National Water Reuse Programme:
Programme Design and Preparation of a Full Funding Proposal to the Green Climate Fund (GCF)

Market Study

Annexure 2

09 June 2023

DEVELOPMENT BANK OF SOUTHERN AFRICA
Building Africa's Prosperity

This deliverable has been prepared by the Development Bank of Southern Africa with the support Pegasys (Pty) Ltd in association with:

- JG Afrika (Pty) Ltd;
- Amber Public Sector Consulting (Pty) Ltd;
- Clarity Global Strategic Communications; and
- Yubifin (Pty) Ltd.

All referred to as the 'Service Provider' in the Service Level Agreement executed between Pegasys and the DBSA on 10 January 2021.

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ACRONYMS & ABBREVIATIONS

AADD	Annual Average Daily Demand
AE	Accredited Entity
AMD	Acid Mine Drainage
ATP	Advanced Treatment Plant
BAC	Biologically Activated Carbon
BNR	Biological Nutrient Removal
BOOT	Build Own Operate Transfer
BOT	Build Operate Transfer
CCT	City of Cape Town
CEC	Chemicals of Emerging Concerns
CHP	Combined Heat of Power
COD	Chemical Oxygen Demand
COGTA	Department of Cooperative Governance and Traditional Affairs
DBO	Design Build Operate
DBSA	Development Bank of Southern Africa
DCOG	Department of Cooperative Governance
DPR	Direct Potable Reuse
DWS	Department of Water and Sanitation
EPC	Engineering Procurement Contract
EUL	Expected Useful Life
FNWS	Faure New Water Scheme
GAC	Granular Activated Carbon
GCF	Green Climate Fund
GTAC	Government Technical Advisory Centre
IMP	Industrial, Mining and Power
IPR	Indirect Potable Reuse
MFMA	Municipal Finance Management Act
MISA	Municipal Infrastructure Support Agency
NPC	National Development Plan
NRW	Non-Revenue Water
NWRS	National Water Resource Strategy
NWSMP	National Water and Sanitation Master Plan
O&M	Operations and Maintenance

PAT	Progress Assessment Tool
PPP	Public Private Partnership
RFP	Request For Proposal
RFQ	Request For Quotation
RO	Reverse Osmosis
RSA	Republic of South Africa
SA	South Africa
SALGA	South African Local Government Association
SANS	South African National Standard
SCM	Supply Chain Management
SDG	Sustainable Development Goal
SLA	Service Level Agreement
TVR	Treasury Views and Recommendations
UWP	uMhlathuze Wastewater Project
WAS	Waste Activate Sludge
WDWCM	Water Demand and Water Conservation Management
WHO	World Health Organisation
WRC	Water Research Commission
WRP	Water Reuse Programme
WSA	Water Service Authority
WSC	Water Sensitive City
WSDP	Water Services Development Plan
WSP	Water Services Providers
WSUD	Water Sensitive Urban Design
WTP	Water Treatment Plant
WTW	Water Treatment Works
WWTW	Wastewater Treatment Works

1. Introduction

1.1 Project Context

South Africa is a water-scarce nation and its national water resource system is continually being subjected to pressures, with a potential 17% water deficit forecast by 2030. A number of interventions have been initiated by national government already to avoid this projected water deficit with a key element of these interventions being to develop an enhanced level of diversification in relation to the "mix" of water supply sources. The South African National Water and Sanitation Master Plan (2018) makes a specific note of the need to reduce water demand and increase water supply through amongst others the "*re-use of effluent from wastewater treatment plants, water reclamation, as well as desalination and treated acid mine drainage*".

At present, most effluent discharge and urban run-off are not reused and in light of the South African National Water and Sanitation Master Plan note, the opportunity to initiate a framework for the scaled development of water reuse infrastructure is evident. To this end, the Development Bank of Southern Africa (the 'DBSA) has partnered with various government departments (including the Department of Water and Sanitation (the 'DWS'), the Department of Cooperative Governance ('DCOG') through its agency the Municipal Infrastructure Support Agency ('MISA'), and the National Treasury for the development of a National Water Reuse Programme ('WRP'). In addition, as an Accredited Entity of the Green Climate Fund ('GCF'), the DBSA also submitted a proposal to the GCF to support the design and implementation of the WRP in South Africa. Noting the importance of water reuse to diversifying the 'water mix' in South Africa, and the challenges and barriers to entry that exist in the development of these water reuse projects at scale, the development of a focussed programme to address these challenges and ultimately implement pathfinder projects is critical to contributing towards building a more resilient water future.

Pegasys (Pty) Ltd, (the 'Consultant') was appointed in January 2021 by the DBSA for the provision of specialist consultancy services in respect of this programme design for the implementation of the WRP in addition to the preparation of a full-funding proposal to the Green Climate Fund (GCF) (the 'Assignment').

1.2 Purpose of the Market Study

The implementation of a national Water Reuse Programme ('WRP') through the scale-up of water reuse approaches and water reuse infrastructure in municipalities would significantly enhance water security in South Africa and combat the impact that climate change has on water security in the country. A successful WRP should be able to demonstrably indicate that climate change resilience objectives will be achieved (by strengthening the country's adaptive capacity against water stress and scarcity), and should be able to measurably maximize climate change mitigation in a manner that meets the criteria and requirements of the GCF.

The purpose of this Market Study is to:

- Present the status quo of the water in South Africa and define a number of barriers and several climatic related drivers that outline the need for the development of a water reuse programme
- Outline several different types of water reuse archetypes and provide a rounded understanding of these archetypes, including their associated implementation costs, options in respect of institutional arrangements and delivery models;
- Describe the national and municipal landscape for the implementation of these archetypes;
- Provide a high-level analysis of the opportunities for water reuse in different municipalities; and
- Set the scene for the development of a portfolio of indicative projects for the prospective water reuse programme.

1.3 Structure of the Market Study

The Market Study is structured as follows:

- Section 2 positions water reuse as a strategic intervention in the South African context.
- Sections 3 and 4 introduce technical archetypes and existing applications of these archetypes, respectively. These sections are critical in outlining the parameters of water reuse technologies that will be considered for the programme, and illustrating where these different archetypes have been applied and are planned.
- Section 5 introduces the institutional, operational and regulatory environment that are enablers for water reuse interventions in South Africa. It also outlines the technical capacity needs and challenges related to this infrastructure typology.
- Section 6 presents an overview of the technical capacity for the development of water reuse projects in South Africa.
- Section 7 presents an overview of the potential delivery models that could be considered for water reuse infrastructure. These include enabling factors for government to unlock finance for water reuse infrastructure.
- Finally, Section 8 presents an indicative pipeline of potential water reuse projects, which will underpin the design of a national water reuse programme. This pipeline of potential projects will be workshopped with the client to determine the most appropriate mix of projects and representative municipalities, to build a strong case for a national programme and GCF funding.

2. Water Reuse in the South African Context

To present the scale of the water reuse opportunity in South Africa it is essential to understand the need for a diversification of the national water mix and to map the water reuse market in South Africa. This section is aimed at providing a general overview of the need for water reuse in South Africa and how it fits into the National Water Resource Strategy, as well as proposing possible approaches to water reuse.

2.1 South Africa's Water Resource Status Quo

Context

South Africa is a water-scarce country, and the sustainable provision of water is amongst its most significant challenges. Basic water-related services including the provision of potable water and access to sanitation and stormwater drainage are not readily available to a significant proportion of the population.

Furthermore, challenges facing water supply are exacerbated by the increased frequency and severity of droughts in recent years – such as Cape Town's 'Drought of the Century' between 2016 and 2018 – and other similar extreme weather events such as the Cape storms and occasional flooding in Gauteng and Kwa-Zulu Natal. The second edition of the National Water Resource Strategy (NWRS2) (issued in 2013) states that South Africa is currently over-exploiting its renewable water resources on a national level and requires both demand-side and supply-side interventions (Figure 2-1).

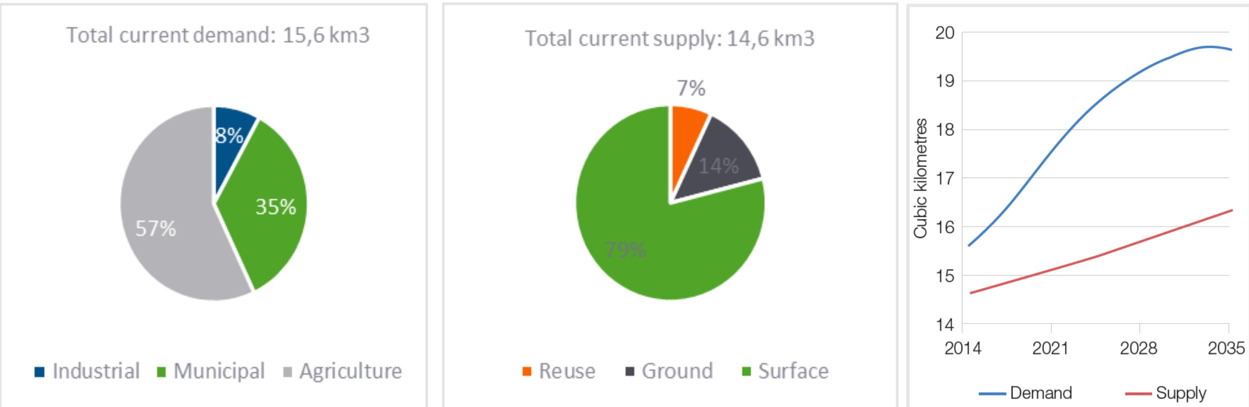


Figure 2-1 (left): South African water demand by sector; (middle): supply mix; and (right) supply vs demand
Source: (Hedden & Cilliers, 2014) adapted from (DWS, 2004)

National water demands in South Africa have increased steadily since 2004 and is likely to continue growing at about 1.2% per annum over the next ten years (DWS, 2013). National water demand was estimated at 15,6 km^3 per annum in 2014, with the largest use arising from the agricultural sector at 57% (8,9 km^3), followed by municipal demand at 35% (5,5 km^3) and lastly, the industrial sector accounting for the remaining 8% (1,2 km^3) (Figure 2-1, left).

South Africa's current water supply mix is strongly dominated by surface water (79%), relying heavily on related surface water infrastructure (over 4,395 registered dams) to meet national water demands. National water supply was estimated at 14.6 km^3 per annum in 2014 with the largest use arising from surface water, followed by groundwater (14%) and then reuse/return flows (13%) – (Figure 2-1, middle). The water balance included National Water Resource Strategy indicated over exploitation as early as 2014 with demand outstripping supply into the future with the 'business as usual' scenarios – (Figure 2-1, right). As a result, by 2030, South Africa is projected to face major water resource shortages (17% supply shortfall). More recently in 2018, the National Water and Sanitation Masterplan (NWSM) provided updated water demand figures per sector as indicated in Figure 2-2 (DWS, 2018).

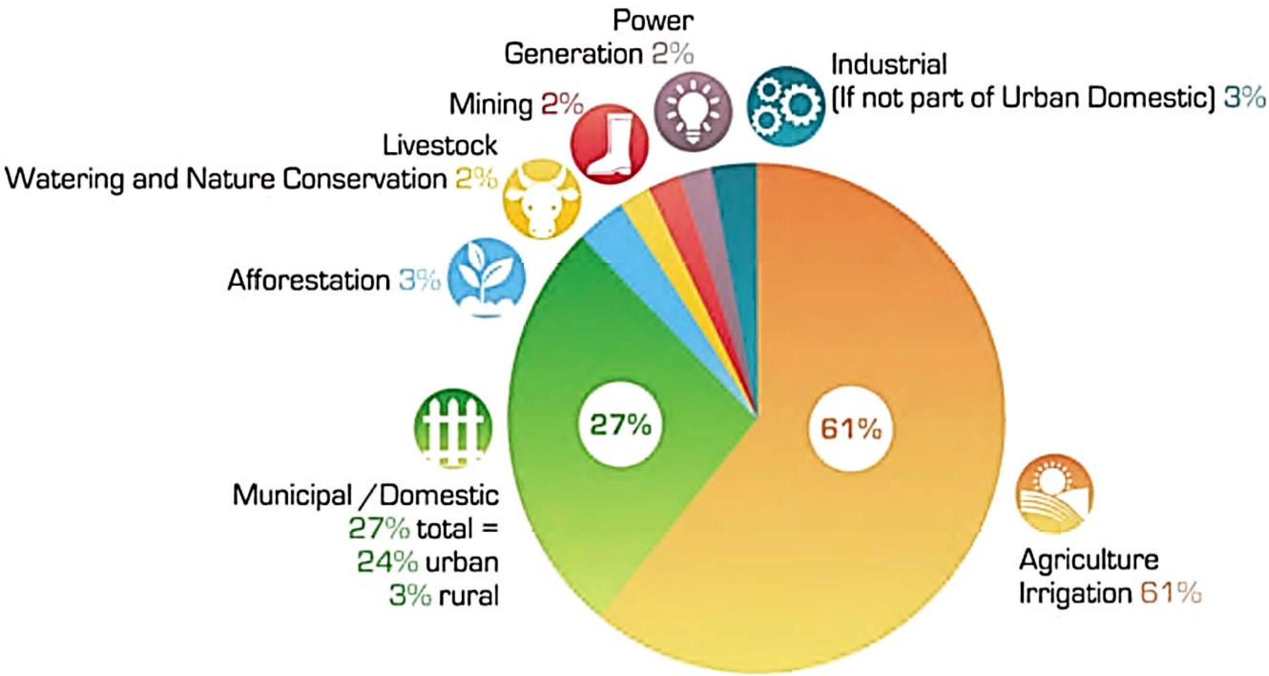


Figure 2-2: Water use by sector
Source: (DWS, 2018)

Challenges

While South Africa has a heavy reliance on surface water, it has low levels of rainfall relative to the world average, receiving an average of 495 mm/year compared with the world average of 1,033 mm/year (Hedden & Cilliers, 2014), thus ranking as the 30th driest country in the world (DWS, 2013). High rainfall variability and evaporation is also experienced, as well as increasing challenges relating to water pollution. Further, despite the range of water related challenges around the country, water consumption is also relatively high compared to international standards, with South Africa's usage of circa 237 litres/capita/day (l/c/d) being almost 30% higher than the international benchmark usage of 180 l/c/d (DWS, 2018).

Many parts of South Africa have reached or are fast approaching the point at which all viable freshwater resources are fully utilised. According to the National Water Resource Strategy (NWRS), 98% of all surface water resources have been utilised, allowing only 2% for future growth (NWRS1, 2004). There are also a number of additional challenges contributing towards increased pressures on water nationwide, including:

- Backlogs in the maintenance and rehabilitation of national water infrastructure and many dams, resulting in reduced storage capacity; and
- Higher than normal levels of water wastage with the average municipal non-revenue water (NRW) estimated to be around 37%, while losses of as high as 60% were estimated in many supply schemes (McKenzie, *et al*., 2012).

The National Water Resource Strategy in the Water Reuse Context

Water reuse is considered as one of several options of augmenting water supply in South Africa and diversifying its water mix. The National Strategy for Water Reuse is a sub-component of and is consistent with the NWRS2 (DWS, 2013). The first (2004) and second (2013) editions of the NWRS, along with the most recent National Water and Sanitation Master Plan (NWSMP) (2018) all identify the need to optimise both demand-side and supply side water management.

The NWRS2 acknowledged that "*the time has now come where a mix of water resources is required to reconcile supply and demand*" and therefore, "*there is a need to find new ways of reducing water demand and increasing availability – which move beyond 'traditional solutions' of infrastructure development*" (DWS, 2013). An innovative approach is required that involves planning, design and implementation of systems that improve water use. Thus, the Department of Water and Sanitation (DWS) has committed to the development of a number of water reconciliation strategies, which includes the reuse of wastewater.

2.2 Water Sensitive Urban Design – contextualised for RSA

Historically, water systems have been developed using a linear design approach, i.e. source, treat, transport, distribute, collect, treat and dispose. This approach is removed from the people it serves and results in primarily technocratic solutions and the fragmented management of the urban water cycle i.e. water management silos. Complex challenges of rapid urban growth and water scarcity require innovative solutions that can work across institutional, sectoral, and geographic boundaries to develop efficient and robust urban water systems to improve supply resilience for future generations.

One possible approach from an integrated water-management perspective is to transition towards 'Water Sensitive Cities' or 'Settlements'. The vision of a Water Sensitive City (WSC) was first proposed by Wong & Brown (2008) and is one where water is given due prominence in the design of urban areas. The concept of 'water sensitivity' was developed from the notion of ecocities – a city that balances social, economic and environmental factors to achieve sustainable development, and attempts to minimise inputs of energy, water and food, and outputs of waste (Howe & Mitchell, 2012, p. 172). As part of the WSC vision, Brown, Keath & Wong (2008: 5) put forward a conceptual framework for visualising and 'benchmarking' the evolution towards water sensitivity through the adoption of what is termed Water Sensitive Urban Design (WSUD). The WSC vision is particularly pertinent in both South Africa (RSA) and other developing countries that are struggling to address the challenge of providing basic services to their people. Brown's framework has been used internationally as a starting point for visualising the transitions within the urban management sector towards WSCs.

Figure 2-3. WSUD considers the various aspects of the water cycle and their inter-connectivity.

Integrated water management approaches, such as WSUD are systems-based approaches that focus on the interactions between the built form and water-resources management. WSUD brings the concepts of 'water sensitivity' and 'urban design' together to ensure that 'urban design' is undertaken in a 'water sensitive' manner (Armitage, *et al*., 2014, p. 4). In its broadest context, WSUD encompasses all aspects (water supply, sewerage, groundwater and stormwater) of integrated urban water cycle management (see Figure 2-3), and requires a significant shift in the way in which water, environmental resources and infrastructure are considered in the planning and design of cities and towns, at all scales and densities (Armitage, *et al*., 2014). Other names for WSD used internationally include low impact development (USA), leading edge technologies (China), Cities of the Future, Greening the city, Resilient cities, Liveable cities and Sponge cities.

