,900,000.00	4,791,352.32	63,112,257.12
18	57.09	0.00	68.70	55.60	9,900,000.00	5,078,833.46	68,191,090.58
19	60.51	0.00	72.83	58.94	9,900,000.00	5,383,563.47	73,574,654.05
20	64.14	0.00	77.20	62.47	9,900,000.00	5,706,577.28	79,281,231.33
21	67.99	0.00	81.83	66.22	9,900,000.00	6,048,971.92	85,330,203.25
22	72.07	0.00	86.74	70.20	9,900,000.00	6,411,910.23	91,742,113.48
23	76.39	0.00	91.94	74.41	9,900,000.00	6,796,624.84	98,538,738.32
24	80.98	0.00	97.46	78.87	9,900,000.00	7,204,422.34	105,743,160.66
25	85.84	0.00	103.31	83.61	9,900,000.00	7,636,687.68	113,379,848.33
<b>Total Cost</b>							<b>113,379,848.33</b>

TABLE 11: ECONOMIC ANALYSIS FOR LAUNDRY FACILITY. CALCULATED COSTS PER YEAR– OPTION B

Year	RC	T <sub>sc</sub>	M <sub>sc</sub>	M <sub>dc</sub>	Contractor Own & Operates (B)		
	R/kL	R/kL	R/kL	R/kL	CAPEX	OPEX	TOTAL
1	0.00	32.10	25.51	0.00	0.00	1,720,009.63	1,720,009.63
2	0.00	34.35	27.05	0.00	0.00	1,830,788.44	3,550,798.06
3	0.00	36.75	28.67	0.00	0.00	1,948,744.45	5,499,542.52
4	0.00	39.32	30.39	0.00	0.00	2,074,345.44	7,573,887.95
5	0.00	42.08	32.21	0.00	0.00	2,208,089.82	9,781,977.78
6	0.00	45.02	34.14	0.00	0.00	2,350,508.73	12,132,486.51
7	0.00	48.17	36.19	0.00	0.00	2,502,168.12	14,634,654.62
8	0.00	51.55	38.36	0.00	0.00	2,663,671.09	17,298,325.71
9	0.00	55.15	40.67	0.00	0.00	2,835,660.34	20,133,986.05
10	0.00	59.01	43.11	0.00	0.00	3,018,820.77	23,152,806.82
11	0.00	63.15	45.69	0.00	0.00	3,213,882.29	26,366,689.10
12	0.00	67.57	48.43	0.00	0.00	3,421,622.75	29,788,311.86
13	0.00	72.30	51.34	0.00	0.00	3,642,871.18	33,431,183.04
14	0.00	77.36	54.42	0.00	0.00	3,878,511.08	37,309,694.11
15	0.00	82.77	57.69	0.00	0.00	4,129,484.11	41,439,178.22
16	0.00	88.56	61.15	0.00	0.00	4,396,793.88	45,835,972.11
17	0.00	94.76	64.82	0.00	0.00	4,681,510.10	50,517,482.21
18	0.00	101.40	68.70	0.00	0.00	4,984,772.89	55,502,255.09
19	0.00	108.50	72.83	0.00	0.00	5,307,797.50	60,810,052.59
20	0.00	116.09	77.20	0.00	0.00	5,651,879.26	66,461,931.85
21	0.00	124.22	81.83	0.00	0.00	6,018,398.90	72,480,330.74
22	0.00	132.91	86.74	0.00	0.00	6,408,828.20	78,889,158.94
23	0.00	142.22	91.94	0.00	0.00	6,824,736.03	85,713,894.98
24	0.00	152.17	97.46	0.00	0.00	7,267,794.81	92,981,689.79
25	0.00	162.82	103.31	0.00	0.00	7,739,787.33	100,721,477.12
Total Cost							100,721,477.12



