CAPE TOWN'S NEW WATER PROGRAMME – AN OVERVIEW

1 INTRODUCTION

1.1 Purpose

The purpose of this document is to present an overview of the City of Cape Town's programme to develop additional water supplies to increase reliability and to avoid the severe restrictions experienced in 2017 and 2018. This program is called the New Water Programme.

1.2 Responsibility for water resource augmentation

It is the responsibility of the national Department of Water and Sanitation to manage water resources and to plan for and ensure a sufficient and reliable water supply to all urban areas. The Department's planning is based on a 98% level of assurance, that is, restrictions on the system are only imposed in the case of a drought that is more severe than a 1 in 50-year event. The Department's next planned augmentation scheme is a surface water scheme, dependent on rain, to provide additional water supplies from the Berg River into the Voelvlei Dam and is called the Berg River Voelvlei Augmentation Scheme. This scheme is due to be implemented in 2021. The risk of delay in the implementation of this scheme could be high.

1.3 A rare drought event or early evidence of climate change?

Cape Town has experienced three low rainfall years in a row. Rainfall in 2015 and 2017 were each individually the lowest rainfall recorded in the last 100 years and the combination of the three years represents a 1 in 400-year event, or worse, based on historical records. This prompts two obvious questions: Is the recent rainfall pattern evidence of climate change? Is Cape Town likely to face more frequent and more severe episodes of low rainfall in future? While it is not possible to answer these questions with any certainty, most (though not all) global climate models predict lower rainfall for Cape Town with more drier years and fewer wetter years. A 2015 study on the overall economic impacts of climate change for South Africa considered a wide range of global climate models and concluded that the majority of climate scenarios for the Western Cape indicate a drying with the change in runoff by 2050 of between -2% and -17%. A reduction of 15% in the mean annual run-off would result in a reduction in the Western Cape Town System yield of around 160 million litres per day by 2050. Climate change could happen through a gradual decline in yield or through a step change as a result of a threshold change in the regional climate.

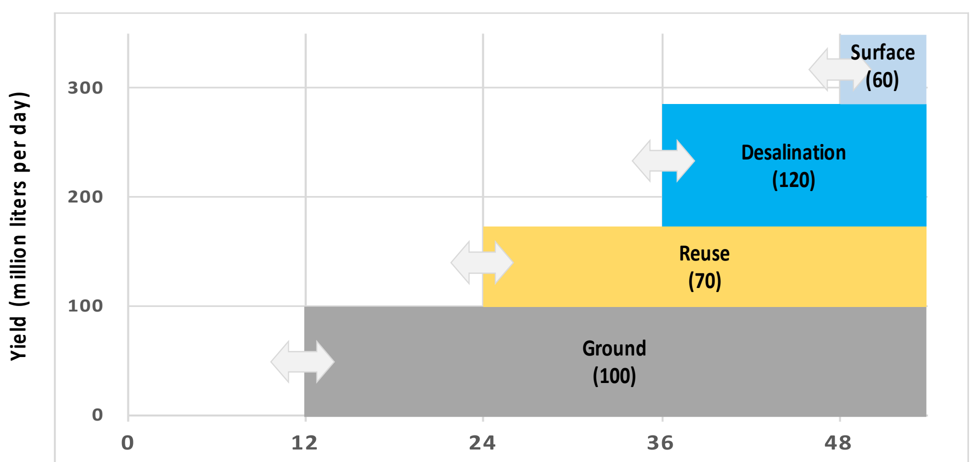
1.4 Getting through the drought by managing demand

Cape Town was able to get through this summer by managing water demand down from 1200 million litres per day in February 2015 to 500 million litres per day in February 2018, a saving of 700 million litres per day (68%) during peak summer usage and a reduction in average usage from 900 million litres per day in 2016/7, a saving of 400 million litres per day (45%) on average over the year. The very low rainfall in 2017 contributed about 680 million litres per day (on average over the year) into the dams. In contrast to this, the total amount of new augmentation into the system achieved from January 2017 to date is about 20 million litres per day, less than 3% of the low rainfall contribution.