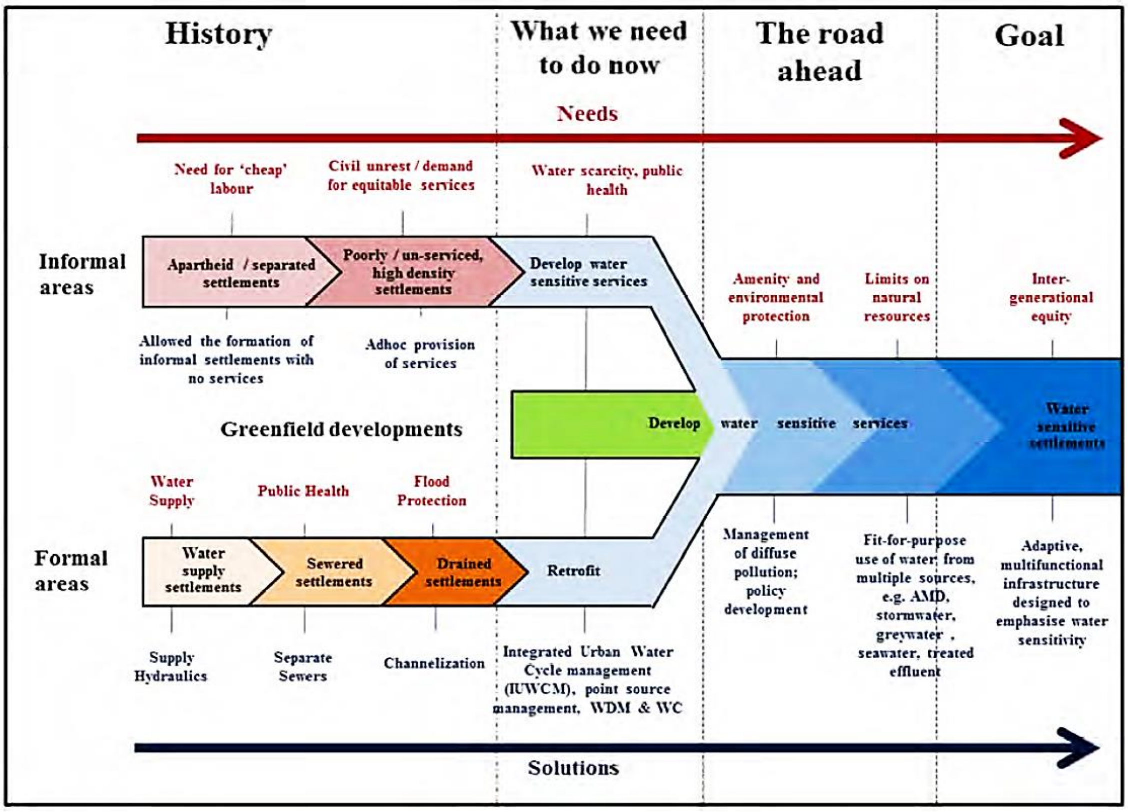


Figure 2-4. SA's transition to water sensitivity: "Two histories, one future".
Source: Armitage, et al., (2014) adapted from Brown et al., (2008: 5).

In the RSA context, the word 'urban' is, largely excluded when referring to this approach, with Water Sensitive Design (WSD) increasingly being used as the descriptive term considered the enabler for assisting local authorities to move closer to meeting developmental goals. The implementation of WSD, adapted for RSA in the 'WSUD for South Africa: Framework and Guidelines' document (Armitage, *et al*., 2014), provides both a long-term vision to transition toward water sensitivity as well as the immediate 'road ahead.' This WSD approach has been included in a number of RSA policies, both local and national. The adoption of this framework/approach is proposed for the purposes of the reuse 'Market Study.'

The WSUD framework and guidelines (Armitage, *et al*., 2014) defined 'water sensitivity' in the RSA context based on the following principles selected from the National Water Act (RSA, 1998), the NWRS2, the RSA Constitution (RSA, 1996) and the Dublin Principles (UN, 1992):

i. RSA is a water-scarce country;
ii. Access to adequate potable water is a basic human right enshrined in the Constitution of RSA;
iii. Management of water requires a participatory approach involving users, planners and policymakers at all levels;
iv. Water has an economic value and should be recognised as an economic good; and
v. Water as a resource is finite and vulnerable, essential to sustaining all life, as well as supporting development and the environment.

2.3 The Market for Water Reuse in South Africa

The need for water reuse as a means of augmenting and diversifying the water mix in South Africa is widely acknowledged in national policies and guidelines (see NWRS1 & NWRS2, WSMP 2018, WSUD framework and guidelines and others). Acceptance for water reuse from municipal wastewater treatment works (WWTW) as an alternative water supply has largely been seen in the industrial sector. However, the industrial use of water in South Africa is estimated to be only 8% (1.248 km^3) of the total annual water demand and there is a gap in the expansion of the use of reused water to other sectors, particularly for the domestic and agricultural sectors.

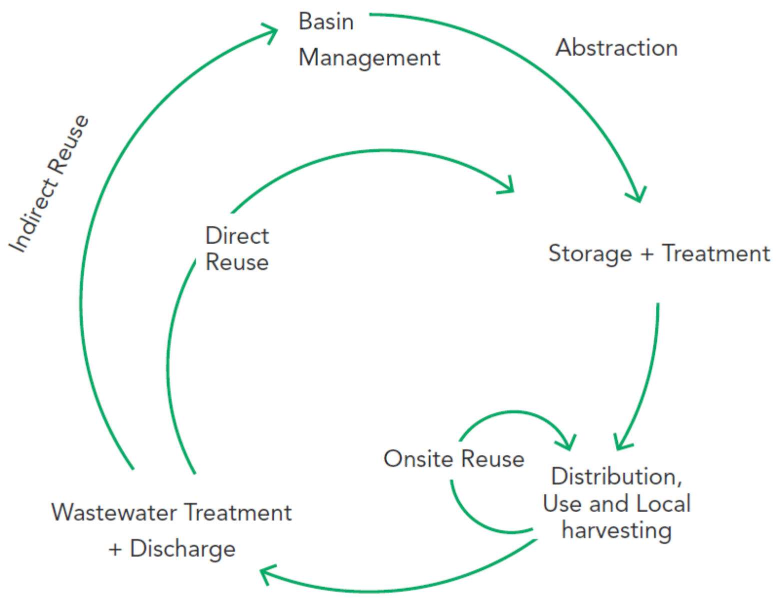


Figure 2-5: Water reuse opportunities across the water value chain (GreenCape, 2018)

South Africa has in excess of 1,000 municipal WWTW that produce and discharge approximately 2.1 km^3/year of treated effluent to receiving waters (DWS, 2013, pp. 3, Appendix D). There is a strong correlation between potable use and effluent discharge in cities, where approximately 60% of the annual average daily demand (AADD) is returned to WWTWs for processing and subsequent discharge as treated effluent. This creates an opportunity for reuse in growing cities, as effluent quantities generally increase in proportion to increased AADD. However, in instances where the AADD is reduced either due to a) water restrictions or b) Water Demand and Water Conservation Management (WDWCM) campaigns, the potable use of water may decrease, but the nutrient loading of effluent generated is likely to remain largely constant.

The8ndustryial, mining and power generation (IMP) sectors reconciliation strategy indicated wastewater reuse can contribute up to 14.3% of the water demand for the sector as part of its water mix (Reddy & Siqalaba, 2018). There is sufficient treated effluent supply to meet these demands, although there are many other factors to be considered before water reuse projects can be implemented, and therefore, a considerable market for water reuse for these applications.

The need for large scale treatment plants in close proximity of significant industrial demand means that water reuse systems are likely to be limited to the largest 8 metros and some secondary cities with large industrial bases (such as Drakenstein, Rustenburg, uMhlathuze and Emfuleni). Graham (2019) noted that a valuable contribution in the water reuse space would be to map locations of suitable municipal wastewater treatment works in relation to suitably large industrial water users to identify the most promising geographic areas for projects. This has been done in Sections 7 and 8. Coastal regions could be the most accessible market for municipal-scale DPR and IPR due to the possibility of brine discharge into the ocean, as well as relatively few downstream users being reliant on return flows, thereby reducing potential regulatory barriers. However, the larger industrial customers are located inland, thus inland opportunities are also available. Also, inland areas don’t have the option of seawater desalination which puts more emphasis on the need for water reuse schemes from WWTW. A GreenCape (2018) analysis estimated typical costs for DPR and IPR being 30-50% cheaper than seawater desalination systems, indicating reuse as a stronger market option than desalination for coastal cities.

Treated effluent from WWTW is already being distributed for non-potable applications in several municipalities, typically focussing on irrigation and selected industrial uses (mostly cooling), albeit at a relatively small scale. Yet, the scale of reuse is usually limited to the contribution that the consumer or municipality is willing to make to the supply network. Also, municipalities are not always able to guarantee consistent quality or quantity of treated effluent supply, resulting in a lack of uptake. For example, Saldanha Bay municipality, that has many heavy industrial consumers, sells only 6% of WWTW effluent, despite the demand exceeding this quantity by a considerable amount. As another example, the City of Cape Town (CCT) invested in WWTW reuse during the Western Cape drought (2016-2018) and currently sells approximately 75 Mℓ/day (from various WWTWs) of a total production of 450 Mℓ/day (i.e. 16%), indicating additional expansion is possible. These factors all contribute to significant market opportunities for water reuse in South Africa.

2.4 Drivers and Barriers to Water Reuse

Drivers

There are several drivers outlined below to the implementation of water reuse projects for public and private investment in municipal-scale projects, in the South African context.

Driver 1: South Africa's vulnerability to the impacts of climate change	South Africa is highly vulnerable to climate change, ranked amongst the top half of most vulnerable countries in terms of climate change vulnerability overall, and water-related climate change vulnerability in particular. It is also ranked amongst the top half of countries that have suffered the most climate change-related historic losses in the last two decades. Climate change is expected to drive a future decline in annual average rainfall over large parts of South Africa, particularly in the southwest of the country. Climate model projections (multi-model ensembles) for future time-periods consistently point to a drier future for most of South Africa, across all scenarios. In terms of baseline water stress, South Africa falls within the top quarter (25%) of the world's most water-stressed nations. According to one global multi-variate index of water risk, parts of South Africa display some of the highest baseline water risk levels in the African continent and across the world. Mean annual precipitation in South Africa is estimated at 454 mm/year, relative to the global average of 786 mm/year. Thus, the country's already-stressed water resources will be put under greater pressure by climate change, with South Africa expected to become drier as the southern African region warms at nearly twice the rate of the rest of the world, becoming a climate change hotspot in terms of both hot extremes and drying. For many South Africans, this will translate into severe water insecurity in the future, given that at present, over a third of the population (an estimated 35%) does not have access to safe and reliable drinking water supply, and nearly a quarter do not have access to safe sanitation. Based on current demand projections and without effective interventions (to augment the water mix, such as an intervention like the WRP), the water deficit confronting the country will only increase.
Driver 2: National water scarcity:	South Africa is a water-scarce country with a projected water supply deficit of 17% by 2030 that will place additional strain on national water resources and restrict the country's ability to meet its growth and development targets. Water allocation in many areas of the country is over extended meaning that demand is greater than the available water supplies. In addition, climate change is projected to increase variability of rainfall in South Africa and reduce average rainfall, particularly in the western part of the country placing additional pressure on already stressed water resources and ecological infrastructure. The projected gap between water demand and supply is driven by a number of factors, including low tariffs, inadequate cost

	recovery, over-consumption, inefficient use, wastage, leakage, inappropriate infrastructure choices (e.g. water borne sanitation in a water scarce country), inadequate planning and implementation, as well as population and economic growth (DWS, 2018). Municipal water restrictions are also common in water-scarce areas and encourage industries to improve supply resilience by seeking alternative supply. For example, level 6 water restrictions in the Western Cape from 2017-2018 required all non-residential users to reduce consumption by 45% compared to 2015 use as well as radically reducing allowable irrigation volumes from conventional sources. This forced businesses and institutions to consider reuse alternatives, such as WWTW reuse, greywater reuse, rainwater harvesting, borehole abstraction and others. For example, Stellenbosch University implemented a borehole augmentation system during the 2016-2018 drought to supplement irrigation, as allowable abstraction volumes from the Eerste River were drastically reduced by the local municipality, which placed the extensive landscaping and sports field areas at risk (JG Afrika, 2021 a). For businesses and industry, the risk of insufficient water supply results in business continuity challenges that can lead to cut-backs, closures and considerable financial losses. This was particularly notable during the Western Cape drought from 2016-2018. According to a survey conducted on members of the Cape Chamber of Commerce and Industry, 51% viewed the drought as a threat to their business, and 23% indicated it caused them to halt or postpone new investments in their business (CCCI, 2017). In response to this risk, some businesses chose to invest in alternative supply options to build water supply resilience. For example, the International School of Cape Town implemented WDWCM measures as well as installing a rainwater harvesting system for their campus in 2017 during the drought to enable students to continue attending classes (JG Afrika, 2021 b).
Driver 3: Higher than average water demand	Despite South Africa being a water-scare nation, it experiences a higher-than-average water demand per capita – 237 litres/capita/day vs. international benchmark of around 180 litres/capita/day. On the demand-side, the national target for reduced average domestic consumption is 175 litres/capita/day by 2025 (DWS, 2018). To achieve this reduction, focus areas include, *inter alia*, water use efficiency, improved quality of water and sanitation fittings and reduced non-revenue water (NRW) loss programmes – this also leads to increases in revenue. Furthermore, losses within urban areas are targeted at being reduced from around 35% to 15% (DWS, 2018). On the supply-side, the current reliance on surface water resources is unsustainable and there is a need to introduce a new “water mix” that provides for a more resilient

	and sustainable development agenda. Water reuse projects can provide an additional water “sources” to assist closing the water supply deficit.
Driver 4: National Development Plan aspirations	Another driver for water reuse is the aspirations of the National Development Plan to reach a national target of 100% universal and sustainable provision of reliable water supply and sanitation services by 2030 – this also aligns with the Sustainable Development Goals (SDGs), particularly Goal 6 to provide clean and sustainable water and sanitation for all. Constitutionally, the responsibility of providing water supply and sanitation services lies with 144 municipalities that are considered water services authorities. Some 33% of these municipalities are regarded as dysfunctional and over 50% have no or very limited technical staff (DWS, 2018). Of these, 27 priority district municipalities have been identified and selected, requiring specific interventions. The state of municipalities and associated water infrastructure impacts water reuse prospects and needs to be taken into account when identifying potential projects.
Driver 5: Water and sanitation regulations and quality standards	Regulation of the water and sanitation sector in South Africa is another driver. Suitable regulation is important to achieve water security including, *inter alia*, water quality, balancing demand and supply and being resilient to climate change impacts. Some municipalities fail to deliver water supply and sanitation at the required levels of service. In the 2014 Blue Drop (water supply) assessment, 86% of WSAs achieved good or excellent status for microbiological water quality compliance, but only 70% achieved good or excellent status for water quality operational compliance. The No-Drop and Green Drop Reports also indicated high levels of non-compliance in wastewater treatment works in many municipalities for not meeting the discharge standards. Municipalities require industrial effluent to meet certain quality standards before discharge into the wastewater stream and failing to do so can result in fines and penalties. Consequently, industries often invest in wastewater treatment systems to improve discharge quality that reduces overall pollutant loads entering the wastewater stream and enhances the business case for reuse. Despite strong regulatory tools in the legislation, the quality of raw water continues to deteriorate across the country, with high levels of water theft and water wastage continuing. This could be partly due to the requirements for courts to impose sanctions on those contravening water legislation which can hamper the ability to get speedy resolution on regulatory non-compliance.

Driver 6: National financial pressures	Financial pressures are another major driver for water reuse projects in South Africa. Water and sanitation infrastructure is capital intensive by nature requiring considerable funding in the face of limited fiscal resources. Currently, the water sector is not being managed sustainably, with a R333 bn funding gap projected over the next decade (DWS, 2018). To close this gap, water sector costs have to decrease while revenue generation needs to increase, to support investment into the water sector. The socio-economic profile of South Africa is highly variable with 63% of households earning less than R38 000 annually (classified as indigent) and therefore, not required to pay for municipal services – this number increases to 77% smaller and/or rural municipalities (DWS, 2018). Municipalities with a large proportion of indigent households are reliant on national grants to facilitate reliable and affordable sanitation and water services as well as equitable share allocations required constitutionally to enable the provision of basic services. Consequently, it is difficult for these municipalities to address infrastructure service backlogs and allocate funds for operations and maintenance (O&M) on existing works. Water sector cost reductions can be achieved through reduced demand and reduced physical water losses (non-revenue water). Revenue increases can be realised collectively through reconsidering the cost of water (pricing) as well as revenue management (metering, billing and collection). Also, a mindset-shift is required where water needs to be regarded as valuable resource requiring protection and responsible use. Fiscal transfers can be increased if cost efficiencies and revenue challenges are addressed. Increased government support for funding structures can also assist in addressing these challenges. Also, loan funding possibilities need to be explored where loan funding is increased through the private sector and simplified PPP structures and water revenue and grants intended for loan repayment need to be "ring fenced". Pricing and pricing expectations are important factors when considering financing water reuse projects. In South Africa, water is generally paid for twice – once for its supply and once for its discharge to sewer systems.
Driver 7: Water tariffs and pricing structures	Water tariffs in South Africa are relatively low compared with European countries (Kelly, 2021). The business case for water reuse can be strengthened considerably in municipalities where tariff increases are scheduled, as seen for example with CCT and Stellenbosch Municipality where sizable tariff increases implemented during the 2016-2018 drought resulted in the uptake of alternative supply options (GreenCape, 2018). Also, pricing and tariff structures within the water sector vary considerably between municipalities and are not consistently regulated (in comparison to energy

pricing in the energy sector), largely due to the water sector not having a distinct or independent regulator.