**TABLE 12: ECONOMIC ANALYSIS FOR LAUNDRY FACILITY. CALCULATED COSTS PER YEAR– OPTION C**

Year	RC	T <sub>sc</sub>	M <sub>sc</sub>	M <sub>dc</sub>	Municipal Supply Only (C)		
	R/kL	R/kL	R/kL	R/kL	CAPEX	OPEX	TOTAL
1	0.00	0.00	25.51	20.65	0.00	2,260,932.17	2,260,932.17
2	0.00	0.00	27.05	21.89	0.00	2,396,588.10	4,657,520.28
3	0.00	0.00	28.67	23.20	0.00	2,540,383.39	7,197,903.67
4	0.00	0.00	30.39	24.59	0.00	2,692,806.39	9,890,710.06
5	0.00	0.00	32.21	26.07	0.00	2,854,374.78	12,745,084.83
6	0.00	0.00	34.14	27.63	0.00	3,025,637.26	15,770,722.10
7	0.00	0.00	36.19	29.29	0.00	3,207,175.50	18,977,897.60
8	0.00	0.00	38.36	31.05	0.00	3,399,606.03	22,377,503.62
9	0.00	0.00	40.67	32.91	0.00	3,603,582.39	25,981,086.01
10	0.00	0.00	43.11	34.89	0.00	3,819,797.33	29,800,883.35
11	0.00	0.00	45.69	36.98	0.00	4,048,985.17	33,849,868.52
12	0.00	0.00	48.43	39.20	0.00	4,291,924.28	38,141,792.81
13	0.00	0.00	51.34	41.55	0.00	4,549,439.74	42,691,232.55
14	0.00	0.00	54.42	44.04	0.00	4,822,406.13	47,513,638.67
15	0.00	0.00	57.69	46.68	0.00	5,111,750.49	52,625,389.17
16	0.00	0.00	61.15	49.49	0.00	5,418,455.52	58,043,844.69
17	0.00	0.00	64.82	52.46	0.00	5,743,562.85	63,787,407.54
18	0.00	0.00	68.70	55.60	0.00	6,088,176.63	69,875,584.17
19	0.00	0.00	72.83	58.94	0.00	6,453,467.22	76,329,051.39
20	0.00	0.00	77.20	62.47	0.00	6,840,675.26	83,169,726.65
21	0.00	0.00	81.83	66.22	0.00	7,251,115.77	90,420,842.42
22	0.00	0.00	86.74	70.20	0.00	7,686,182.72	98,107,025.14
23	0.00	0.00	91.94	74.41	0.00	8,147,353.68	106,254,378.82
24	0.00	0.00	97.46	78.87	0.00	8,636,194.90	114,890,573.72
25	0.00	0.00	103.31	83.61	0.00	9,154,366.60	124,044,940.32
<b>Total Cost</b>							<b>124,044,940.32</b>

## ANNEXURE C: ISO17025 ACCREDITED LABORATORIES

Lab No.	Name
T0276	<i>AL Abbott and Associates (Pty) Ltd</i> Address: 1 Pk Vine, Vine Rd, Woodstock, Cape Town, 7925 Phone: 021 448 6340
T0278	<i>Bemlab (Pty) Ltd</i> Address: Gant's Sentrum, 16 Van Der Berg Cres, Strand, Cape Town, 7140 Phone: 021 853 1490
T0484	<i>City of Cape Town, Water and Sanitation, Scientific Services Department</i> Address: Off Jan Smuts Drive, Athlone, Cape Town, 8018 Phone: 021 444 2000
T0010	<i>CSIR Knowledge Services – Centre for Specialised Environmental Analysis</i> Address: CSIR Stellenbosch Phone: +27 (0) 21 658 2773 / 082 783 8914
T0215	<i>Distell Central Laboratory</i> Address: Adam Tas, Stellenbosch, 7600 Phone: (021) 809-7460
T0232	<i>Hearshaw and Kinnes Analytical Laboratory</i> Address: 9 Regent Park, Bell Cres, Westlake, Cape Town, 7945 Phone: 021 702 4129
T0054	<i>J Muller Laboratories</i> Address: 30 Marine Drive, Paarden Eiland, Cape Town, 7405 Phone: 021 511 8301
T0136	<i>Micron Laboratories</i> Address: No. 1 Davison Street, Woodstock, Cape Town, 9725 Phone: (021) 440-7828
T0164	<i>Rhodes Food Group</i> Address: Pniel Road, Paarl, Western Cape, South Africa, 7680 Phone: 021 870 4192
T0050	<i>Swift Micro Laboratories (Pty) Ltd</i> Address: 7 Warrington Road, Claremont, Cape Town, 7708 Phone: 021 683 8436
T0205	<i>Vinlab (Pty) Ltd Main Laboratory</i> Address: Distillery Road, Stellenbosch, 7599 Phone: 021 882 8866
T0375	<i>Water Analytical Laboratory cc</i> Address: 3 Hulett Street, Stellenbosch, 7561 Phone: 021 883 8905

Note: Obtained from [www.wrc.org.za](http://www.wrc.org.za). As the list was compiled in 2009, any lab chosen must be able to prove ISO 17025 and SANAS accreditation upon request by the WCG.