1.5 The impact of the drought on future demand

Experience with previous drought events in Cape Town and elsewhere show that droughts cause a structural downward adjustment in water demand over the medium and long term. It is anticipated that demand will readjust (after the end of the drought) to 80% of the demand prior to the drought. Thereafter demand is projected to grow at the rate of 3% per annum to cater

Indicative target time-frames to implement



Time to implement (months from a firm commitment to proceed)

for population and economic growth. These growth forecasts have been taking into account, and tested for sensitivity, in the modelling of water requirements discussed below.

2 CREATING A RESILIENT CITY THROUGH DIVERSIFYING WATER SOURCES

Cape Town is committed to becoming a resilient city and is part of the 100 Resilient Cities Initiative. It is therefore both prudent and appropriate for the city to take climate change risks into account in its planning. In line with international best practice thinking for coastal cities, Cape Town's resilience will be increased through the diversification of water supplies away from dependence on surface water only towards a situation where the city also obtains a share of its water from ground water, wastewater reuse and seawater desalination. Consequently, a resilient city will be able to both optimise and sustain water use through integrated management of four sources of water – surface water from rainwater (including urban storm water runoff) managed in dams and wetlands, ground water (with recharge), reused wastewater and desalinated sea water.

2.1 How much water is available?

Cape Town is fortunate to have good availability of water resources. Cape Town's major dams store about 900 million cubic meters of water. The Cape Flats Aquifer has above sea-level storage capacity of more than 600 million cubic meters, and the Table Mountain Group Aquifer more than 1 000 million cubic meters. Total ground water storage, which is not affected by evaporation, is therefore much larger than the total storage of surface water dams.

Western Cape Water System Yield	Unconstrained daily demand MLD	Average restricted daily demand MLD
Cape Town	888	488
Agriculture	395	158
Other Urban	63	35
Total	**1,346**	**681**

The firm yield of the Western Cape Water Supply system (comprising the major dams) is 1 500 million litres per day, and Cape Town's allocation is about 900 million litres per day. The augmentation of Voelvlei Dam would add another 60 million litres per day. The sustainable yield (with recharge) of the ground water sources far exceeds 200 million litres per day. In addition, Cape Town could produce over 200 million litres per day of potable water from wastewater. The quantity of water available from the sea is only constrained by the cost that would be incurred in desalination. Of the three 'new sources' of water – ground water, wastewater reuse and seawater desalination – only desalination is totally independent of rainfall.

2.2 How much additional water is needed?

The quantity of additional supplies needed to achieve a secure supply depends primarily on a decision on risk appetite and on assumptions related to the future probability rainfall distribution. Detailed modelling has been undertaken based on the available historical rainfall records, hydrological modelling and climate change forecasts.
The modelling shows that, using a stochastically-generated set of rainfall patterns based on past rainfall records, and assuming a 1 in 200 level of assurance, an augmentation of 50 to 100 million litres per day would be sufficient. This scenario does not take possible climate changes into account. If the very low rainfall of the last three years is assumed to continue into the future, then an augmentation of 200 to 250 million litres per day will be necessary to keep dam levels above 25% at the end of summer, providing a margin of safety. Any augmentation over and above this would increase levels of assurance and result in 'surplus water' through more frequent dam spillages during winter. Further modelling, using rainfall predictions from global climate models, is currently being undertaken to inform the City's decision making, taking into account the combination of climate change impacts with natural variability, that is, a combination of the climate change risk assessment with stochastic time series generation of rainfall. In the interim, Cape Town's augmentation plans are based on an augmentation of 350 Ml/day. This is a risk averse view that will give the City of Cape Town a very high level of assurance of supply and will prevent the kind of restrictions currently being experienced from being implemented again in the foreseeable future.

3 HOW MUCH WATER FROM EACH SOURCE AND WHEN?

The available sources exceed Cape Town's needs by some margin. What is an appropriate amount of water to be obtained from each source?