Pricing of water services in South Africa is complicated further by national legislation. Access to adequate potable water is a basic human right enshrined in the Constitution of RSA and indigent households receive 6-9kl/day free water service provision under the Water Services Act (No. 108 of 1997). Therefore, water pricing needs to consider covering infrastructure costs without impeding people's right to access it.

To incentivise efficient use while allowing equitable access to water, tariffs are often structured in rising tiers (rising block tariffs), an example is given in Table 2-1. This allows tariff calculations to be based on the principles of full cost recovery to protect the basic level of service and to ensure long-term sustainability of the service (including backlogs, O&M, new infrastructure and others), while addressing the issue of over consumption. Historically, the first water step has been charged at a zero rate to all domestic users but in recent years this has changed in some municipalities, particularly those experiencing drought.

Also, there are some municipalities (e.g. Stellenbosch Municipality) that base sanitation tariffs on land-use as opposed to a volumetric function. In this case, this tariff structure may impact payback periods for water reuse and can disincentivise reuse projects. For example, Stellenbosch University implemented a campus shower greywater reuse system for toilet flushing in 2019. As a result of the municipal tariff structure being linked to land use, payback period calculations for the system were limited to savings from reduced potable use and savings from reduced sewage volumes were not realised. Had the sanitation tariff's been linked to consumption, payback periods could have been reduced by 1-2 years (JG Afrika, 2021 a).

Table 2-1: Example – domestic water tariff for Western Cape municipality for 2020/2021

Water steps (kl)	Non-indigent		Indigent households	Comment
	Level 1	Level 0		
0-6	R 17.92	R 17.37	R 0	Some municipalities incur a zero charge for the first water step, others as a function of average cost of water
6-10.5	R 25.49	R 23.87	R 0	Basic usage charged at a function of the average cost of water
10.5-35	R 36.19	R 32.43	R 0	Basic usage charged at a function of future incremental marginal cost
35 and above	R 79.46	R 59.85	R 0	Use that will jeopardise water conservation at punitive charge to deter high water usage

Domestic sanitation tariffs are generally based on wastewater volumes discharged and calculated by applying a factor (70% - 90% depending on municipality) to the monthly metered water consumption. Effluent discharge rates (R/kl) are typically 70%-95% less than water supply rates (R/kl). In contrast, industrial tariffs are set at a constant rate (as a function of future incremental marginal cost), rather than a rising block tariff. These are estimated from applying a factor, say 95%, to the monthly metered water consumption – see Table 2-2.

Unfortunately, in many municipalities the true economic cost of water (including O&M and risk considerations) is not known and therefore, tariff structures are not cost-reflective. Although water pricing is a sensitive and politicised topic, without cost reflective tariff structures (including rising block tariffs), it is difficult to finance and develop bankable projects (Kelly, 2021).

Table 2-2: Example – domestic sanitation tariff for Western Cape municipality for 2020/2021

Water steps (kl)	Non-indigent		Indigent households	Comment
	Level 1 (R/kl)	Level 0 (R/kl)		
0-4.2	R 15.74	R 15.26	R 0	Some municipalities base tariffs on land use rather than as a function of consumption
4.2-7.35	R 22.40	R 20.97	R 0	
7.35-24.5	R 33.52	R 29.45	R 0	
24.5-35	R 60.32	R 46.33	R 0	

Table 2-3: Example – water & sanitation tariff for Western Cape municipality for 2020/2021

Service	Level 1 (R/kl)	Level 0 (R/kl)	Comment
Water	R 32.83	R 31.10	Constant rate applied per unit volume rather than rising block tariff, typical for domestic users
Sanitation	R 29.49	R 27.94	

Barriers

While there are numerous drivers, there are also significant barriers to investment in municipal-scale water reuse projects in the South African context. In general, water reuse not only requires additional treatment capacity to reach potable standards for DPR or IPR, but also often requires upgrading local municipal WWTW to meet quality discharge standards. This creates a barrier to water reuse as the required capacity (technical, institutional and financial) to facilitate these upgrades is not always available in the public sector. Some of these barriers will require consideration during the design of the WRP, while others will need to be addressed during its implementation/operational stage. These can be broadly categorised into three categories, technical barriers, financial barriers and governance barriers, detailed below.

Technical barriers

i. Technical and institutional **capacity constraints** can limit municipalities implementing advanced water reuse projects as highly skilled teams are required to prepare, design, install and operate such systems.

ii. South Africa experiences high water losses in most municipal water networks that results in loss of revenue and reduced viability. This water loss is exacerbated by aging water and WWTW infrastructure that can require considerable maintenance before these areas and/or systems become viable for water reuse. **Brine disposal**, produced from the treatment process, is another barrier although the introduction of new technologies, as undertaken in Windhoek, Namibia is not producing the brine effluent that is typically associated with Advanced Treatment Plants. A saline brine waste stream may remain after recovery for some types of treatment. This presents a challenge as most municipalities do not permit the direct discharge of brine into sewerage lines. Therefore, in these situations, industries often concentrate waste streams to reduce volumes and improve ease of removal, thereby incurring additional treatment costs. Coastal sites typically dispose brine in the sea. For inland sites, disposal is more complicated and costly. Brine is beginning to be viewed as a resource with extractable value, but it remains an environmental barrier, nonetheless.

iii. **Land availability** to accommodate water reuse infrastructure can also pose a challenge, particularly in densely populated areas.

iv. **Health risks** associated with direct potable reuse remain a concern, although advances in water treatment technologies can mitigate these risks. Treatment systems need to be designed, implemented, operated and maintained adequately and failure to do so negatively impact on the future market.

v. **Downstream users** of riverine systems (including the ecological reserve requirements) often rely on treated effluent discharges. Diverting discharge for upstream reuse can reduce downstream quantities and availability.

vi. **Project preparation:** the inability of municipalities to adequately prepare projects to bankability will impact the ability to create a strong pipeline of bankable and implementation ready water reuse projects. It is the intention that the WRP will address this challenge and provide support to municipalities to prepare their water reuse projects.

Financial barriers

i. Municipal-scale projects are **capital-intensive** and **access to funding** can be a major constraint, particularly for small, less financially stable municipalities. These often lack capacity to develop bankable projects and struggle to raise funds. Also, capital costs range significantly depending on effluent quality, treatment requirements and the reuse application. For example, local projects focussing on organic effluent treatment cost in the order of R 20 – R120 million per Mℓ/d produced, while those for inorganic effluent cost in the order of R 10-15 million per Mℓ/d produced (GreenCape, 2018).

Governance barriers

i. **Municipal procurement processes** can be tedious and difficult to navigate. In addition, Public Private Partnerships (PPP) are complex and difficult to arrange at a municipal scale (Graham, 2019). Reuse projects are generally associated with burdensome regulatory requirements and controls often resulting in other alternatives being more favourable to municipalities. These regulatory and procurement challenges increase project timeframes and costs. As an example, the Overstrand Municipality took more than four years to outsource the O&M of its water and wastewater treatment works (GreenCape, 2018). Some of the possible institutional models that have been discussed over recent years will have interfaces with the WRP and obtaining clear guidance on these institutions and their mandates as well as establishment process will be important.

ii. **Public perception** is also a consideration. While reuse is steadily becoming more accepted, there are risks of negative public perception relating to the reuse of effluent, particularly regarding acceptability on religious or cultural grounds and any water reuse project must remain sensitive to these values. Water reuse has not been widely implemented in South Africa partly due to overwhelmingly negative public perceptions. A lack of knowledge or **awareness** is also common, acting as a barrier to reuse technologies being adopted.

iii. **Ownership and leadership** is another barrier. Support of the key lead departments of DWS and DCOG/MISA will be imperative in ensuring the successful implementation of the WRP and ultimately the development of the broader water programme. This will require active engagement in the programme design as well as an understanding of the commitments (technical and financial) to support the programme's implementation.

iv. **Municipal buy-in** will be needed for any WRP to be successful. The lack of capacity at municipal levels is considerable and this is exacerbated by political challenges and lack of support. There is specifically limited understanding and mistrust of the role of the private sector in municipal projects. The engagement of SALGA through the wider Reference Group / WRP Community of Experts will not only provide useful "municipal" input into the WRP design, but will also provide the chance for SALGA to provide information to municipalities that progressively builds awareness and buy-in. This could be done with priority municipalities where projects are likely to be in the portfolio.

v. **A regulatory and enabling environment** is also needed. There is a significant array of regulatory aspects that must be taken into consideration across the project preparation cycle. These instruments include water, environmental, financial, contractual and municipal dimensions and will have implications for project preparation processes. These need to be considered in the operational case for the Water Partnership Office and as part of the guidelines.

vi. During the set-up, implementation and phased development of the WRP there will be a complex array of roles and responsibilities that will develop over time. Being clear of where **accountability** resides across the project cycle and how these change with time as the programme develops will be important and needs to be clarified during the design phase, in the operational case.

State of Public Acceptance

A recent study found that the top three words that South African study participants associated with recycled water were "cleanliness" (26.4%), followed by "disgust" (11.6%) and "contamination" (15.3%) (Etale, *et al.*, 2020). When combined, the negative connotations of "disgust" and "contamination" totalled 26.9%, fractionally higher than the 26.4% "cleanliness" score, indicating how polarised the debate about wastewater reuse – especially for potable purposes – is likely to be in South Africa.

Study respondents further displayed "state disgust" (disgust elicited by some perceived state of the water itself) rather than "trait disgust" (defined as an indication of an individual's general disgust-sensitivity). "State disgust" is regarded as a learned attitude, leading the authors to conclude that negative associations with wastewater treatment could be shifted by improving public knowledge about water reuse (Etale, *et al.*, 2020). According to the Water Research Commission (WRC), knowledge about water in general, and reuse, is low across all demographic groups and education levels in South Africa (Slabbert & Green, 2020).

In addition to assessing subjective associations with treated wastewater, the study also assessed the effect of trust in local water authorities on willingness to use treated wastewater. Unsurprisingly, higher levels of trust were linked to higher levels of willingness, and vice versa. The study authors suggested that experiencing water restrictions may diminish public trust in water authorities (Etale, *et al.*, 2020). However, the WRC study found that experiences of drought and water restrictions increased overall willingness to consider using treated wastewater, which could have a balancing effect (Slabbert & Green, 2020).

Interestingly, cultural beliefs and environmental concerns were found to have less of an effect on willingness to use recycled water (Etale, *et al.*, 2020). However, there are signs of a growing awareness of environmental challenges among the public, with a recent WWF International report finding a 71% increase in online searches for sustainable goods over the past five years (Economist Intelligence Unit, 2021).

Given the scale of investment required for water reuse infrastructure, it is crucial that barriers to acceptability be addressed. The national Water Reuse Programme will include a comprehensive communications strategy that broadly aims to:

- **Improve public knowledge of South Africa's water situation** to drive reduction in water demand and improve acceptance of the need to seek alternative water sources, including treated wastewater.
- **Help the envisioned Programme Management Office communicate with water authorities** about its role in supporting the development of water reuse projects.
- **Empower municipalities that choose to augment potable water sources with treated wastewater to communicate clearly and transparently** about their choice and the project process to build the public's trust in their ability to do so safely and sustainably.

The programme communications strategy will provide necessary background on South Africa's climate and water situation, set out key messages backed by evidence, and identify appropriate communication channels. It will be complemented by an implementation plan for public-facing communications, top-level information architecture for an online information hub managed by the Programme Management Office, and a communications toolkit for use by municipalities wishing to communicate to a broader public about their projects.

3. Water Reuse Project Archetypes

The section provides an overview of several water reuse project archetypes that may be employed to characterise a portfolio of water reuse projects that will initially comprise the Water Reuse Programme.

3.1 Introduction

This section presents an overview of various water reuse archetypes that may be considered as potential project implementation options within the WRP. Until recently, wastewater treatment plants have been simply seen as a necessary evil to clean our sewage so as not damage the environment. They are also seen as a generator of a side stream waste in the form of sludge. However, with a move to Circular Economy thinking and Water Sensitive Urban Design, it has been realised that WWTWs can now rather be viewed as potential sources of valuable resources such as water, energy and nutrients. As such, WWTWs may be viewed as Water Resource Centres, where one is able to extract these resources and reuse them within a city environment, thus reducing the pressures placed on non-renewable and other stressed resources.

3.2 Direct Potable Reuse

What is Direct Potable Reuse?

Direct Potable Reuse (DPR) can be described as the treatment of final wastewater effluent in an advanced treatment plant (ATP) and transfer of the product water to the inlet of a bulk water treatment plant or directly into the water distribution network. This is shown schematically in Figure 3-1 below.

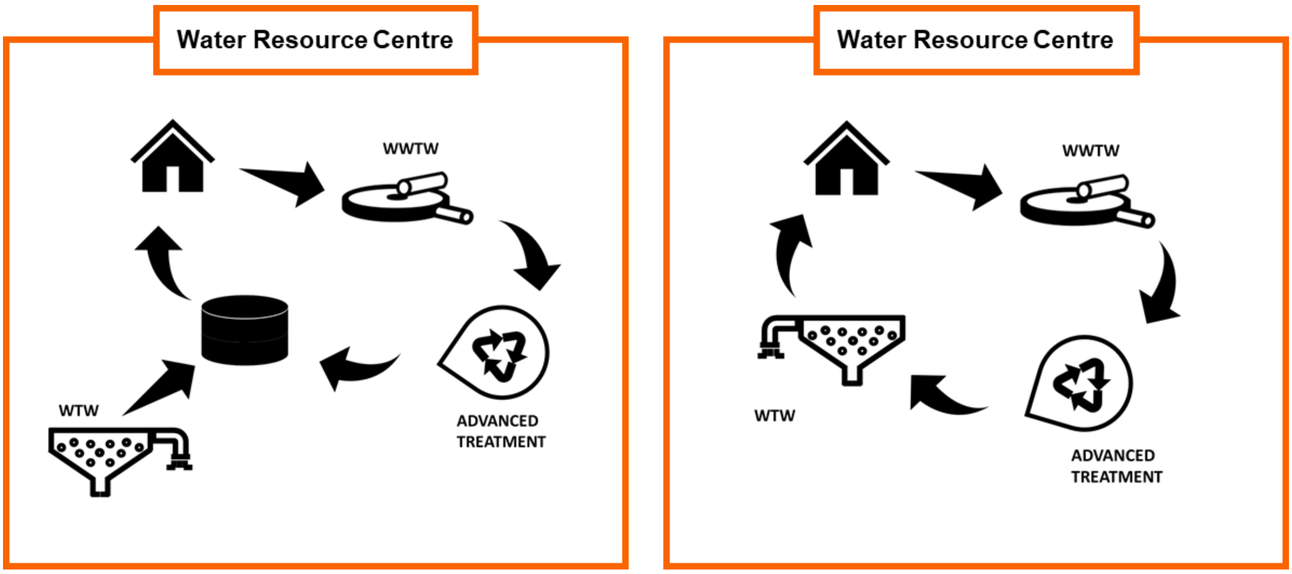


Figure 3-1 : Schematic of typical Direct Potable Reuse Projects

DPR Capex and Opex Ranges

Direct Potable Reuse projects tend to have high capital and operational costs due to the advanced technology and extent of controls required to ensure the strict water quality standards. The capital cost is naturally dependant on the size of the works and the type of technology employed. Processes that utilise membrane technology (Reverse Osmosis) have higher capital and operational costs, whereas non-membrane technologies (typically ozone based) have slightly lower capital and operational costs. Also, as the size of the advanced treatment plant increases, the unit cost per Ml/d reduces due to economies of scale.

By way of example, a 20 Ml/d advanced treatment plant would have a capital cost of between R26 million and R33 million per Ml/d (i.e. between R520 million and R660 million). Typically, 50% of the capital cost would be required for the civil infrastructure with 10% allocated towards electrical equipment and a further 40% towards mechanical equipment. Based on past project experience, the operational cost would typically range between R5.50/kl and R6.50/kl of reused water produced.

Expected Useful Life (EUL) of Components and approximate Construction Period

- Typically, the mechanical equipment has a useful life of approximately 15 years after which major overalls/refurbishment are required. This excludes membrane replacement which needs to take place throughout the life of the equipment, the cost of which is included in the operational cost estimated.
- The construction period and required plant footprint will also vary depending on the size of the advanced treatment plant, but construction periods would typically be between 18 months and 3 years for large plants.

  In terms of required footprint, advanced treatment plants take up less space than the equivalent size of a WWTW. Advanced treatment plants between 20 and 50 Ml/d in size would typically require between 1 and 2 hectares of space. It would be beneficial for most projects to locate the advanced treatment plant on the same premises as the WWTW as there are a number of inter-dependencies that require piped connections. This could potentially also ease environmental regulatory processes.

3.3 Indirect Potable Reuse

What is Indirect Potable Reuse?

Indirect Potable Reuse (IPR) can be described as the treatment of final wastewater effluent in an advanced treatment plant and the transfer of the product water to an environmental buffer (such as an aquifer or surface water reservoir) where it will blend with raw water before treatment in a bulk water treatment plant. This is shown schematically in Figure 3-2.