## ANNEXURE D: COST ESTIMATES FOR “AIR-TO-WATER” TECHNOLOGIES

Current estimates price the *technology cost* (i.e. the amount needed to only purchase the technology) anywhere between R200 and R700 / Litre capacity, for high capacity and small capacity units, respectively. For instance, a 30L per day production unit will cost approximately (R700 x 30 =) R21 000.00 to purchase. Another cost often overlooked is the energy cost. In general, this technology consumes an average of 4.5kW per kilolitre of water produced. The implications of this energy cost are presented in the table below, using the water consumption figures of four existing hospitals. It can be seen that the total energy cost easily exceeds five times that of the current annual water cost (which includes estimated drainage costs).

	Beds	Avg Water Consumption	Avg Water Consumption	Tech cost rate	Tech cost (i.e. CAPEX)	Rate of Energy Consumption	Total Energy Consumption	Electricity Tariff	Total Energy Cost	Current Municipal Cost	Current Annual Water Cost
	[-]	kl/Month	kl/Day	R/L per day	R 000's	kW/kl	kW/Day	R/kWh	R 000's / Year	R/kl	R 000's
Alexandra Hospital	300	1,370	46	200.00	9,132	4.50	205.48	2.00	3,599.94	20.00	558.32
Lengtegeur Hospital	722	14,845	495	200.00	98,969	4.50	2,226.80	2.00	39,013.54	20.00	6,050.71
Stikland Hospital	318	3,850	128	200.00	25,669	4.50	577.55	2.00	10,118.62	20.00	1,569.32
Valkenberg Hospital	340	1,390	46	200.00	9,269	4.50	208.56	2.00	3,653.95	20.00	566.70

## REFERENCES

- Bester, F. (2017). Water Sustainability in Hospitals. *SAFHE / CEASA 2017* (p. 48). Durban: South African Federation of Hospital Engineering 2017.
- Richard Speares (NetCare). (2017). Eliminating water wastage - not just a pipe dream... *SAFHE / CEASA 2017* (p. 11). Durban: South African Federation of Hospital Engineers.
- World Health Organisation. (2011). *WHO Guidelines for drinking water quality*. Switzerland: WHO Press, 20 Ave Appia, 1211 Geneva 27, Switzerland.

## ANNEX E: LIST OF CHANGES

Version 1.0 -> Version 2.0		
Location	Revision	Author
Table 2	-Domestic more clearly defined as “Potable”. -Evisceration tables added, Category 3 requirement (to protect evidence). -Autopsy floors and Decontamination areas specified as requiring Category 4 effluent.	A. Y
5.1, pg 5	Text removed: <i>(Current estimates price the technology cost anywhere between R200 and R700 / Litre when extracted from air, significantly greater than R0.02 / Litre provided by the municipality.)</i> Replaced by: <i>Refer to Annexure D for cost estimates pertaining to “air-to-water” technologies.</i>	A. Y
Table 4	Microbiological requirements to meet quality requirements specified (Total coliform and E. Coli).	A. Y
6.0, pg 9	-Typo corrected, should be “seven” stages as opposed to “six”. -Stage 7 modified to include pH control. -Stage 7 included as necessary step for all effluent categories.	A. Y
Fig.8, pg 13	“Polishing” changed to “Remineralisation”.	A. Y
6.6, pg 14	Paragraph added: <i>In some areas the pH of rainwater may be low enough to promote corrosion in copper piping if left untreated. If the pH is found to lie below the minimum figures specified in Table 4, pH balancing must be performed using Sodium Bicarbonate. For small primary healthcare facilities including EMS, pathology Labs, clinics and CDC’s, manual pH correction will be undertaken by maintenance staff. For larger facilities including CHC’s and hospitals, an automated dosing system is acceptable.</i>	A. Y
6.10, pg 16	Water Quality Assurance added. <i>Refer to section 7.8 for measures required to ensure sufficient water quality. If (untreated) harvested rainwater is not stored within a man-made structure isolated from the surrounding elements, as is such the case with open retention ponds forming part of the surrounding landscape, water tests on a bi-weekly basis through grab sample analysis at the retention pond must be made (as per SANS 241).</i>	A. Y
Table 5	-Renal Dialysis Filtration Plant specified. -Staff Urinals & Toilets specified.	A. Y
9.0	Procurement strategies more clearly defined.	A. Y
10.0	Technology costs more clearly defined as L/Day plant capacity.	A. Y
12.0	Laws and regulations added.	A. Y
Annex D	Breakdown of “Air-to-Water” costs provided.	A. Y