3.1 Cost considerations

The actual costs of any water augmentation scheme is only accurately known after the project has been commissioned. Until that time, reliance must be made on comparable experience with similar projects elsewhere, together with engineering estimates for the specifics of the proposed project.

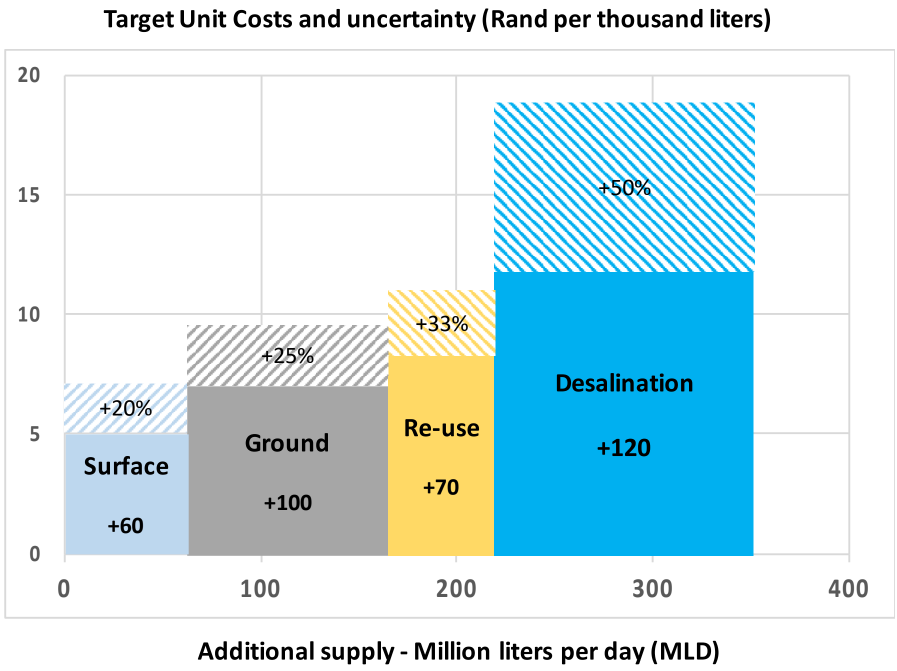
Desalination costs are primarily a function of scale, water salinity quality and temperature, marine works requirements, network integration costs and procurement methodology. The optimum scale for sea water desalination is in the range of 120 to 150 million litres per day. Both smaller and larger plants suffer from diseconomies of scale. Expensive marine works involving tunnelling increase costs substantially and should be avoided where possible.

Project costs are also a function of procurement method. Well-managed procurement, attracting reputable international companies, and contracted through a build-operate-transfer contract has delivered desalinated water at less than US$1 (R12) per thousand litres in many places. In contrast, projects contracted through an owner-engineer design-build model are exposed to cost escalation and have proved to be more expensive, with costs in the range of $2 to $3 per thousand litres. An appropriate comparison for an understanding of the different cost outcomes between these two procurement models is the difference in the cost outcomes between the owner-engineer model Eskom adopted for the Kusile and Medupi power stations (both of which experienced massive cost escalations) and the Renewable Energy Independent Power Procurement Programme (REIPPP), which has delivered cost-efficient coal, wind and solar power through competitive bidding processes linked to power purchase agreements. In the case of a 150 million liter per day desalination plant, the difference in cost outcomes between $1 (R12) and $2-3 (R24-36) per thousand litres results in additional "inefficiency" costs of R0.65-1.3 billion per annum, or R6.5-13 billion over ten years. Achieving cost-efficient outcomes for the development of desalination capacity is therefore very important.