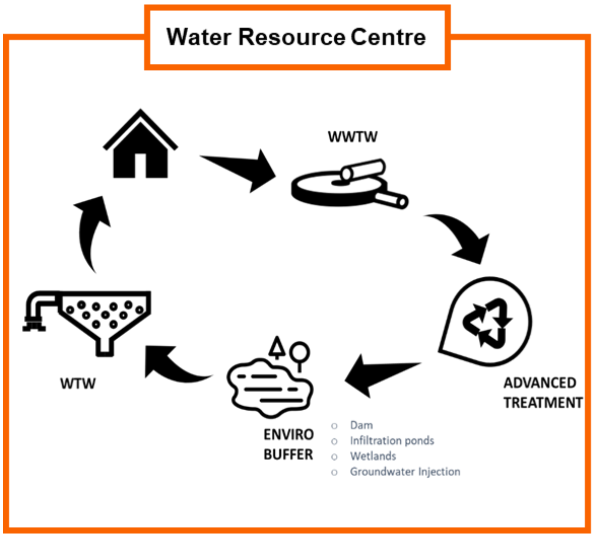


Figure 3-2 : Schematic of typical Indirect Potable Reuse Projects

IPR Capex and Opex Ranges

Indirect Potable Reuse projects also tend to have high capital and operational costs due to the advanced technology and extent of controls required to ensure the strict water quality standards but should be lower than direct potable reuse plants as there are fewer steps in the process. The capital cost is naturally dependant on the size of the works and the type of technology employed. Processes that utilise membrane technology (Reverse Osmosis) have higher capital and operational costs, whereas non-membrane technologies (typically ozone based) have slightly lower capital and operational costs. Also, as the size of the advanced treatment plant increases, the unit cost per Ml/d reduces due to economies of scale.

By way of example, a 20 Ml/d advanced treatment plant would have a capital cost of between R22 million and R30 million per Ml/d (i.e. between R440 million and R600 million). Typically, 50% of the capital cost would be required for the civil infrastructure and 10% for electrical and control equipment and 40% for mechanical equipment. The operational cost would be in the range of that offered by a DPR reuse plant, which is between R5.50/kl and R6.50/kl of reused water produced.

Expected Useful Life (EUL) of Components and approximate Construction Period

- Typically, the mechanical equipment has a useful life of approximately 15 years after which major overalls/refurbishment are required. This excludes membrane replacement which needs to take place throughout the life of the equipment, the cost of which is included on the operational cost estimated.
- The construction period and required footprint will also vary depending on the size of the advanced treatment plant, but construction periods would also typically be between 18 months and 3 years for large plants, with the required footprint of the advanced treatment plants (of between 20 Ml/d and 50 Ml/d in size) also being in the region of 1 and 2 hectares. Similar considerations to that of a DPR project would need to be taken into account in respect of the location of the advanced treatment plant in order to gain efficiencies from existing infrastructure and in order to smoothen environmental regulatory processes.

3.4 Industrial Reuse

What is Industrial Reuse

Industrial Reuse can be described as the treatment of final wastewater effluent in an advanced treatment plant to a quality suitable for industrial purposes and the transfer of the product water to a specific industry or generally to an industrial area. This is shown schematically in Figure 3-3.

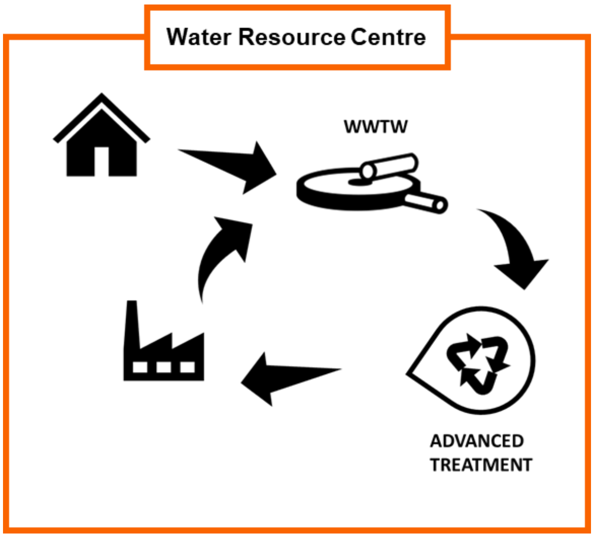


Figure 3-3 : Schematic of typical Industrial Reuse Projects

Industrial Reuse Capex and Opex Ranges

Industrial reuse treatment plants vary significantly depending on the specific quality required by the industry or group on industries. There is thus a corresponding variability in the capital and operational costs of such plants. Some industries (e.g. mines) may only require an ultrafiltration step and additional disinfection, while others may require a water quality that is close to potable standards. As such, the capital costs could vary from R10 million to R30 million per Ml/d. Similarly, the operational cost could vary from R2.00/kl to R6.00/kl of reused water produced.

Expected Useful Life (EUL) of Components and approximate Construction Period

The useful equipment life, construction periods and split between mechanical/electrical/civil capital costs would be similar to potable reuse projects. The required footprints would however typically be smaller than potable reuse plants.

3.5 Irrigation Reuse

Irrigation Reuse can be described as the transfer of the polishing final wastewater effluent to quality standards required by agriculture or other irrigation users. This is shown schematically in Figure 3-4. Irrigation reuse projects require a relatively minimal additional treatment before the treated water is distributed into an irrigation reuse network or a rising main and therefore, the subsequent capital investment on the associated WWTW is relatively minor. For irrigation reuse to be effective, significant capital expenditure may be required in respect of the reused water's distribution network and this should be carefully considered in terms of the climatic objectives of the WRP. However, it is noted that each project will be carefully assessed by the Water Partnership Office and the DBSA (as the AE) on a case-by-case basis, and as such, in the case that it can be demonstrated that a particular irrigation reuse project contributes towards achieving the proposed climatic-related benefits of the WRP, that project may be considered for inclusion with the WRP.

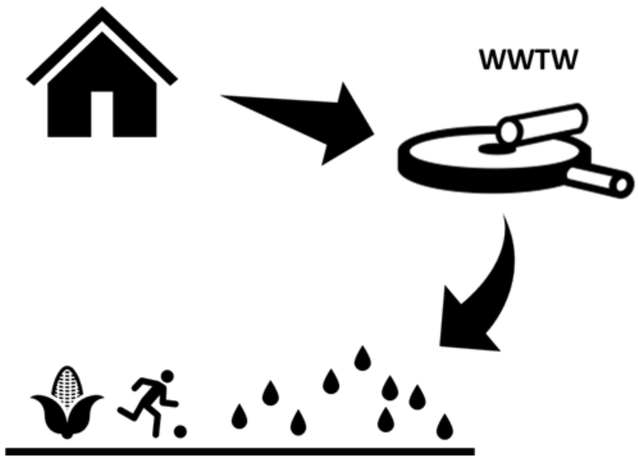


Figure 3-4 : Schematic of typical Irrigation Reuse Projects

3.6 Reuse Project Archetype characteristics

Each type of water reuse project is associated with various characterises. A qualitative summary of the characteristics of each type of water reuse (IDR, IPR, industrial reuse and irrigation reuse) is provided in Table 3-1. A longer bar indicates a more favourable solution.

Table 3-1: Summary of water reuse archetype characteristics.

Reuse characteristics	Direct Potable (DPR)	Indirect Potable (IPR)	Industrial	Irrigation
Advanced treatment plant product quality:	Highest ■■■■■	Very High ■■■■	Medium ■■■	Lowest ■■
Range of usability of water:	Highest ■■■■■	Highest ■■■■■	Medium ■■■	Lowest ■
Capital Cost:	Highest ■	High ■■	Medium ■■■■	Lowest ■■■■■
Operational Cost:	Highest ■	High ■■	Medium to High ■■■■	Lowest ■■■■■
Public Acceptance:	Lowest ■■	Medium ■■■	High ■■■■	Highest ■■■■■
Operational Expertise Required:	Highest ■	High ■■	Medium ■■■	Lowest ■■■■■

3.7 Sludge Beneficiation

Wastewater treatment works are not only a potential source of water, but the various types of sludge generated by the treatment process are a potential source of energy and nutrients. There is therefore a potential for sludge to energy to be part of the Water Resource Centre concept. To understand the potential for sludge to energy / other by-products projects for the WRP, a brief summary of the types of sludge typically generated and the potential sludge beneficiation project types is discussed here.

Sludge Types

- **Primary Sludge** is generated by settling the raw sewage at the start of the works before biological treatment. This is done by means of primary settling tanks through a simple gravity action. This sludge has a very high energy content as it has not been digested or metabolised and thus the energy has not been consumed. It also has a high pathogen content. This sludge is highly desirable for anaerobic digestion to generate gas due to its high calorific value. It has a solids concentration of between 2% and 4% dry solids and is thus quite liquid in nature. Primary sludge is usually digested in anaerobic digesters and the digestate (digested sludge) is dried and then typically disposed of on land as a soil enhancer.
- **Waste Activate Sludge (WAS)** or Secondary Sludge is generated in an activated sludge treatment process and consist of waste bacteria that accumulates in the reactors. This sludge has a lower calorific value as it is made up of bacteria that has already metabolised the energy in the wastewater and converted it into cell growth. This sludge is usually high in nutrients with a solids concentration of between 0.5% and 1% dry solids.
- **Faecal Sludge** is generated in pit toilets, conservancy tanks and septic tanks and is often collected separately at WWTWs, but then combined with the raw sewage and/or primary sludge. This sludge is usually very thick with solids concentrations of between 5% and 15% dry solids. The calorific value is variable, depending on how long it has been sitting in the tanks where it is being digested. It also usually contains large amounts of unbiodegradable contaminants such as plastics, stones etc.

Sludge to Energy

- The calorific energy in sludge can be extracted by digesting the various sludges in an anaerobic digester and harvesting the biogas that is generated. This biogas (made up of a combination of methane and carbon dioxide) can be transferred to a combined heat of power (CHP) engine for the generation of electricity and heat. Typically, the amount of energy that can be extracted in a CHP engine **from the primary and secondary sludge** at a WWTW is less than the energy required to operate the WWTW. As such, the "revenue" generated is in fact in the form of electricity savings on the WWTW. Heat from the CHP would be used to heat the digesters to keep the digestion process at an optimal temperature to extract the highest yield and quality of biogas.
- These projects can exist separately from reuse projects as there is not a requirement for sludge to energy to make a water reuse project function and vice versa. However, the electricity from the sludge to energy project can supplement the electricity needed on the advanced treatment plant.

- Design and operation of a CHP is relatively complex, and the consistency of the sludge stream and optimisation of the anaerobic digester is vital operational task.

Sludge to Gas

- A slight variation on the above is harvesting the gas from the anaerobic digesters and selling it to others who wish to utilise the energy in their own processes (often boilers). Slightly less infrastructure is required on site, but space would be required for storing gas bottles or bulk storage tanks. This process still requires careful operation of the anaerobic digesters to optimise the gas year. Consistent quality and quantities of sludge is also essential to ensure consistent gas supply.

Composting

- Waste activate sludge as well as digested primary sludge can be composted together with a bulking agent to beneficially utilise the nutrients in the sludge. The process is operationally relatively simple and capital costs are low.
- There are however limitations to how much compost can be sold as markets can become easily saturated. As such, securing regular off-take agreements is essential to the success of a composting project. Equally important is a reliable source of bulking agent and consistent sludge generation.

Pelletisation

- Another way to harness the energy or nutrients in wastewater sludge is a pelletisation process whereby the sludge is dried to pellets for either fertiliser use or as a fuel pellet.
- These are complex, high-energy processes that require very specific skills. There is only one active pelletisation project in South Africa that is run by a private company to make custom fertilisers. It would thus seem that these processes are generally not preferred by Municipalities in the South African context. However, this does not mean that the technology cannot be considered when undertaking feasibility studies in this regard.

3.8 Sludge beneficiation Approaches and Associated Characteristics

Each type of sludge beneficiation is associated with various characterises. A qualitative summary of the characteristics of each sludge beneficiation use is provided in Table 3-2 overleaf.

Table 3-2: Summary of characteristics of sludge beneficiation technologies

Project Element	Sludge to Elec.	Sludge to Gas	Composting	Pelletization
Capital Cost:	Highest ■	High ■■	Low ■■■■■	Highest ■
Revenue:	High ■■■■	High ■■■■	Low ■■	High ■■■■
Operational Expertise Required:	High ■■	High ■■	Low ■■■■	Highest ■
Beneficiation:	Energy	Energy	Nutrients	Energy/Nutrients

Note that a longer bar indicates a more favourable solution.

4. Reuse Projects in South Africa

The section presents a list of existing and planned reuse projects in South Africa with the aim of determining trends, appetites and preferences with respect to water reuse within the South African municipal environment.

4.1 General

Water reuse from WWTWs is historically not a widely implanted water augmentation solution in the South African context and hence there are not a great deal of project-related case studies.

A summary of the known water reuse projects in Southern Africa that are operational and in progress is included in Table 4-1 and Table 4-2. Only potable and industrial reuse projects have been listed.

4.2 Water Reuse Projects in operation

Table 4-1: Operational reuse projects

Name	Type	Municipality**	Status	Procurement method*	Size	Date Completed
New Goereangab Water Reclamation Plant	DPR	Windhoek, Namibia	Operational	DBOO	21 Mℓ/d	2002
eMalahleni (Mine Water)	AMD - Potable	eMalahleni, MP	Operational	DBO	50 Mℓ/d	2014
Optimum Coal (Mine Water)	DPR	eMalahleni, MP	Operational	DBO	15 Ml/d	2010
Durban WWTW reuse	Direct Ind	eThekwini, KZN	Operational	BOOT, PPP	47.5 Ml/d	2001
Frasers WWTW	Direct Ind	Ballito, KZN	Operational	EPC	1.5 – 6 Ml/d	2015
Beaufort West WWTW reuse	DPR	Beaufort West, WC	Operational	BOO	2 Mℓ/d	2010
Zandvliet WWTW reuse (Pilot)	DPR	City of Cape Town, WC	Operational	EPC	10 Mℓ/d	2018
Woodlands Dairy	DPR	Private, WC	Operational	DBO	1.5 Mℓ/d	2017
Old Mutual Office reuse	DPR	Private, WC	Operational	BOO, PPP	0.65 Mℓ/d	2018
Mossel Bay WWTW reuse	Direct Ind	Garden Route, WC	Operational	Unknown	5 Mℓ/d	2010
George WWTW reuse	IPR	Garden Route, WC	Operational	Unknown	10 Mℓ/d	2019
Hermanus	DPR	Overberg, WC	Operational	Unknown	5 Mℓ/d	2011
Darville WWTW reuse	DPR	Umgeni Water, KZN	Pilot	N/A	2 Ml/d	2016
Rustenburg	Direct Ind	Rustenburg, GP	Inception	Municipal Entity	25 Mℓ/d	2004

***Note –** the following relates to procurement methods used:
EPC: Engineering, procurement, construction and commissioning; PPP: Public Private Partnership; BOOT: Build, Operate, Own and Transfer; BOO: Build, Own and Operate; BOT: Build, Operate and Transfer; DBO: Design, Build, Operate

****Note** – the follow relates to South African provinces incorporating the municipalities: WC: Western Cape; KZN: Kwa-Zulu Natal; GP: Gauteng; EC: Eastern Cape; MP: Mpumalanga

4.3 Water Reuse Projects being planned and prepared

Table 4-2:Wastewater reuse projects under initiation, planning and preparation

Name	Type	Municipality**	Status	Procurement method*	Size	Date Initiated
eThekwini Remix	DPR Remix	eThekwini, KZN	Procurement	PPP	6.25 Mℓ/d (demo); 100 Ml/d	2018 (demo)
Northern WWTW	DPR	eThekwini, KZN	Feasibility	PPP	50 Mℓ/d	2017
KwaMashu WWTW	DPR	eThekwini, KZN	Feasibility	PPP	50 Mℓ/d	2017
uMhlathuze WWTW reuse	Industrial	uMhlathuze, KZN	Procurement	PPP	75 Mℓ/d	2018
Nelson Mandela Bay	DPR	Nelson Mandela Bay, EC	Feasibility	Unknown	2 Mℓ/d pilot	-
Drakenstein water reuse	Direct Ind	Drakenstein, WC	On hold	PPP	10 Mℓ/d	-
Faure Reclamation Plant WWTW reuse	DPR	City of Cape Town, WC	Detailed design	Conventional FIDIC	70-100 Mℓ/d	2018
Cape Flats WWTW reuse	IPR	City of Cape Town, WC	Procurement	Conventional FIDIC	40 Mℓ/d	2018
Borcherds Quarry	IPR	City of Cape Town, WC	Cancelled (up to detailed design)	EPC	6 Mℓ/d	2018

***Note –** the follow relates to procurement methods used:
EPC: Engineering, procurement, construction and commissioning; PPP: Public Private Partnership; BOOT: Build, Operate, Own and Transfer; BOO: Build, Own and Operate; BOT: Build, Operate and Transfer; DBO: Design, Build, Operate

****Note** – the follow relates to South African provinces incorporating the municipalities:
WC: Western Cape; KZN: Kwa-Zulu Natal; GP: Gauteng; EC: Eastern Cape

4.4 Comments on existing and planned reuse projects

Drought a Key Driver

The primary driver in many of the existing and planned reuse projects (particularly with respect to DPR) is the onset of drought conditions in a particular area. Six of the existing reuse projects and at least six of the planned projects were initiated because of drought and were therefore done on an emergency / reactive basis. Drought conditions accelerate the prioritisation of potable reuse projects as an alternative water source to traditional surface water.

It is anticipated that the drought experiences of a number of the large metros (e.g. City of Cape Town) and the subsequent move to reuse as a mechanism to provide water resilience can be used as a tool to promote reuse in other Municipalities that may not be experiencing a drought at present (i.e. in a proactive manner), but who are aware that they are not immune from such occurrences. The reality is that it takes many years to develop these projects and if one were to start with the implementation when a drought starts, the water will not be available until after the drought ends. It thus makes sense to plan for these projects in anticipation of needing the additional water in the future to improve water resilience and security.

