THE GREATER CAPE TOWN WATER FUND

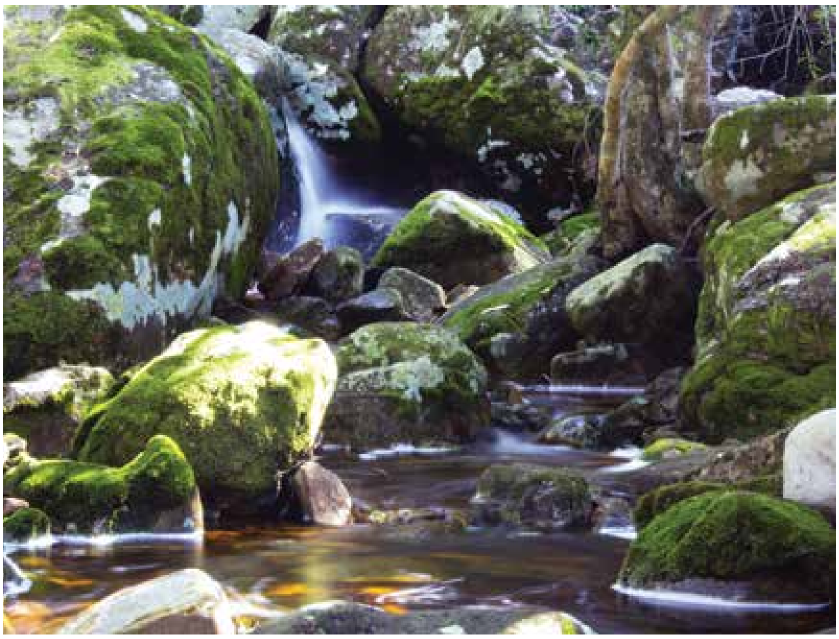
ASSESSING THE RETURN ON INVESTMENT FOR ECOLOGICAL INFRASTRUCTURE RESTORATION

BUSINESS CASE: MARCH 2019

The Nature Conservancy

Water Funds for Africa

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EXECUTIVE SUMMARY

MAIN SECTION

ABBREVIATIONS

CSIR .... Council for Scientific and Industrial Research

DEA.. Department of Environmental Affairs

DWS.. Department of Water & Sanitation

DWAF.. Department of Water Affairs and Forestry

EI.. Ecological Infrastructure

IAP.. Invasive alien plant

GCTWF.. Greater Cape Town Water Fund

GEF... Global Environmental Facility

GIS.. Geographic Information Systems

MAR.. Mean Annual Run-off

MLD .... Million liters per day

MTO.. Mountain to Ocean

NPV .... Net Present Value

PD.. Person-day

ROI .... Return on Investment

R... South African rand

SANBI... South African National Biodiversity Institute

TMG.. Table Mountain Group

TNC... The Nature Conservancy

WCWSS.. Western Cape Water Supply System

WFW .... Working for Water

WMA.. Water Management Area

UBCEG.. Upper Breede Collaborative Extension Group

URV... Unit Reference Values

USD... United States dollar

GLOSSARY

Currency

All monetary values are expressed primarily in South African rand (R) and if United States dollars (USD) are used they are based on the late October, 2018 exchange rate.

Catchment

Catchment is the area of land that drains water from a divide or ridge to an outlet location such as a stream channel, which may also lead into waterbodies such as bays or dams. The word catchment is used interchangeably with the terms watershed and drainage basin

Dam

Dam is an artificial body of water used for water storage before it is supplied for later use. This report follows the terminology used in South Africa. Therefore, the term "dam" is used to describe what might be termed a "reservoir" in the USA and many other countries.

Discount Rate

Refers to the interest rate used in discounted cash flow analysis to determine the present value of future cash flows.

Ecological infrastructure

Ecological infrastructure is the nature-based equivalent of grey or engineered infrastructure. It forms and supports a network of interconnected structural elements such as catchments, rivers, riparian areas and natural corridors supporting habitats and movement of animals and plants.[1]

Ecosystem services

The benefits people obtain from ecosystems. The Millennium Ecosystem Assessment [2] categorised ecosystem services as provisioning, regulating, cultural, and supporting services.