Wastewater reuse is expected to be less costly compared to desalination because the capital costs are lower (no expensive marine works are needed) and energy costs are about half of that needed for desalination – 2 kWh for reuse compared to 3.5-4 kWh for desalination per thousand litres. The latest engineering estimates for treating wastewater reuse to a potable standard in Cape Town is about R7.50 per thousand litres, just more than half the cost of efficient desalination. Scale is reasonably important for wastewater reuse too. For example, a single wastewater reuse treatment facility for 50 million litres per day is about 15% cheaper than a 20 million litres per day facility, and a single combined facility of 70 million litres per day is strongly preferred for operational reasons and is cheaper compared to two separate facilities.

Ground water. Ground water is cheaper than wastewater reuse because both the capital and operating costs are significantly lower. The technology required is much simpler and the energy requirements are much lower. Costs are sensitive to water quality (and hence the required treatment costs) and the infrastructure costs are related to borehole depth, yields and location. Cape Town has successfully developed a sandy aquifer ground water scheme, with recharge, in Atlantis and Silverstroom, with a yield of 12 million litres per day. Plans are in place to extend this. While drilling is in progress in both the Cape Flows Aquifer and the Table Mountain Group Aquifer, accurate estimates of the full cost of development of these aquifers, including the associated infrastructure, treatment and recharge, is still awaited.

Surface water. Surface water schemes are cheaper than the other sources of water. The average cost, including bulk infrastructure and treatment, is about R5 per thousand litres. For this reason, preference has been given historically to surface water schemes. In fact, the Western Cape Water System is almost exclusively dependent on surface water.



3.2 Timing considerations

The complexity and logistical implications of project implementation differ depending on the source of water and technology employed. This affects the implementation time frames from the time a decision is made to proceed. Indicative target timeframes are shown, based on international experience. In principle, ground water projects should be fastest to implement, then re-use and then desalination, based on project complexity and logistical requirements. However, the actual timeframes are dependent on regulatory requirements as well as the approach to procurement that is adopted. In South Africa, the regulatory requirements are both complex and lengthy. This, together with stringent public procurement regulations, means that a moderately large infrastructure project that is procured in the standard way (through an owner design-build model) is more likely to take four to five years to implement rather than the two to three years shown for re-use and desalination in the figure.

3.3 Environmental and social considerations

The development of water resources, no matter what the source, has some environmental impacts. Large surface water schemes involve the construction of dams (often in environmentally important or sensitive areas such as mountainous wilderness areas) and associated infrastructure, including long pipelines, pump stations etc. Desalination is energy intensive, with a large carbon footprint if reliant on coal-based electricity, and the discharge of brine (and the related marine works) may affect sensitive coastal areas. The treatment of wastewater for reuse also uses energy (though less than desalination) and will involve infrastructure development (treatment works and pipelines). The flow of wastewater to riverine environments and wetlands will be reduced. Groundwater abstraction, provided it is not over-abstracted, has the least environment impact compared to the alternatives. The terrestrial impact is low, with a very low footprint, especially compared to surface water schemes. Sustainable ground water yield is regulated through a licencing system, together with monitoring, and can be managed through groundwater recharge from rainfall, stormwater systems and treated wastewater.

Health risks related to drinking water sourced from wastewater or ground water that may be polluted are readily managed through the implementation of appropriate treatment technologies and processes, including multiple protection barriers. Cape Town is already operating a sandy aquifer ground water abstraction and recharge system that is being used for drinking water. The City of Windhoek has treated its wastewater for reuse as drinking water for many years without incident. Nevertheless, negative social perceptions related to these two sources of water may exist and need to be managed.

3.4 What is an appropriate mix and sequencing of 'new water'?

Because desalination is the only truly climate resilient source of water that is independent on rain, there is a strong argument to be made that desalination should be a component of Cape Town's future source of water supply. However, desalinated water is the most expensive and is likely to take longer to implement than the alternatives. For these reasons, Cape Town should not rely on desalination as the only alternative source of water. Ground water is faster to implement, compared to permanent desalination (at scale) and is also much cheaper. Ground water has a lower environment impact compared to the alternatives. Importantly, groundwater can be managed as a form of water storage through recharge and without evaporation losses. This means ground water is a very sustainable source of water that can help mitigate drought events. On these grounds, the prioritisation of ground water as a means to diversify Cape Town's water supply is compelling. In this light, Cape Town has already committed itself to developing the Cape Flats, Atlantis and Table Mountain Group aquifers to the level of at least 100 million litres per day. Reuse is both cheaper than desalinated water and should be quicker to implement because the logistical requirements are less onerous and complex. There is therefore a compelling argument to include reuse as part of the diversification of Cape Town's water sources.