Procurement Model / Contracting Structure

Based on the projects developed to date, a Design-Build-Operate (DBO) model or some form of PPP-related contractual structure appears to be the preferred procurement and delivery model. Further, there does appear to be a general preference for the operations to be privately managed.

Typical Project Size

The existing reuse projects are generally (with some exceptions) small scale, but it is evident that the planned reuse projects appear to be much larger. There is naturally an economy of scale with such projects, but also a reluctance to invest a large amount if the technology appears to be unproven. This is to be expected, as initially the projects would need to be based on proven technology and would need to not be excessively large (in terms of capacity and investment costs required) in order to prove a 'proof of concept' and achieve the public's acceptance, whereafter a move to larger full-scale projects may be made to realise the economy of scale benefits of this programmatic approach.

Preferred Reuse archetypes

Although Direct Potable reuse appears to be the preferred reuse archetype, it should be noted that most operational DPR projects are rather small in scale. However, there are several planned DPR projects indicating that Potable Reuse (over industrial reuse) is gaining popularity. This is understandable given the potable reuse technology is relatively new.

Indirect Potable Reuse appears to be only preferred when there is an existing environmental barrier, such as in the City of Cape Town and George. Many of the existing and planned projects do not necessarily have the luxury of an environmental barrier to implement IPR, but it is not certain whether this was even considered in some of the cases and further consultation with Municipalities would assist in this regard.

The larger existing projects tend to be Industrial Reuse projects which one would expect as these should theoretically be easier to promote.

Possible role of the WRP

The number of planned reuse projects represent an opportunity for the WRP as most of these projects are likely to require further project preparation, funding as well as procurement support. This analysis does therefore appear to indicate that since the technology is becoming more accepted and Municipalities are starting to see the need to improve water resilience by means of water reuse this would be the right time to initiate the WRP.

4.5 Case studies

Cape Town – Faure New Water Scheme (DPR)

Water reuse has been considered for some time to improve the City of Cape Town's (CCT) water supply resilience, but the recent drought accelerated reuse to form a key component of the latest water strategy. In 2018, the CCT received a R1.3 billion loan from the German government owned KfW Development Bank aimed at targeting energy-efficient, economical and sustainable urban wastewater management through the expansion and refurbishment of some of the City's 25 wastewater treatment plants over the next few years (Graham, 2019).

The Faure New Water Scheme (FNWS) was identified as one of two water reuse projects in Cape Town and with construction forecast to commence in 2024, the project is currently in the design phase (Graham, 2019). In addition, concept designs appear to be developed for DPR water reuse from the Cape Flats (at a capacity of 75 Ml/d) and Athlone (at a capacity of 75 Ml/d), but it is understood that CCT was opposed to investing heavily in reuse at this stage.

The fnws is being designed as a permanent 70 Mℓ/d (with allowance to expand to 100 Mℓ/d in the future) system that will source treated wastewater from the proposed upgraded Zandvliet WWTW (currently providing 50 Ml/d) and Macassar WWTW (20 Ml/d) (CCT, 2020). The Zandvliet and Macassar plants were selected as supply sources due to proximity, as well as being able to provide sufficient volumes of treated effluent. The Zandvliet WWTW is also being upgraded to include enhanced treatment processes to ensure improved quality source water for the reuse scheme. Water from these sources will be piped to the FNWS located at the existing Faure Water Treatment Plant (WTP), approximately 5 km away.

This Faure New Water Scheme brings together purification technologies, monitoring and control systems and operating protocols and includes a multi-barrier purification process for removing contaminants as indicated below (CCT, 2020).

- **Ozonation:** oxidising properties destroy pathogens and break down complex organic substances into simple biodegradable organic substances removed in the filtration process.
- **Biologically Activated Carbon (BAC) Filtration:** removes particles and biodegradable organic substances.
- **Granular Activated Carbon (GAC) Filtration:** removes non-biodegradable micro-organic substances through adsorption.
- **Ultrafiltration :** removes particles, pollutants and pathogens.
- **Advanced Oxidation and UV Disinfection**

This treated reuse water will be blended with raw water from dams, at a ratio of 20% reuse water and 80% dam water. This blend will be treated by conventional processes at the existing Faure WTP, stored in the Faure reservoir, from where it will be introduced into the distribution network to supply the wider Cape Town metropolitan area.

Durban – Industrial Reuse

In the 1990's Durban was facing sewerage capacity constraints. In addition, Mondi Paper approached the city of Durban in 1993 to request recycled water, at a lower rate than potable water (Graham, 2019). The municipality identified this opportunity to develop a wastewater treatment plant to cater for these increased demands and a solution was identified comprising an upgrade of the existing activated sludge process from 50 Mℓ/d to 77 Mℓ/d and the construction of a new 48 Mℓ/d tertiary (final treatment) plant.

However, upon review of the technical capabilities within the municipal sanitation division, it was clear that the municipality was not able to implement a project of this scale. Also, the financial feasibility study conducted indicated suitability to attract private capital. Thus, eThekwini invited international tenders for a public-private partnership (PPP) for the project.

A 20-year concession contract was awarded to the Veoila Water Systems consortium in 1999, with Veoila Water Solutions and Technologies as the lead, Zetachem, Khulani Holdings Limited, Umgeni Water and Marubeni. This was a Build-Own-Operate-Transfer (BOOT) contract that remained valid until 2021, making it the first PPP of its kind in the country. Also, it should be noted that this PPP was developed prior to the current PPP legislation, amended in 2003. Construction commenced in 2000 and was designed to treat 48 Mℓ/d – around 10% of the council's wastewater. A total project investment of R72 million (€4.5 million) was needed and this was provided by the consortium totalling R14 million, the Development Bank of Southern Africa who provided R34 million, as well as the Rand Merchant Bank who contributed R24 million (Graham, 2019). The project went live in 2001 and began selling water to Mondi Paper (85% of supply) and the South African Petroleum Refineries (15% of supply). Stringent quality requirements needed for Mondi paper processing were met by the new plant. These included 32 quality parameters specified in the contract that the treated water must comply with, including 95% COD removal (to a max 15mg/l) and 98% ammonia reduction (to a max 0.2mg/l) (Veolia, 2019).

An annual management fee and an annual fee for the lease of municipal land is paid to the municipality by the consortium. Importantly, the consortium also pays a lost cross-subsidisation opportunity fee to the municipality to account for industrial consumers.

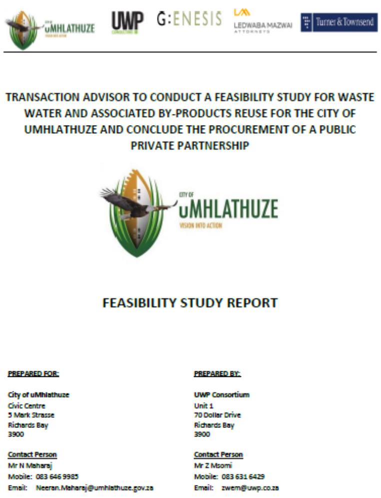
The plant minimises wastewater released to receiving waters and runs at an efficiency of 98% water utilisation. When operating at design capacity, Durban's water consumption is reduced by 7% and sea outfall pollution reduced by 24% (Veolia, 2019). This has also contributed to sewage now being considered a potential natural resource.

Pietermaritzburg – Darvill DPR Pilot

The Darvill Wastewater Treatment Works (WWTW) is situated in Pietermaritzburg, South Africa and is the largest plant run by Umgeni Water. Umgeni Water is a state-owned business enterprise (Water Board) that operates within the South African legislative parameters. The primary function of Umgeni Water is to supply treated water in bulk to its municipal customers. Darvill WWTW currently has a design capacity of 65 Mℓ/day and it in the process of being upgraded to 100 Mℓ/day as part of a municipal tender to address running over capacity.

A 2 Mℓ/d direct potable reuse demonstration plant was installed in 2016 at the WWTW which was designed to treat final effluent to potable water standards, being one of the first plants of its kind in the province. Construction commenced in 2015. The demonstration plant incorporated several advanced technologies to provide multiple barriers against bacteria, viruses, and endocrine-disruptor breakthrough such as advanced oxidation and biologically activated filters and ultrafiltration membranes. The plant functions as a separate facility and was commissioned for a 5-year period where a portion of final effluent is taken from the secondary clarifiers at the Darvill WWTW and diverted to the reuse plant. This pilot was implemented while the upgrade to the main plant was being done. The increasing cost of additional bulk water resources was a primary driver for the reuse plant pilot. It is used as a demonstration facility to promote public acceptance of the technology as well as to pilot various process unit types to have a more informed selection process during full scale implementation.

UMhlatuhuze – Feasibility Study



TRANSACTION ADVISOR TO CONDUCT A FEASIBILITY STUDY FOR WASTE WATER AND ASSOCIATED BY-PRODUCTS REUSE FOR THE CITY OF UMHLATHUZE AND CONCLUDE THE PROCUREMENT OF A PUBLIC PRIVATE PARTNERSHIP

FEASIBILITY STUDY REPORT

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The City of uMhlatuhuze published a feasibility study looking at a potential wastewater industrial reuse project to be implemented as a PPP. The feasibility study was published as part of a Transaction Advisory service by the uMhlathuze Wastewater Project (UWP) Consortium. Publication date was 12 May 2017.

The project essentially entails collecting the domestic effluent from five municipal (domestic) wastewater treatment works plus three industrial effluent treatment plants and sending it to a regional treatment works. At this regional facility, there will be a conventional activated sludge WWTW to treat the domestic sewage plus an advanced tertiary treatment works to treat a portion of the treated effluent to a higher industrial standard. Final product water from this regional plant would then be sold to at least five industrial users.

Water sources and off-takers

Table 4-3 indicates the proposed sources of wastewater for the project. The flows are assumed to be average dry weather flows, although this is not stated clearly in the report.

Table 4-3: Portable water sources

Treatment Works	Return to Source	Current Flows (Measured 2017)
Empangeni WWTW	Mhlathuze River	9 Mℓ/day
eSikhaleni WWTW	To Sea	8 Mℓ/day
Ngwelezana WWTW	Mhlathuze River	2,4 Mℓ/day
eNseleni WWTW	Lake Nzezi	1 Mℓ/day
Vulindlela WWTW	Mhlathuze River	1,6 Mℓ/day
Alton Macerator (Untreated)	To Marine Outfall	5 – 7 Mℓ/day
Arboretum Macerator (Untreated)	To Marine Outfall	10 – 12 Mℓ/day
Mondi Paper Mill	To Marine Outfall	45 Mℓ/day
TOTAL		**82 – 86 Mℓ/day**

The report this indicates that there is, on average, at least 82 Ml/d available for tertiary advanced treated at the proposed regional site.

The transaction advisor engaged with potential used for the product water and identified a total of five potential end users who could potentially purchase up to 71.7 Ml/d on average of the industrial product water. A summary of these potential users (names redacted) is provided in Table 4-4.

Table 4-4: Potential off-takers

Industry	Current Usage as Indicated	Future Use as Indicated	Envisaged Date of Future Use	Current Provider
	14,15 Mℓ/day	25 Mℓ/day	Not Indicated	Mhlathuze Water (Current Use)
	10,00 Mℓ/day	30 Mℓ/day	2020	Mhlathuze Water (New Use)
	-	11,71 Mℓ/day	2020	City of uMhlathuze (New Use)
	1,20 Mℓ/day	1,20 Mℓ/day	-	City of uMhlathuze (Current Use)
	-	5 Mℓ/day	2023	City of uMhlathuze (New User)
TOTAL	25,20 Mℓ/day	71,71 Mℓ/day		

It was reported that all 5 potential off-takers signed a formal letter of intent.

Conceptual design

A total of 7 potential technical options and configurations were identified and analysed through a comprehensive weighting and assessment system. The option of a new regional treatment (capacity 75 Mℓ/day) at a new regional site with a pump collection system was selected as the preferred option.

A site between the Nseleni and Mhlathuze river was selected and the preferred site for the treatment plant. A total of 25 ha will be required for the regional treatment facility.

Mhlathuze Waterboard and Mondi undertook pilot plant testing which indicated that the effluent can be treated to an acceptable standard by utilising filtration (presumably ultra-filtration) and reverse osmosis processes. Some additional pre-treatment steps will be necessary.

The total capital cost estimate in 2017 (including land costs) amounted to R1 736 209 178. The Unitary Reference Value was estimated at R10.82 / m^3.

The potential for biogas generation was also include in the study and it was recommended that thermophilic digestion for CHP engines be implemented as part of the project. It was however stated that the viability of the project was not dependant on the biogas electricity generation. Furthermore, composting of sludge was also included as part of the project.

A collection system consisting of five pumpstation and rising mains will be required to collect and transfer the effluent to the regional treatment facility. Preliminary designs of these collection pipelines indicated a total of 31.6 km of pipelines varying from 500mm to 864 mm pipelines will be required. A total installed power of 585 Kw will be required for pumping.

The regional facility will produce two quality streams. One of the larger users will receive lower quality re-use water directly from the WWTW (30 Ml/d). The other users will receive a higher quality water from the tertiary treatment plant (45Ml/d). Treatment at the regional facility will take place in three treatment modules as follows:

- 50 Ml/d domestic WWTW
- 35 Ml/d Industrial treatment work
- 10 Ml/d water treatment works for higher quality water

A 50 Ml/d Biological Nutrient removal activated sludge plant will treat the raw sewage diverted from Ngwelezane WWTW, Empangeni WWTW, Alton Macerator and Arboretum Macerator. Ngwelezane and Empangeni WWTWs will potentially be decommissioned depending on the ecological reserve.

The 35 Ml/d industrial treatment plant will treat industrial effluent from the pulp and paper mills using conventional water treatment, plus advanced oxidation and reverse osmosis membrane treatment.

The 10 Ml/d water treatment plant will treat a portion of the treated effluent from the WWTW to an industrial standard using conventional treatment processes (Flocculation – sedimentation – filtration) plus advanced oxidation (Ozonation) and GAC.

The distribution network to off-take users will be via a gravity driven network. This is made possible by the location of the regional facility. An estimated 27 km of pipelines ranging from 225 mm diameter to 762 mm diameter pipes will make up the network.

PPP Process

From an institutional perspective, the feasibility study report states: “In line with Section 78 (1) of the MSA, the study has shown that the internal service delivery option is the not the preferred choice as the City of uMhlathuze does not have the necessary resources and skills to undertake fulfil the requirements of this option. It is recommended that the City of uMhlathuze look to an external mechanism for service delivery.

In line with the requirements of Section 78 (3) of the MSA, the study has shown that long term funding with an external provider can generally bring skills, capacity, expertise and funding to the service. Their experience and motivation can bring efficiency benefits that can be greater than the profit earned.”

This effectively paves the way for the process to initiate a Public Private Partnership.

The project has also undergone a legal and economic due diligence based on the preferred option. The tariff structure for sale of the treated industrial water is comparable to tariffs that they currently pay. The risk for design, build, finance, manage and operations would be transferred to the private entity. An Environmental Impact Assessment needs to commence as soon as Treasury Views and Recommendations (TVR)-I approval for the project was obtained.

The findings state that “Overall, the PPP-procurement approach is therefore shown to yield significant value for money over the concession period, and as such, is the recommended procurement approach, subject to securing the necessary subsidy for the project.”

The project procurement plan will follow the RSA Treasury’s PPP procurement phasing starting with a RFQ, followed by an RFQ for shortlisted bidders. The site for the regional treatment works is in the process of being secured by the City of uMhlathuze before the RFP process.

5. Institutional Considerations

In understanding the scope of potential water reuse projects across South Africa it is important to understand the institutional and regulatory environment within which these projects will take place. This section provides a review of the institutional and regulatory environment and outlines the various challenges that are experienced within this governance framework

5.1 Introduction

The interpretation of what constitutes water governance is still evolving internationally as countries endeavour to find more optimal approaches that will provide for sustainable water resource management and development, and the provision of water services that underpin growth and development. This ranges from the exercise of government authority to more contractual arrangements that include public private partnerships, through to the less tangible dimensions of participation and engagement by civil society that hold government to account. Whilst there is a legally entrenched governance framework, there is increasing recognition of the importance of looking to new arrangements that support improved levels of management and service delivery.

The governance arrangements that support the water sector are inherently complex and involve a range of policy, legislative, regulatory and institutional instruments. In the South African context, these need to be understood across differing spheres of government (national and local government) as well as across the various dimensions of water resource management and water services provision. Water reuse has interfaces with both water resource management and water services provision, and it is important to reflect upon these interfaces, how these impact upon the WRP and the projects that will be supported and the various challenges that needs to be addressed through the programmatic support that the WRP will provide.

5.2 Institutional and Operational Environment

The Constitution of South Africa (Act 108 of 1996) allocates the mandates of national, provincial and local government with water resource management being a national government competency and the provision of water and sanitation services being a local government function. The details of these functional responsibilities are provided in the National Water Act (Act 36 of 1998), the Water Services Act (Act 108 of 1997), the Municipal Structures Act (Act 117 of 1998), the Municipal Systems Act (Act 32 of 2000) and the Municipal Finance Management Act (Act 56 of 2003). The Department of Water and Sanitation (DWS) has the responsibility to manage and regulate the water sector and this role is supported by Catchment Management Agencies that function within defined water management areas. The DWS is legally the custodian of the national water resource and overall leader of the water sector. DWS oversees the activities of water sector institutions and regulates water resources and water services provision (DWAF, 2003).

The provision of water services is constitutionally mandated to local government and is supported through bulk water supply undertaken by Water Boards that are utilities that operate some water resource infrastructure, bulk potable water supply schemes (selling to municipalities and industries), some retail water infrastructure and some wastewater systems (Figure 5-1).