Greater Cape Town Region

For the purpose of this document, the Greater Cape Town Region refers to the service area of the Western Cape Water Supply System (WCWSS) and includes the Cape Town Metropolitan area, the agricultural sector, and smaller municipalities and communities who depend on the WCWSS for their water supply.

Invasive alien plants spreads aggressively

Invasive alien plants are introduced vegetation that is non-native to an ecosystem, spreads aggressively, outcompetes native plants, and which may have adverse economic and environmental impacts They can impact biodiversity negatively through competition and disrupt local ecosystems and their functioning.

Millions of cubic meters (Mm^3)

The default volumetric unit of water in this document is the cubic meter, typically expressed in millions given the large volumes of water discussed in this document. One cubic meter is equivalent to 1000 liters, making the conversion quite simple.

Unit reference value (URV)

The URV was developed by the South African Department of Water Affairs as a means of comparing the cost of delivering water from different water supply schemes, by estimating the cost in rands of delivering one cubic meter of water. The URV of a project is calculated by dividing the present value of the total cost of the infrastructure (construction, maintenance, operation) by the discounted stream of water generated over the economic life of the project. It therefore does take the growth in savings over time into account, making it comparable to other investments.

Water Fund

A Water Fund is a funding and governance mechanism that enables water users to provide financial and technical support collectively in catchment restoration alongside upstream communities.

Water security

Societies can enjoy water security when they successfully manage their water resources and services to: satisfy household water and sanitation needs in all communities; support productive economies in agriculture, industry, and energy; develop vibrant, livable cities and towns; restore healthy rivers and ecosystems; and build resilient communities that can adapt to change.

Wetland

Land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil.[3]

FOREWORD

By Dr. Guy Preston, Deputy Director-General of Environmental Affairs, National Resources Management Programme

The summer of 2017/18 saw the cumulative impact of one of the worst recorded droughts in the south-western Cape. Unprecedented restrictions were put in place, to curtail the use of water by agriculture, industry, residential use and others. Human population has grown at a high rate; industry has grown; water quality has declined; redressing the political devastation of apartheid demands more water to be used by those so callously denied in the past, and the spectre of climate change looms large. The authorities have been compelled to confront the social, economic and ecological choices for water security.

There is no doubt that demand-side management of water is the first obvious step in seeking water security (including addressing "unaccounted-for" water — that lost to leaks, poor metering and theft).

However, it is not sufficient on its own. There will be a need to augment the supply of water over time, and the authorities face some difficult choices in deciding what interventions to prioritise. These will likely be seen to be some combination of building new dams, raising the walls of existing dams, building desalination plants, water transfers, groundwater abstraction, water re-use, rainwater harvesting and other choices. Catchment management — and particularly the control of certain invasive alien plant species — is one of the other choices.

The difficulty that the authorities have is that understanding the real costs and benefits of the different interventions is complex. There is also a tendency to look at simplistic financial costs, rather than understanding the externalities associated with each choice that can indicate more accurately where investments should be made, and which may be sustainable in the long-term.

A resource-economic assessment of choices will confirm that the management of catchments, and particularly the control of invasive plants in our mountains (the "water factories"), riparian areas, wetlands and groundwater-recharge areas, is

essential. Other than for demand-side management, it has the highest return on investment. Moreover, a failure to do the work timeously will lead to escalating costs, as invasive plants spread and grow.

The knee jerk responses of building a new dam or desalination plant are not truly alternatives to catchment management. Desalination plants are expensive and can never address agricultural needs. Building new dams is difficult and does not solve the problem of the supply needed to fill the dams.

The old Department of Forestry used to be responsible for managing catchments, and without their work our task would be almost impossible now. The Government's Working for Water programme picked up the dropped baton in 1995, and has cleared some 3.3 million hectares of land across the country. But the invasives are still spreading faster than they are being controlled, and particularly in the more inaccessible areas like our mountain catchments.