It is accepted that it is appropriate to get water from all three sources – ground water, wastewater reuse and sea water desalination – to ensure Cape Town is resilient to future water climate change or shocks, and if the argument related to timing is accepted, then the remaining question is how much should be obtained from each source?

Because desalination is the most costly, it is important to procure this efficiently. This means that desalination should be procured in modules of 120 to 150 million litres per day. The analysis above suggests that 120 million litres per day will be sufficient for the medium term.

The optimum arrangement for reuse augmentation has been identified as a single reuse treatment plant with a capacity of 70 Ml/day (expandable thereafter) at the Faure water treatment works, taking wastewater from Zandvliet and possibly Macassar wastewater treatment works.

Working backwards from the 350 Ml/day augmentation target, and taking into account a future surface scheme of 60 million litres per day, the 120 from desalination and 70 from wastewater reuse, leaves a requirement of 100 million litres per day from ground water. The current plans for groundwater exceed this for the reasons discussed in the next section.

Source	Target yield MLD	Notes
Ground	100	More could be abstracted from ground water sources in dry years.
Re-use	70	One large re-use reclamation plant (economies of scale)
Desalination	120	Optimal scale for desalination is 120-150 MLD
Surface water	60	Lower Berg River Voelvlei Augmentation scheme
Total (diverse sources)	**350**	

4 INTERNATIONAL REVIEW

An international review of the program facilitated by National Treasury's Cities Support Programme, undertaken during November. advised the following:

- **Manage demand and dam draw-down**. Assuming it will not rain again is not realistic. Augmentation will not make a significant difference to dam levels this summer and there is therefore no alternative but to ensure effective demand management during this summer. Ensuring agriculture

is restricted is very important and the city should also pursue opportunities for water transfers from agriculture. The critical point for dam levels is June 2019 if there is poor rain in the winter of 2018.
- **Prioritise ground water**. Ground water is much quicker to exploit and is cheaper. There is a large resource available. It is possible to over-exploit the groundwater resource in the short-run as part of the emergency, taking future recharge into account.
- **Do not pursue temporary desalination and reuse**. Temporary desalination and reuse is very expensive. Multiple small plants are logistically complex, and are not sustainable. Providing temporary desalination at scale is not a quick solution, It will take longer than planned and anticipated.
- **Do not use ship or barge-based marine desalination plants.** Current experience shows that such plants are very costly and have a poor track record of producing target fresh water quantity due to the source seawater challenges when the plant is docked in ports located in an urbanized or industrial area.
- **Re-use is cheaper than desalination and may be faster to execute**. Pursue the most promising opportunities for re-use in a cost-effective and time-effective way, in parallel to permanent desalination.
- **Pursue permanent desalination at optimal scale.** Plan and execute permanent desalination at a optimum scale, at a plant size or in modules of 120-150 million litres per day. Do not build desalination plants of capacity larger than 200 million litres per day.
- **Procure time and cost-effectively**. A competitively bid turnkey approach for reuse and desalination, using the private sector and with a water purchase agreement, will yield the lowest cost per unit of water compared to the alternatives and be quicker to implement provided regulatory processes are fast-tracked as part of the emergency.
- **Make decisions on the long term now and implement**. Do not delay decisions on permanent reuse and desalination, and implementation.

The experience during this summer has demonstrated the fact that augmentation will not make a difference to dam levels this summer. The New Water Program is aligned to the recommendations from the International Review.