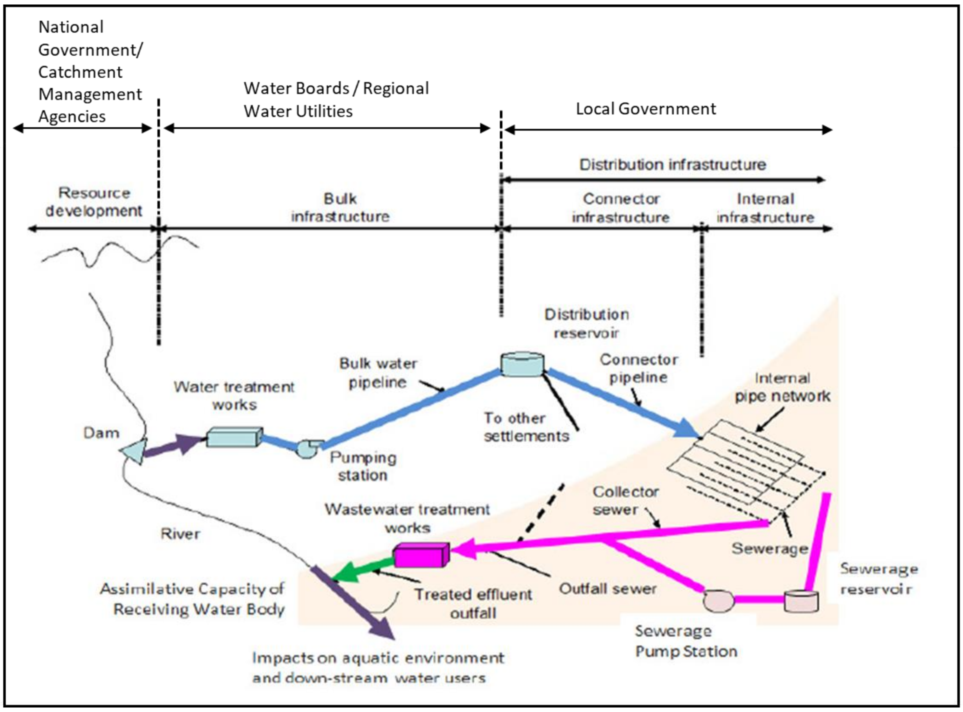

Figure 5-1: Water services business lifecycle (DWS, 2013a)

Constitutionally, local government has the executive authority of, and right to administer water services limited to potable water supply systems and domestic wastewater and sewage disposal systems[1]. In executing its water services authority function, it must plan for, and access water and invest in and operate and manage the infrastructure to do so. This can be in the form of abstraction of raw water, duly authorised by license, or by receiving bulk water from a bulk water services provider in terms of a contract. It must also discharge wastewater which is regulated by the Water Services Act, 1997, National Water Act,1998 and the National Environmental Management Act, 1998. Municipalities who are water services authorities (WSAs) must take progressive steps to ensure service delivery. This includes considering and how to provide water and sanitation services to their community and tariff setting.

In executing its Constitutional mandate, a WSA must decide how to structure itself to deliver water services (Figure 5-2). This may take the form of providing these services themselves or through contractual arrangements with external water services providers (WSP) who do so on behalf of the WSA. Local WSPs would provide only services to one municipality/ WSA, whereas regional WSPs may provide services to a number of municipalities on behalf of multiple WSAs.

[1] Section 156(1)(d) read with Schedule 4 Part B of the Constitution of the Republic of South Africa Act No 108 of 1996.

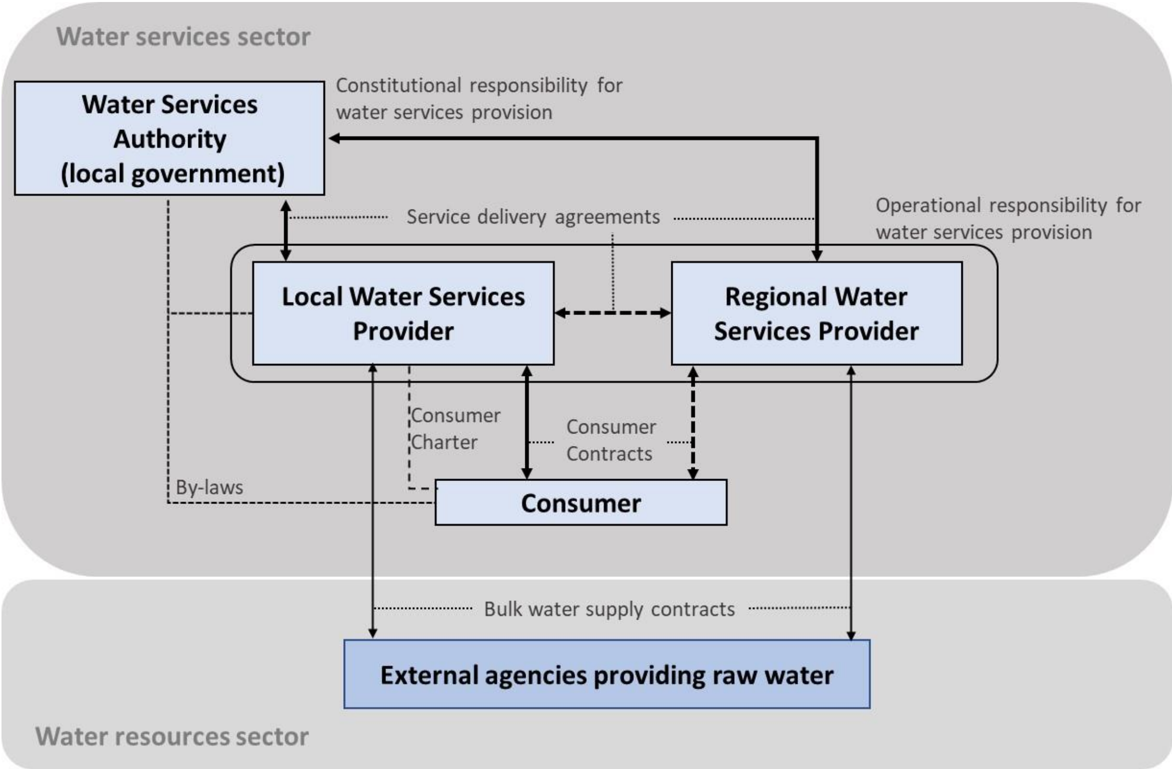

Figure 5-2: Institutional arrangements for water services provision (after (DWAF, 2003)

Water reuse is a function of ensuring water services provision. Like planning and deciding how to access raw water, whether by license under the National Water Act or in terms of a bulk supply contract with a water board, water reuse is an option in the water resource supply mix. A function is distinct from a municipal service[2] and enables municipalities to undertake municipal services. It can be argued that structuring a water reuse project is not the structuring of a water services provider mechanism. In most instances the WSP mechanism will continue to deliver the municipal services (water supply and sanitation services directly to consumers) and bill and collect revenue directly from consumers. Water reuse projects are unlikely to have direct interface with the community but may interface with the WSP. Interface with the WSP will likely be required around quality and quantity of wastewater and reclaimed water supplied. It will either be with the WSP in the case of water for municipal services or can, with the permission of the WSA[3], be direct with the industry when it is water for industrial use or supply of non-potable water for non-municipal services purposes (e.g. water for industrial use or for irrigation of golf courses etc).

[2] This view is based on the published opinion of National Treasury in the MFMA PPP Guidelines (Municipal Service Delivery and PPP Guidelines: Solid Waste Management: Introduction).
[3] Section.7. of the Water Services Act.

5.3 Regulatory Environment

Objective & approach

The regulatory environment directly impacting implementation of water reuse projects by municipalities in South Africa needs to be understood in terms of addressing the following **key questions**:

- Is the concept of water reuse supported by our national regulatory framework?;
- Can municipalities undertake water reuse projects? And If yes, how do they go about structuring the project?; and
- Finally how can municipalities then implement the project?

In addressing these issues, the statements are high-level and generic, as the enquiry and advice is in the absence of project specific information. It is assumed that a "*water reuse project*" means a project that is structured to:

- enable reclamation of water from municipal wastewater systems;
- appropriately allocate responsibility for the design, build, finance of the infrastructure;
- appropriately allocate the responsibility for the operation and maintenance of infrastructure to treat the wastewater to standards appropriate for the use intended; and
- supply the reclaimed water to intended users.

Background

In principle, the concept of water reuse has been accepted as part of the water resource supply options for a while, both in the water sector and in managing climate change.

Water reuse "can be direct or indirect, intentional or unintentional, planned or unplanned, local, regional or national in terms of location, scale or significance" (National Strategy for Water Re-use, DWS 2011). The intent of the water reuse strategy is to encourage wise decisions relating to water reuse for all the different decision makers.

Water reuse is supported as an option for water supply mix. Water reuse projects typically involve a range of activities that are subject to water and environmental regulatory authorisation and control. These controls exist in a range of legislation that includes, but is not limited to the National Water Act, 1998 (Act 36 of 1998), the Mineral and Petroleum Resources Development Act, 2002 (Act 28 of 2002), the National Environmental Management Act, 1998 (Act 107 of 1998), the National Environmental Management: Waste Act, 2008 (Act 59 of 2008), the Water Services Act, 1997 (Act 108 of 1997), the National Environmental Management: Integrated Coastal Management Act, 2008 (Act 24 of 2008), and municipal bylaws.

Reuse is also supported by the climate change policy. In a policy review report, it is assessed that "South Africa has put in place one of the most elaborate and consultative climate governance systems observable among developing and emerging economies" (Averchenkova, *et al*., 2019). National climate change governance in South Africa has received attention over the last 20 years, including development of policies, strategies, regulations and institutions. The 2004 National Climate Change Response Strategy, followed by the National Climate Change Response White Paper approved in 2011 (Climate Response Policy) form the foundation of national climate policy. In 2012 climate change became a key element of the National Development Plan, the overarching plan South African development. South Africa's Climate Response Policy, 2011 and the National Development Plan (NPC 2011), present a vision for an effective response to climate change. The policy is guided by the Constitution, Bill of Rights, National Environmental Management Act, Millennium Declaration and the UN Framework Convention on Climate Change. In 2015 South Africa signed the Parise accord.

Water use

Because of being the WSA, a municipality is a "water user" under the National Water Act, 1998. The National Water Act regulates the abstraction and discharge of water, in terms of the National Water Act and regulations and standards.

As a water user, the municipality must also comply with the suite of environmental legislation including the National Environmental Management Act,1998 and South Africa's commitments in its Climate Response Strategy. This regulates design and build of infrastructure, as well as operations.

In terms of the National Water Resource Strategy, municipalities can include considering use of reclaimed water in the resource mix.

The WSA must develop and adopt a water services development plan (WSDP). The WSDP must address water services and water for industrial use and include proposals on infrastructure required and water services to be used. It can also be inferred from section 13 of the Water Services Act, 1997 dealing with the contents of a Water Services Development Plan.

Water quality

A key issue for water reuse projects is the quality and standards of the wastewater in and reclaimed water. There are standards for potable water for drinking water quality, but not for reclaimed water. Quality standards to be achieved will depend on the intended use of the reclaimed water, whether direct or indirect etc. Specifically, with indirect water reuse the quality of water discharged back into the resource is regulated by a water use license issued in terms of the National Water Act (1998) and these conditions are captured within the conditions of the water use license.

Project structuring

A project is structured depending on several parameters which are informed by what is achievable and feasible in the local context. There are several technical, social and environmental considerations that need to be established which inform the structuring argument. Once the project is structured, initially conceptually and then in detail, the regulatory compliance requirements can be identified with certainty to inform the contract structuring and the procurement strategy.

Parameters

The parameters which will influence the project structure, and the consequent regulatory requirements include:

1. Scope: - what activities is the contract to regulate, considering the activities of design, build, operate, finance etc. (this influences the risk allocation, determination of roles and responsibilities etc).

2. Key objective: - this sets the framework for establishing the KPIs and motivating the funding structure and sources of funding.
3. Parties: – who does the municipality intend contracting with? Private sector or public sector (this influences the procurement strategy).
4. Performance: - how will performance be measured? This is especially relevant for the undertaking regarding wastewater input from the water services provider; and reclaimed water output to be provided to off-takers. All performance requirements must be identified as these need to be costed and allocated.
5. Funding mechanism: - how will the activities in the contract be paid for? Is there grant funding for the infrastructure? Is there a secured revenue stream against the supply of reclaimed water. Who will use and pay for the reclaimed water. How will it be paid for?
6. Project Site: - where will the reuse project infrastructure be developed and operated? If it is on the municipality's land it impacts the risk of hand back, especially in the case of early termination, interface with WSP function, environmental compliance requirements if it can be linked to existing infrastructure operated with similar conditions (WWTW etc) etc. and capital cost of acquisition of land on which the project infrastructure is developed. Note that there is no requirement for PPP contractors to own the land, even for green field projects. They just need contractually secured and uninterrupted right of access.

Risk transfer

The project structuring process will be undertaken through feasibility studies. If the most appropriate project delivery model is determined to be via a PPP, this is assessed with reference to transfer of significant technical, financial and operational risk, section 120 of the Municipal Finance Management Act (MFMA) and the PPP Regulations must be complied with [4].

Procurement strategy

If a contract with a public sector body is an option, there is no need to follow a competitive procurement route, but value for money and affordability will still need to be determined.

If a contract with private sector operators is identified, the process must follow supply chain management processes in terms of which a transparent, fair, competitive bidding process be undertaken in line with the MFMA Supply Chain Management (SCM) Regulations and aligned to the municipality's SCM Policy and existing procurement structures including the bid committees. If it is a PPP procurement process, it will likely be a two-phase, process with an expression of interest to pre-qualify bidding consortia based on technical experience where after prequalified bidders will be issued with the detailed RFP and contact to enable due diligence and pricing of a technical solution. This because longer-term complex contracts require significant time and effort from bidders and the procuring authority. It is also a lesson learnt from international experience that potential operators should be engaged early to finalise parameters (Frijns *et al.,* 2016). If the contract is to be concluded through a transversal contract or on behalf of the municipality the appropriate procurement and contract structure will need to be determined depending on who the contracting authority is.

Unsolicited bids, although allowed in terms of Regulation 37 of the MFMA SCM Regulations, should be treated with caution as the project is not likely to be demonstrably unique or subject to a sole provider. It is further not recommended to deviate from official procurement processes in terms of Regulation 36 of the MFMA SCM Regulations, as the circumstances such as emergency, single source provider do not prevail to make it impossible or impractical to follow competitive bidding.

Future financial commitment

If the contract period is likely to be longer than 3 years, and there is a financial commitment required from the municipality, a "future financial commitment" is anticipated by the contract structure. A municipality will then have to comply with Section 33 of the MFMA regarding future financial commitments. The MFMA regulatory compliance processes will involve Council approving the granting of the right and the future financial commitment, and public participation processes to ensure transparency and affording the community the opportunity to make comments or representations, and soliciting the views of national and provincial treasuries, Department of Cooperative Governance and DWS. This engagement process is anticipated and planned for whilst the procurement strategy is developed but is implemented towards the end of the procurement process, once the contract is in its final form.

Right to use, control or manage a capital asset

If the infrastructure is over R10 million and if the contract is for longer than three years there will be a need to comply with the MFMA Municipal Asset Transfer Regulations[4] in so far as the contract amounts to the granting of the right to an operator to use, control or manage capital assets for longer than three years. This process also requires Council resolutions and an engagement process with the public and the regulators. Compliance can potentially be scheduled to run simultaneously with the MFMA Section 33 process.

Programmatic support

The Constitution, 1996 and the Local Government Municipal Systems Act, 2003 oblige national and provincial government to support local government. This is echoed in the Climate Response Strategy. Programmatic support to local government is thus supported by the regulatory framework. In designing the support approach, the following activities are already identified by DWS in the Strategy for Water Reuse (2011). These activities could be addressed in design of the governance structure of the programme and includes (amongst others):

- Developing guidelines for water reuse projects.
- Supporting DWS to working with other national departments to align legislation, reduce the regulatory burden wherever practical, and unblock regulatory obstacles to water reuse.
- Working with Regulators in getting approval for justifiable water reuse projects and working with municipalities to identify, structure and implement projects, and ensure that municipal by-laws support the appropriate reuse of water.
- Ensuring the water quality standards implemented are appropriate in a context where water reuse is a strategic imperative.
- Support DWS to use the water licensing process as a key tool to promote water use efficiency.

[4] Local Government: Municipal Finance Management Act, 2003 (Act No. 56 of 2003): Municipal Asset Transfer Regulations in Government Gazette No. 31346 dated 22 August 2008.

- Advising DWS regarding the need to revise the regulatory framework to drive water reuse projects.

The legislative framework for water reuse projects is complex and multi-sectoral with a number of key documents and stakeholders, requiring a targeted approach and supporting the need for a programmatic approach to identification, structuring and implementation of water-reuse projects. The Drinking Water Standards do not specifically provide standards for reclaimed water. International experience indicates that operators rather choose to be contractually measured to achieve water standards, rather than to be obliged to undertake specific processes (i.e., output based contracts rather than technology and process input specific) (Frijns *et al*., 2016).

It has been identified that a regulatory risk includes the potential lack of clarity in the National Water Act around whether treated wastewater is classified as ‘waste’ or a ‘water resource’, creating uncertainty about licensing requirements (Pegasys, 2020). This needs to be addressed in discussion with DWS. Further the potential impact on the rights of downstream users to wastewater effluent flows in rivers (i.e. those impacted by decrease in discharge into water resources due to recycling of water) is identified as potential risk to water reuse projects. This will need to be addressed in the project-specific feasibility studies with due consideration to the impact of the specific project on the environment and the other water users.

Concluding Remarks on the Regulatory Environment

Although the process for structuring a water reuse project is regulated, there is nothing in legislation specifically prohibiting a municipality from implementing a water reuse project, including the development of infrastructure and appointment of an operator.