5 NEW WATER PROGRAM PROJECTS

5.1 Current projects

A list of current augmentation projects is given in the insert. Although the planned scale of ground water abstraction is large, these projects will not materially affect dam levels through to June/July 2018.

SUMMARY OF KEY OBJECTIVES FOR THE NEW WATER PROGRAM

Water from agriculture
- Explore short-term opportunities for trade (achieved)
- Ensure agriculture restrictions are enforced
- Explore opportunities for trade in summer of 2018/19

Prioritising and scaling up ground water and recharge
- Maximise potential of Cape Flats in short term (and arrange for recharge to maintain sustainable yield)
- Take Atlantis off surface water *(achieved)* and add 20 Ml/day additional capacity
- Continue with the sustainable development of TMG aquifer (up to 50 million litres per day)

Identifying and implementing a least cost permanent re-use project at appropriate scale:
- Develop one 70 million liters per day water reuse treatment plant (an appropriate scale), fast tracking procurement, ensuring cost-effectiveness (competitive turnkey procurement?), with indirect use (managing perception) and avoiding reverse osmosis (to reduce cost).

Permanent desalination
- Agree on the volume (120 to 150 Ml/day), decide on preferred site/s, Decide on procurement model and implement

CAPE TOWN'S CURRENT AUGMENTATION PROJECTS
(status as at 18 March 2018)

GROUNDWATER (±150MLD variable, permanent augmentation)
- **Cape Flats aquifer** ±80 MLD) underway.
  Exploratory drilling has proceeded well. Yield and quality testing is still underway, which will determine the infrastructure installations at the various sites. Water use licenses were received in March. The City has requested a meeting with DWS to amend some of the licence conditions which are not practically possible. The licence condition provides for an annual yield as well as annual recharge requirement. The augmentation programme currently shows a constant yield across the year of 55MLD, but this will be varied as required, to a maximum yield of approximately 80MLD for the first phase. The aquifer has substantial capacity and while recharge will be introduced as soon as possible, it is apparent that it is not immediately required at the license condition yield.
- **Atlantis aquifer**, ±20MLD additional capacity underway, 12MLD already into system
  Atlantis is already operating off-grid at 12MLD, and the additional yield of 20MLD will be fed into the bigger water supply system. Investigation of required infrastructure requirements to absorb the 20MLD are underway.
- **TMG aquifer** ±50 MLD underway (incremental)
  The City has renewed efforts to ensure environmental sustainability in providing water from the TMG. Currently borehole placement is under review following environmental inputs which threatened to reduce the yield in the medium term considerably. The license covers a variety of different sites, and the City is prioritising sites to minimise environmental impact while optimising yield. Current planning includes Steenbras, Cape Peninsula, Bergriver, Theewaterskloof and possible Wemmershoek while Helderberg is being re-assessed.

WATER TRANSFERS (±60 MLD over two months)
- ~8 Mm^3 from Groenland Water User Association, based on a release of ~10Mm^3 (assuming approximately 20% losses);
  This was planned to happen over 4 months (Feb-May 2018), but the release from Groenland will be completed between February and April. Reporting of the full volume of water received at Steenbras Dam has not yet been concluded but the additional water is expressed in the dam levels reported.

TEMPORARY DESALINATION (16MLD fixed yield over ~ 2 years)
The temporary desalination projects are generally progressing well and will be introducing new water into the system as per the program.
- Strandfontein, 7MLD, full production early in 2018;
- Monwabisi, 7MLD, full production early in 2018;
- V&A, 2MLD, full production early in 2018 (to be converted to a permanent yield of 5MLD by the V&A. Off-take agreement not yet finalised).

TEMPORARY WATER RE-USE (10 MLD fixed yield over ~ 2 years)
- Zandvliet, temporary re-use scheme - full production in late-2018.