In response to the three key questions raised in Section 5.3 above, it can be concluded that although there are challenges in the existing framework, and it is complex and multi-sectoral, in principle, the drivers of water reuse projects are supported in our national policy framework including the National Water Resource Strategy 2 (2013) and the Climate Response White Paper (2011). Municipalities who are WSAs for their area of jurisdiction can undertake water reuse projects as a function of their water services provision obligation. The concept of support from a national programme is supported in the legislative framework.

There is no “one-size-fits-all” project structure and to structure a project a pre-feasibility should be undertaken to identify potential options and a detailed feasibility undertaken of the preferred option. This to inform the appropriate project definition and to identify the supply, demand, technology options, funding structure and consequent contracting options, depending on the local circumstances. Once structured in principle, a detailed feasibility can be undertaken to inform the decision makers regarding the appropriate procurement strategy, contract design and implementation obligations. It can then be implemented – either internally or by direct contract with a public sector operator (e.g. water board) or through a competitive procurement process. The procedural requirements for feasibility, decision making and contracting will be determined by the proposed allocation of risk in the project design and proposed contracting structure. Procedural compliance should be a consequence of project structuring rather than a driver.

6. Technical capacity for Project Development

6.1 Private Sector Technical Design/Consulting Capacity

The private consulting sector is generally well advanced in the design or wastewater treatment plants and it should be noted that the Activated Sludge BNR process was essentially pioneered in South Africa. The tertiary training of professionals in the country is relatively on par with the training received by professionals in many developed and emerging economies. The expertise required for the design of Water Resource Centres is more specialised than conventional wastewater treatment, but there is sufficient expertise within the consulting industry to undertake this programme. This experience stretches back to the Windhoek plant that was designed by a South African team. There are at least five consulting practices that have the expertise to undertake designs of reuse plants and there is even more technical engineering capacity for industrial reuse projects in the private sector.

6.2 Private Sector Technical Construction Capacity

The local construction industry is sophisticated and has the capacity to undertake the construction of reuse projects. This has been demonstrated in several projects that have already been constructed, both in terms of civil construction and mechanical and electrical equipment design and construction. Local EPC and O&M contractors will need to team up with specific technology suppliers from outside of the country for the specialist equipment (i.e. it is not manufactured locally), but this is the norm within the industry and a number of the larger firms have already procured the specific technologies required for water reuse on previous projects. There are also a few private companies who have the capability to operate and maintain the reuse plants once constructed (some of whom can also do the construction thereof).

If a number of reuse plants however come to market at the same time, these few firms could get overloaded, and pricing may become uncompetitive. There is thus sufficient capacity within the private sector to construct and operate such Water Resource Centres, provided that the work is sufficiently staggered. There is however interest from international EPC and O&M companies to get involved in the South African water market who could potentially supplement the local capacity.

6.3 Public Sector Technical Capacity

The technical capacity within the public sector to prepare, procure and project manage the envisaged reuse projects is varied across the municipalities. Many of the large Metros have sufficiently robust procurement systems and (to a slightly lesser extent) internal project management capacity to implement such reuse projects. However, there are many municipalities that will require a significant amount of external support in the areas of planning, project preparation, procurement and project management to implement such projects.

Long term infrastructure planning is often a weakness in many of the municipalities and masterplans often don't existing. There is thus often a need to support municipalities to develop these masterplans so that they can anticipate the need for reuse projects. Also, there is generally little to no internal technical engineering capability within the Municipalities to plan, evaluate and technically assess the technologies required for reuse. This function would have to be outsourced to the private sector. The WRP/Water Partnership Office would thus be structured with the aim to support Municipalities with these various functions as needed.

In terms of operational capacity, it is unlikely that municipalities will have the appetite to operate and maintain potable reuse projects given the risks involved and the technical complexity. This function is highly likely to be outsourced to the private sector. Some municipalities have the technical capacity to operate and maintain industrial reuse projects, as some are in fact doing at the moment.

6.4 Laboratory Infrastructure and Design Standards

An important part of potable reuse projects is the need to conduct regular highly specialist effluent quality verification that is over and above conventional laboratory testing. These specialist tests are particularly needed for Chemicals of Emerging Concern (CECs) in potable reuse projects. There are sufficient laboratories in South Africa to test for the conventional water quality criteria (which would be needed for Industrial and Irrigation reuse), also test for Chemicals of Emerging Concern (CECs) regularly but at present, there is no laboratory that can do a full suite of CEC tests in the country. It is anticipated that in the next year or two they will be fully functional and CEC testing will be available in South Africa.

The existing national potable water quality standard, SANS 241, defines the minimum water quality required for human consumption. It was however developed with surface and groundwater sources in mind and is not extensive enough to cover the specific water pollutants found in potable reuse projects. For instance, it does not have a standard for phosphate or organic COD and the microbiological standard is not approached from a log reduction perspective as has been adopted internationally. There is thus a need to develop a national water quality standard for potable reuse. However, in the absence of such a standard, existing reuse projects have generally adopted the California Department of Health standards for potable reuse, as these are state-of-the-art standards internationally. These set a require standard for pathogen log reduction across a potable reuse treatment train as well as maximum CEC levels in the final product water. This is all in-line with the WHO’s Potable Reuse Guidelines.

7. Delivery Models

To understand the likely opportunities for water reuse projects in the market, it is essential to define the range of potential delivery models for municipal water reuse projects. ***The delivery model encompasses the possible arrangements relating to ownership, financing, contracting, and operations****. This section provides details in respect of five potential delivery models, with varying degrees of public and private sector involvement for the development of water reuse projects under the WRP based on the assumption that each project will involve the reclamation of municipal wastewater.*

7.1 Overview

A range of alternative, generic delivery models exist for the implementation of infrastructure projects (including water reuse projects) in South Africa. These can be summarised into five overarching delivery types:

1. The delivery of the project by a municipality;
2. The delivery of the project by a municipality with a support contract with a public sector operator such as a water board or public sector utility.
3. The delivery of the project by a municipality with a service level agreement (SLA) with a private sector operator;
4. The delivery of the project by a municipality in partnership with a private sector operator via a Public-Private Partnership (PPP) procurement and contracting arrangement; and
5. The undertaking of a water reuse project by the private sector with no direct relationship to the public sector.

In the context of municipal water reuse projects, the first project delivery type – where projects are developed, implemented and operated by the municipality – is being employed less frequently, as public sector in South Africa often lacks, amongst others, funding and the expertise and capacity during operations, for the development and operation of new projects. However, in the case of funding being made available for project preparation and development, the second project delivery type may be employed – where the municipality develops the project, but contracts specialised and experienced private sector entities to operate the project, using SLAs (Service Level Agreements) between a municipality and that private sector service provider.
In the second project type, it is possible for example for a water board to undertake a water reuse project. It would not be the “primary function” of the water board in terms of the Water Services Act, 1997 and so various approvals would be required including an agreement with the implementing municipality regulating the contractual arrangements.

PPP delivery models may be used, provided that the private sector entity is willing to take significant technical, financial and operational risk in designing, building, financing and operating the project. If the project is funded off-balance sheet, with project finance structures, the funders will require adequate risk flow-down and mitigation measures to ensure an acceptable project risk profile. Such approaches will require careful structuring of the project to ensure the securing of finance as well as the expected development impact.

7.2 Assessing potential delivery models

To determine the delivery model that is potentially the most viable for a specific project within the WRP, municipalities may need to assess the project and their own capacity in a number of areas, including their financial position at the time, their operational and resource capacity and the existence and/or willingness for capable private sector partner involvement. Broadly, each project may be reviewed under the six aspects, listed below and detailed thereafter:

- **Income:** Potential project-related revenue streams and associated opportunities;
- **Roles:** Identify roles and responsibilities against possible delivery models;
- **Merits:** Compare advantages and disadvantages with different delivery models;
- **Structure:** Identify possible financing mechanisms and contract types;
- **Ratings:** Identify and implement credit risk solutions; and
- **Collaboration:** Establish Contacts with private sector players.

The aspects listed above and detailed below are only indicative for the consideration of municipalities for the development of project-specific preparation activities and are not necessarily exhaustive.

- **Income: A review of potential project-related revenue streams and associated opportunities:**
  - Water reuse projects offer a variety of revenue opportunities, both upstream and downstream, which include the sale of treated water to industrial, agricultural or even domestic off-takers, the sale of by-products such as biogas, heat, electricity, fertilizer and sludge or service payments to service providers for the treatment of incoming water.
  - These revenue options should be explored during a project review by local government to increase each individual project's contributions towards achieving climate adaption or climate mitigation impact.

- **Roles: Identify clear roles and responsibilities against possible delivery models:**
  - Because of their revenue potential and technical complexity, water reuse projects may lend themselves to the involvement of the private sector. Although water reuse projects may require significant levels of investment in terms of the upgrade of an existing waste water treatment works (WWTW) and the construction of an advanced treatment plant, they can be developed by using a PPP model.
  - For a PPP model to be effective, both supply-side and demand-side risk may need to be addressed. In the context of water-reuse projects, predictable long-term revenue streams from creditworthy off-takers can be secured (addressed the demand / offtake risk), while supply-side agreements can be entered into with municipalities that operate existing WWTW's.
  - As the magnitude of investment required for a project increases, the likelihood of local government developing and implementing the project decreases. Further, as the magnitude

of investment required increases, so does the need to ensure longer contracting periods and more stable revenue forecasts.

- Depending on the delivery model chosen, the various roles and responsibilities between involved parties can be shared and allocated in numerous ways, as outlined in Table 7-1 overleaf.

- **Merits: Compare advantages and disadvantages of different delivery models:**
  - Pooled project development resources, such as detailed designs and standardised Engineering Procurement Contracts, Service Level Agreements and the primary PPP contract can allow local governments to develop and procure projects more effectively. However, standardised PPP agreements may require some inputs from technical advisors on a project-by-project basis to ensure that risks are shared appropriately between the public and private sectors based on the local government's capacity and creditworthiness. However, it should be noted that regardless of the delivery model adopted, it is critical that local governments engage proven project structuring financial, legal and technical professionals early-on to achieve a cost-effective and climate-smart project.
  - The advantages and disadvantages of the four different delivery models are summarised in Table 7-2 below.

Table 7-1 Roles and responsibilities for selected project elements based on four project delivery models

Delivery Model / Project Element	Municipality (with or without other public sector support)	Municipality *with Private Sector Service Provider* (SLA)	Public-Private Partnership (PPP)	Privatisation
Design **Construction**	Public sector through local government **assumes significant responsibility**		**Private sector assumes significant responsibility and financial risk**	
Capex and initial Opex funding	Public sector through local government **raises grants and debt**		**Private sector mobilises debt and equity. Local government may provide its share of funding and/or provides land. Private sector raises rest of funds**	**Private sector mobilises funding via debt and/or equity.**
Employment of Grants	Public sector through local government **may raise grants to make funding model more affordable**			**Private sector mobilises funding via debt and/or equity.**
Operations and Maintenance **Sales and Marketing**	Public sector through local government	**Private Sector**		

Table 7-2 Comparison of Delivery Models for Water Reuse Projects

Delivery Model / Project Element	Municipality (with or without other public sector support)	Municipality *with Private Sector Service Provider* (SLA)	Public-Private Partnership (PPP)	100% Owned Private Company
Marketing Skills	The public sector is unlikely to have the necessary skills to develop/ grow a market for a Climate Project's outputs (e.g. organic fertilizer).	The private sector has the necessary skills and incentives to market the outputs (e.g. compost, biogas) and to develop the market if it does not exist already.		
Contract term for operation of facility	No contract required	Unless contract is long enough to recoup investment, the private sector will not make necessary investment	Long term contract gives private sector incentives to grow the market.	Outright ownership of all rights to revenue and profit incentivises the private sector.. This would be for wastewater generated by private sector and reclaimed privately for re-use.
Access to finance	Reliant on grants from NG and donors unless LG can raise debt or issue bonds.		Private sector can raise commercial debt to fund project and provide equity, reducing reliance on government funding.	
Access to climate finance	May need to access climate finance via programme as size of project may not justify direct application to international climate facility.			Will need to access climate finance via private sector facility.
Technology risk	Public sector is unlikely to have the necessary skills.		The private sector has the necessary skills and experience to manage and operate niche technologies available in the water reuse infrastructure and equipment market	
Costs and time to implement	Lesser requirements in respect of financial and legal expertise normally make SLAs and public sector delivered solutions cheaper and faster to implement.	PPPs require technical, financial and legal expertise to develop. Unless large project or programme that pools project, development costs may not be justified.		Private sector is able to respond to opportunities quickly and to fund development costs.
Opportunities for pooling projects via programme	Engineering Procurement Construction (EPCs), SLAs and PPPs could be procured and developed across a number of LGs or a number of sites within an LG.			Sometimes private companies can manage several projects in the same country and/or region.
Ability to mitigate construction risk	Engineering Procurement Construction (EPC) contracts can be used to reduce the risk of cost overruns and nonperforming technology.			

Table Notes:

- ***SLA = Service Level Agreement between a municipality and a private sector service provider for delivery of services.***
- ***Red coloured boxes signify disadvantages; green coloured boxes signify advantages. The darker green colours indicate relatively greater advantages.***
- ***Grey coloured boxes are used if the stated factor is neutral, representing neither advantage nor disadvantage.***
- ***This table is intended to provide indicative information only***

- **Structure: Identify possible financing mechanisms and contract types:**
  - To determine which contract type and funding model are most appropriate and affordable for a water reuse project in this WRP, the impact of a number of factors will need to be reviewed by local government to inform the potential funding and contracting mechanisms. These factors include an assessment in respect of the following (amongst others):
    - the net cost of the proposed water reuse project;

        - the capacity of that municipality to manage and monitor the chosen contracts effectively for the design, installation, and operations of the project, including the provision of technical and legal support for contract negotiations;
        - the total annual spend by that municipality annually on wastewater and water treatment;
        - that municipality's experience and/or capability to enter into an SLA with private sector for the delivery of operational services during the life of the project .
    - However, should it be determined by the municipality that it does not have the ability and/or willingness to develop and own a water reuse project, it can also use private sector entities to contract debt (commercial and concessionary debt). Water reuse projects developed under this WRP should also have access to climate finance as they will contribute towards climate benefits
    - The chosen structure for the development and implementation of water reuse projects under the WRP will be determined on a project-by-project basis, based on the specificities of that project, its stage of development and the municipality where it is located. The chosen structure will impact the time that the project will take from its inception to financial close, its capex, its service delivery arrangements and its associated financial considerations, in terms of the tariff to be charged for the reused water, the cashflow and maintenance obligations and the nature of the various project agreements.

- **Ratings: Identify and implement credit risk solutions;**
    - Water reuse projects can greatly benefit from credit risk solutions, such as the use of guarantees and debt service escrow accounts, that can be structured to protect lenders and the private sector against risks that include:
        - default or late payment by local governments;
        - default or late payments by other off takers; or
        - lower than guaranteed levels of feedstock.
    - Given that the GCF may be amenable to providing funding to the WRP in the form of guarantees, it is important to note that guarantees provided may be used for a number of reasons, including:
        - Enhancing the credit worthiness of a project to demonstrate the capacity of the project to make timely and complete payments;
        - Enhancing the projects investability in order to secure additional funding or counter-guarantees from other creditworthy entities (such as the national government); or
        - Providing additional collateral or liquidity via secured guarantee escrow accounts.

- **Collaboration:**
    - The water and water reuse industry can be served by a number of reputable international firms, but it should be noted that the 10 largest water companies are all either European or American and that only a limited number currently undertake operations in Sub-Saharan Africa. To enhance the likelihood of securing private sector investment in projects under the

WRP, municipalities may undertake the following, through the Programme's Project Management Office:

- Liaison with generators of wastewater to potential users of wastewater by-products to drive a circular economy rationale;
- Securing additional revenue streams or material savings on a project-by-project basis by identifying which by-products may be sold to make projects more financially viable;
- Appointing reputable transaction advisors that will help in the structuring of projects and contracts to share risks and rewards appropriately between the government entity and the private sector (in the case of a PPP delivery model).

7.3 Enabling Factors

Several enabling factors can be put into place to enable local governments to unlock finance for water reuse projects. For example, if a local government is able to provide land or existing infrastructure at no cost to the private sector developer, it will reduce the private sector's upfront investment. Understanding and identifying these enabling factors in the water reuse market will be essential to the success of the WRP. A list of key enabling factors is summarised in the table below for each of the four delivery model options.

Table 7-3 Local Government Enabling Factors for Water Reuse Projects

Local Government Enabling Factors	Municipality (with our without public sector contract)	Municipality *with Private Sector Service Provider* (SLA)	Public-Private Partnership (PPP)	Privatisation
Has own source of revenue	✓	✓	✓	✓
Can incur debt	✓	N/A	✓	N/A
Can access CAPEX grants	✓	✓	✓	N/A
Can be a shareholder in a company	N/A	N/A	✓	N/A
Can enter into long term contracts for services/products	✓	✓	✓	✓
Can reallocate existing budgets to pay contracts for PPPs and SLAs	✓	✓	✓	✓
Can guarantee feedstock	✓	✓	✓	✓
Can implement and charge cost reflective tariffs	✓	✓	✓	✓
Has capacity to develop projects (planning, budgeting, engage experts, etc.)	✓	✓	✓	N/A
Can make land available at no or minimal cost	✓	✓	✓	✓
Has capacity to procure EPC contractors	✓	N/A	N/A	N/A
Has capacity to procure and manage long term contracts	✓	✓	✓	N/A

Note: Light blue denoted less enablement than unshaded checked boxes.

8. Potential Project Pipeline

The section is aimed at developing a potential project pipeline for water reuse in South Africa for the WRP.

8.1 Methodology for the development of the project pipeline

Although the WRP is a programmatic approach for the development of water reuse projects in South Africa, the existence of a potential project pipeline is key to demonstrate to funders that a programme of this nature is practical, implementable and sustainable.

A methodology has thus been conceived for the development of this project pipeline, with the aim of the methodology being to illustrate that, based on certain constraints and exclusionary criteria, an indicative list of potential water reuse projects may be initially assessed for receiving funding through the WRP.

Constraints

In the development of this methodology, a number of practical constraints were applied to develop a methodology that is robust based on the stage of this programme and the availability of data. These constraints are listed below:

- Project ownership was assumed to be linked to municipal entities or water utility companies (as State Owned Enterprises) and did not include large private entities (such as mines and/or industry) as project owners. It is however noted that private entities will play a role during the development or implementation of projects under the WRP, either as project co-owners (in the case of a PPP delivered project) or as off takers (in the case that treated water will not be primarily sold back to the implementing municipality) .
- The methodology for the potential project pipeline development is based on a top-down approach, whereby publicly available data was used to develop the indicative list of potential projects. Specific engagements or discussions were not undertaken with any municipalities.
- Publicly available data on treatment plant design capacity is relatively dated, with the last update of such data being in 2014 (circa 7 years ago). However, since it is unlikely that a WWTW would increase in size significantly since 2014, the impact of this datedness was assumed to be minimal in the selection of projects that constitute the potential project pipeline.

The methodology included municipalities, and by implication, the water utility companies that supply the water and wastewater treatment services. WWTWs that are owned and operated by private companies, the Department of Public Works or State-Owned Enterprises were excluded from the project selection process, primarily because it was noted that those WWTWs were relatively small in size (< 2 Ml/d), and thus would be unlikely to be feasible water reuse projects within the initial phases of the WRP.

Criteria

In the development of this methodology, a number of exclusionary criteria were applied to ensure that the potential water reuse projects selected would be able to make a strong case for inclusion in the WRP project pipeline. These criteria are listed below

- **Treatment plant size:**
    - The size of the WWTW is the primary criteria as it directly impacts on the size of a potential water reuse project and the associated investment costs for that project. The 2014 Green Drop Progress Assessment Tool (PAT) reports published the design capacity of WWTW's in South Africa.
    - Although, as mentioned above, this data is relatively dated, it provides sufficient indication of the present size of plants in South Africa. It is also noted that the design capacity does not necessarily indicate the actual flow arriving at the WWTW but may be assumed to be a fair indication of the potential water available for a reuse project that is developed at that location.
- **Compliance:**
    - The Department of Water and Sanitation (DWS) publishes a periodic report containing the overall effluent compliance for each municipality based on the data submitted to the DWS by that municipality. This data provides an insight into how well the wastewater systems are managed in that municipality. Since the final effluent from a WWTW is the raw water for the ATP within a Water Resource Centre, the effluent compliance is an important indicator of the technical viability of a potential water reuse project. Best practice dictates that final effluent should maintain a very high level of compliance in order for a reuse project to be viable.
    - The reasons for poor compliance could be operational, infrastructure capacity, institutional or other factors. Some of these factors are easier to resolve than others and since the reason for poor compliance is not known from the data, it is also not known how easy it would be to resolve the poor compliance. Thus, poor compliance cannot be considered a fatal flaw in the selection criteria. It can however be used to determine which municipalities are likely to be more viable from a technical perspective.
    - Because of the disruptions of 2020, the 2019 compliance data was used as the selection criteria. The compliance is published in three categories, namely:
        - Physical Compliance : pH, Suspended Solids, Electrical Conductivity
        - Chemical Compliance: COD, Ammonia, Nitrate, Ortho-phosphate
        - Microbiological Compliance: e-coli/ f-coli
    - The chemical compliance is of more interest in reuse projects as COD and ammonia non-compliance are much more difficult to resolve on an advanced treatment plant. Having said that, physical and micro-biological compliance should also be considered, but with less weight.
- **WWTW type:**
    - There are essentially two types of WWTW technology in South Africa, namely biofiltration plants and activated sludge plants. Biofiltration is an older technology that has little to no control mechanisms for ammonia removal and they also tend to struggle to de-nitrify. The effluent compliance is thus often variable. As a result, biofiltration plants are not recommended

for potable or industrial reuse projects and treatment plants with this technology were excluded from the list.

- **Status of existing reuse projects:**
    - A municipality that has already initiated reuse projects has clearly indicated their favourable appetite for reuse. Thus, Municipalities that have already initiated reuse projects in some form (whether it be feasibility studies or full procurement), and that have large WWTWs, were included in the list.

8.2 Advanced Treatment Plant Recovery

The design capacity of a WWTW is not equivalent to the potential size of its associated advanced treatment plant (and as outlined in Section 3 above, these can collectively be referred to as the Water Resource Centre). This is because majority of advanced treatment plants use water as part of the treatment process (e.g. backwashing) or to discharge brine (reverse osmosis). The amount of water leaving an advanced treatment plant and thus leaving the Water Resource Centre, as a percentage of the amount of water entering the advanced treatment plant, is termed as "*recovery*". Advanced treatment plants typically have a recovery of between 65% and 75% (of the design capacity of the WWTW).

Furthermore, inland WWTWs have a requirement to discharge a certain percentage of their final effluent back into the catchment and as such this is water that is not available for reuse. The percentage of effluent that is released is dependent on the Water Use Licence issued for each WWTW, which is specific for each WWTW. This data is not publicly available, but the percentage water that needs to be discharged could range from 10% to 40%. Thus, the volume of treated product water is always going to be less that the flow into the works and will be less than the design capacity. The possible plant recovery for coastal and inland reuse projects is shown schematically in Figure 8-1 and Figure 8-2.

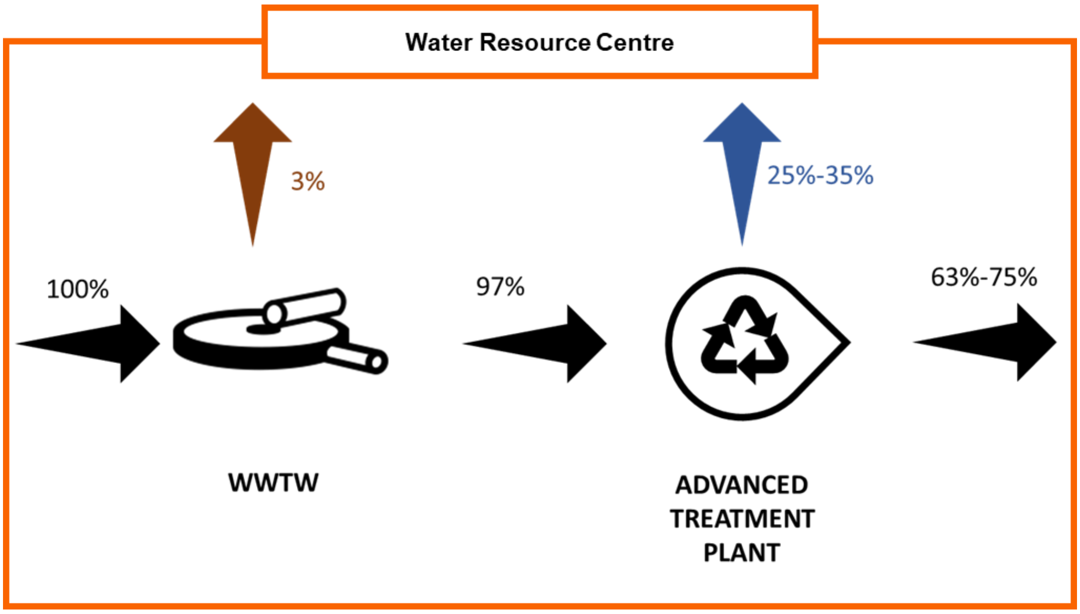

Figure 8-1 : Schematic of typical plant recovery for coastal reuse plants

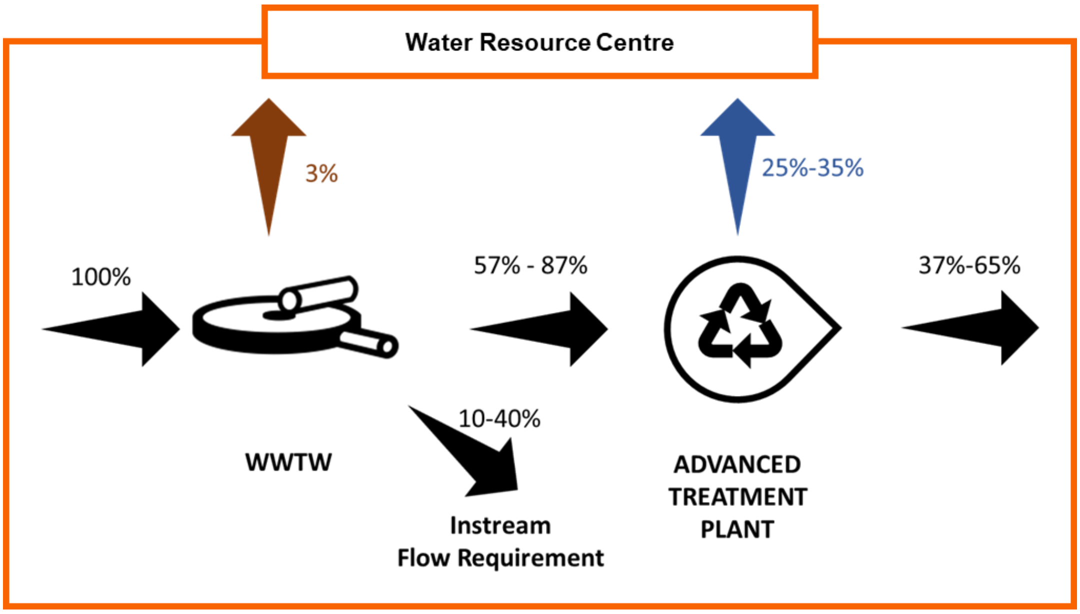

Figure 8-2 : Schematic of typical plant recovery for inland reuse plants

8.3 Selection of Municipalities with most viable reuse potential

The selection of Municipalities with the most viable reuse potential was done by applying the following criteria. Those that met all these criteria were selected.

Table 8-1: Criteria for the selection of the potential reuse project

Criteria	Value
WWTW Design Capacity	Greater that 20 Ml/d
Compliance (Chemical)	Greater than 50% compliance
WWTW Type	Biofiltration plants excluded
Already Initiated Reuse Projects	Yes

A WWTW with a design capacity of 20 Ml/d would be capable of accommodating an advanced treatment plant of 10 Ml/d to 15 Ml/d. Based on the costs of previously developed advanced treatment plants, the cost for the development of such an advanced treatment plan (with a capacity of between 10Ml/d and 15Ml/d) would be in the region of between R250 million and R525 million.

It should be noted that this cost is based on the capacity of the advanced treatment plant and excludes the costs to upgrade or refurbish the WWTW to achieve the necessary compliance (which is likely to be the case in most municipalities). If the existing WWTW required some refurbishment of existing infrastructure to bring the plant up to current optimal capacity, this could cost between R1 million and R8 million per Ml/d. A full upgrade would cost approximately R15 million per Ml/d.

There is also likely to be further costs to transport the final reuse water to the off-takers, which is specific to the project, but needs to be considered.

After following the methodology described above, a list of potential reuse projects that could form the initial project pipeline was developed. There are many project specific details that may make a project potentially viable, but that information can only be obtained during the detailed preparation of individual / specific projects. Some of these criteria that would need to be addressed to determine the actual project viability may include (amongst others):

- Latest effluent compliance data;
- The reasons for non-compliance in respect of particular water quality parameters;
- The actual flow leaving the WWTW;
- The location of WWTW in relation to bulk water infrastructure;
- The capacity of the bulk water infrastructure to accept flows (which can sometimes be a significant constraint);
- The availability of an environmental buffer (such as an aquifer or dam) and its characteristics such as its type, depth and quality; and
- The types of sludge for sludge to energy projects.

8.4 Estimating the size of projects in the potential pipeline

Since project specific information is not available, the location of the WWTW that would likely form part of the project pipeline have not been included. However, an attempt has been made to estimate the potential number and size of reuse projects for each of the selected municipalities.

This was done by assuming that at 15% of the average daily water demand for the City/Town could potentially be obtained from reuse. The 15% is based on the approach that the City of Cape Town took in their latest New Water Strategy in which it was decided (by CCT) that to improve the City's water resilience, at least 20-25% of the potable demand needed to be met by alternative water sources. Reuse made up the bulk of that at approximately 15% of average daily water demand.

8.5 Potential Reuse Project Pipeline

The first draft of the potential project pipeline for the National Water Reuse Program based on the methodology above, is provided in Table 8-2 overleaf

Table 8-2: Draft potential project pipeline

Province and Municipality	No. of projects	Potential Project Size (Ml/d)	Total Reuse Flow (Ml/d)	Already initiated Reuse projects
Eastern Cape				
Buffalo City Local Municipality	1	25	**25**	N
Nelson Mandela Metropolitan Municipality	1	40	**40**	Y
Free State				
Mangaung	1	25	**25**	Y
Gauteng				
City of Ekurhuleni	3	60	**120**	Y
		40		
		20		
City of Johannesburg Metropolitan Municipality	3	100	**200**	N
		50		
		50		
City of Tshwane Metropolitan Municipality	2	80	**110**	N
		30		
Emfuleni Local Municipality	1	30	**30**	Y
Kwa-Zulu Natal				
eThekwini Metropolitan Municipality	3	50	**200**	Y
		100		
		50		
Msunduzi Local Municipality (Umgeni Water)	1	30	**30**	Y
City of uMhlathuze	1	75	**75**	Y
Limpopo				
Polokwane	1	10	10	Y
Mpumalanga				
Mbombela/Umjindi	1	10	**10**	N
Emalahleni Local Municipality	1	7		Y
Northern Cape				
Sol Plaatjie Local Municipality	1	15	**15**	N
North-West Province				
Rustenburg Local Municipality	1	25	**25**	Y
Western Cape				
Breede Valley Local Municipality	1	15	**15**	N
City of Cape Town Metropolitan Municipality	2	70	**110**	Y
		40		
Drakenstein Local Municipality	1	10	**10**	Y
Stellenbosch Local Municipality	1	10	**10**	N
Total	**27**	**1067**	**1067**	**12**

It should be noted that Table 8.2 is an indicative potential project pipeline and there may be some project specific constraints that may result in some of these projects being technically or financial unfeasible.

8.6 Potential for sludge beneficiation within this potential portfolio

Sludge beneficiation projects would form part of the water reuse projects within the WRP and as such, criteria are outlined below that can be used to assess for the viability of sludge beneficiation projects to form part of any of the potential projects in the WRP.

Essentially in order for a sludge to electricity (or gas) to be technically viable, the WWTW is required to have anaerobic digesters in order to generate the gas as a by-product. This would be the first requirement for any potential sludge to energy project.

The second requirement is that there should be a sufficiently large amount of energy that is able to be generated by the sludge. A plant that generates primary and secondary sludge will be able to generate significantly more energy than one that only generates secondary sludge. In fact, experience has shown that, without some form of hydrolysis, a WWTW which only generates secondary sludge (WAS) is usually not feasible for a sludge to energy project. Thus, the amount of primary sludge generated is the basic defining criteria for assessing project viability. This level of detail however is very plant specific but can be undertaken when one knows which WWTW will be investigated for reuse feasibility.

The third level of detail is to undertake tests on the sludge to determine the biogas potential. These are specific to each WWTW and determines how much biogas potential the sludge has, and in turn how much energy can be generated. This would be used to undertake a financial feasibility of a sludge to energy project. This is essential, as sludge to energy projects can be marginal with respect to financial feasibility, depending on the sludge biogas potential.

Thus, the following high-level criteria can be used to determine whether projects (once sufficient detail on the actual WWTW site selected) can incorporate sludge beneficiation processes:

- WWTW infrastructure: the presence of anaerobic digesters and the production of primary sludge are exclusionary criteria.
- Sludge quantities produced: the amount of primary sludge generated in relation to secondary sludge on the WWTW
- Sludge quality: the biogas potential of the various sludge streams to assess the energy potential of such sludge.

Further criteria may include operator expertise and municipal capacity, but these would already have been covered in the shortlisting processes. It should also be noted that should sludge to energy be included in a particular project, the operation and maintenance of that sludge to energy plant would ideally be outsourced to the private sector, as it is understood that most municipalities in South Africa do not have the request experience, capacity or capability to of operate these types of facilities optimally. This is due to the importance of the control of the sludge train and digestion process, which drives the efficiency of the sludge to energy system and in the case that the anaerobic digesters are not optimised, the system is unlikely to operate as efficiently as envisaged with the result that the financial viability of the project will be compromised. By way of example, there is a sludge to electricity (using CHP engines) facility that was procured by a municipality in South Africa approximately 5 years ago. The engines were built and are able to operate to specification by the construction contractor. However, the anaerobic digesters (under the jurisdiction of the municipality) were not able to generate the specified volume and quality of gas due to non-optimal operations at the facility and as a result, these engines remain unused.

8.7 Possible First Phase

The WRP is likely be developed in phases whereby the first phase targets projects with the highest probability of being implemented. There may be only a few projects within the first 3 years to prove the concept and build confidence in the WRP as well as the technology.

Clearly the initial list of projects is likely to come from those Municipalities that have already started planning for reuse and have initiated feasibility studies. There are also a few that have a strong wastewater and water treatment capability who may also be interested but may not have initiated a project just yet. These first phase Municipalities could thus come from the following list:

- City of Cape Town (Project 1 and 2);
- Nelson Mandela Metropolitan Municipality;
- City of Ekurhuleni;
- City of Johannesburg Metropolitan Municipality;
- City of Tshwane Metropolitan Municipality (Project 1 and 2);
- eThekwini Metropolitan Municipality; and
- Drakenstein Local Municipality;

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