SPRINGS & RIVERS (7.5 MLD)
- Newlands – Albion spring in operation at ~3MLD. We aim to add all feasible springs into the reticulation system which will increase the volume;
- Oranjezicht – routed 1MLD into the system, looking at other springs to enter into system where possible to increase volume;
- Lourensriver – injection of 3.5MLD into system.

PERMANENT RE-USE AND **DESALINATION:**
- **Desalination:** The City is currently contending with the decision of the right volume, location, timing and procurement method of permanent desalination. At the current stage of evaluation, this appears to be optimal between 120 – 150MLD at a single plant, with delivery of first water possible in 2021. In parallel work is continuing at the pilot site at Koeberg which is planned to produce ~20MLD in 2 years' time (March 2020);
- **Re-use:** The introduction of more expensive water such as ground and desalinated water necessitates maximising value by re-use. Having assessed all the available capacity at the City's waste water treatment plants alongside the Cape Flats aquifer injection requirements, a plant of between 70 – 90MLD is being assessed for injection at Faure water treatment plant at an attractive cost with first water in the second half of 2020.

The long-term outlook for additional augmented water needs to be balanced with water provision from DWS (such as 60MLD from Berg river to Voelvlei surface water augmentation scheme) as well as changing rainfall patterns and risk appetite.

The above assessment with Cape Town providing in the region of 350MLD thus needs to be considered as provisional and is likely to change.

5.2 Future projects

Water demand in Cape Town will continue to grow as a result of population and economic growth. Providing water from diverse sources in the region of 350 MLD will increase the city's resilience to periods of drought at the same time as provide for future growth. The greater resilience provided from these diverse sources, with the ability to extract more from aquifers during droughts and to re-charge with other water sources during wet periods, is significant. The impact of climate variability will be continuously assessed and the planned augmentation volume may be increased in future years, in consultation with DWS.

Detailed design work is proceeding on a 70 MLD wastewater reuse plant to be sited at Faure Treatment Works, taking water from Zandvliet (50 MLD) and Macassar (20 MLD). Concept designs have been developed for water reuse from Cape Flats (75 MLD) and Athlone (75 MLD)

Work is proceeding on options for recharge of the Cape Flats aquifer.

The optimum site for a 120-150 MLD permanent desalination plant is being explored and a pilot plant at Koeberg (20 MLD) is being constructed which will inform the design for a larger desalination plant at that site in the future.

6 CONCLUSIONS

- Creating new water supplies from diverse sources of about **300 million litres per day** is sufficient to secure Cape Town's water supply, more is not necessary.
- Water with a high level of security costs more than surface water. This will require a re-negotiation of arrangements with the national Department of Water and Sanitation on water allocations from the system, security of supply and cost allocations between urban water users and agriculture.
- This document, together with supporting documents and presentations, will be used as a basis to develop a consensus on the New Water Program within and beyond the City of Cape Town municipality.
- It is challenging to budget in a context of uncertainty with respect to both the timing and costs of projects. This is the case for ground water, reuse and desalination in light of the fact that these projects have not been implemented before at scale by the City. Processes to allow for adjustments to the budget line items within the year need to be developed to cater for this uncertainty;
- While re-use and desalination will take longer to implement, decisions on these need to be made as soon as possible and implementation initiated.

7 RECOMMENDATIONS

- It is necessary to continue to **implement demand management** initiatives effectively through communications, stakeholder management, roll-out of the pressure management programme and acceleration of WMDs;
- It is important to **investigate opportunities in agriculture for transfers** /trade next summer, depending on winter rainfall;
- It is imperative that the **ground water program is fast-tracked** to bring additional water at scale into the system soon. The ground water license conditions need to be renegotiated with the Department of Water and Sanitation as existing licences are not wholly appropriate to the context; Environmental concerns need to be urgently addressed. Failure to implement this program timeously creates significant risk to the city with serious economic consequences.
- A **decision** on proceeding with the Faure semi-indirect **re-use plant** needs to be made, including investigating ways to expedite the project.
- A **decision** on the procurement a 120MLD **permanent desalination** is needed, including a decision on the approach to procurement.