The Greater Cape Town Water Fund is a most welcomed intervention to present the business case for a return on investment in catchment management. Based on compelling data that can inform authorities and the public alike about their real choices, it may well bring on board the private sector in supporting the authorities to address priority sub-catchments, and restore the ecological infrastructure for optimal outcomes. It may also enable us to find a better combination of incentives, disincentives (including the application of our laws), advocacy and research, in our quest to address the decline of our life-support systems.

The Working for Water programme is a partnership intervention of the Departments of Environmental Affairs, of Water and Sanitation, and of Agriculture, Forestry and Fisheries, as well as various partner entities such as the South African National Biodiversity Institute, the Water Research Commission, the Council of Scientific and Industrial Research, and the Agricultural Research Council. We welcome the call for action represented in the Greater Cape Town Water Fund, and will seek to align our ongoing efforts to mutual benefit. Done well, this may well be a model for similar interventions in other key areas across the country.

EXECUTIVE SUMMARY

This Business Case puts forward ecological infrastructure restoration as a critical component of efforts to enhance water security for all users of the Western Cape Water Supply System (WCWSS). Funding and coordination of restoration will be catalysed by a collective action Water Fund that pools financial support across multiple public and private water users and others interested in ecological infrastructure solutions to Greater Cape Town's water challenges.

AVOIDING DAY ZERO

Water security is a major concern for the City of Cape Town which faced the possibility of running out of water following a three-year drought between 2015 and 2018. The day the taps would run dry, dubbed "Day Zero", was narrowly avoided but the threat remains. Cape Town's population is growing fast, at a rate of about 2.6% a year, while climate models show decreased rainfall accompanied with increased temperatures in the future, increasing the risk of water shortages.

Water demand is predicted to outstrip current supply in the Greater Cape Town Region by 2021. Current forecasts suggest that an additional 300 - 350 million liters (0.3 – 0.35 million cubic meters) of water a day will be needed by 2028 to ensure supply meets demand. Over R8 billion ($540 million USD at the late October 2018 exchange rate) in public funding is being considered for augmenting water supply through investments in deep aquifer drilling, desalination, water reuse and increased surface water storage to meet the required demand.

THE CASE FOR ECOLOGICAL INFRASTRUCTURE

While until recently the focus has been on "grey", or engineered, infrastructure solutions to combat water scarcity, there is another cost-effective option with the potential to augment water supply. Long-term water security in the Greater Cape Town Region, as elsewhere, begins at the source with the ecological infrastructure (native vegetation, wetlands, etc.) that regulates source water quality and supply.

Over two-thirds of the sub-catchments supplying the WCWSS are affected by alien plant invasions, reducing the amount of water that reaches the rivers and dams that feed the region by 55 billion liters (55 Mm^3) per year. In a place where every drop of water counts, these losses are significant. These plants, trees such as pine and eucalyptus, quickly replace native species if unmanaged and threaten the diversity of native plant life in the Cape Floral Region, where 70% of plants are found nowhere else on the planet, and alter the habitat for the region's fauna. Invasive alien plants alter soil ecology, increase the frequency and severity of wildfires and significantly impact river flow and aquifer recharge.

Despite ongoing efforts to remove invasive trees by programmes such as Working for Water, the problem is increasing. In response, a coalition of partners —The Nature Conservancy, National Department of Water and Sanitation, National Department of Environmental Affairs (Environmental Programmes), Provincial Department of Environmental Affairs and Development Planning, City of Cape Town, SANBI, CapeNature, Coca-Cola Peninsula Beverages, Nedbank, Remgro Ltd, and WWF — came together under the auspices of the Greater Cape Town Water Fund Steering Committee. The Committee commissioned studies to evaluate the impact of nature-based solutions on water supply, beginning with targeted removals of alien plant invasions, and determine whether investing at scale in catchment restoration is cost competitive with other supply-side solutions.

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RETURN ON INVESTMENT ANALYSIS AND RESULTS

The business case analysis models a 30-year period, discounting both costs and water gains at 6% for surface water sub-catchments.

A six-step process was followed to identify priority source water sub-catchments for invasive alien plant removal and to understand the return on investment associated with implementing these interventions at scale

Seven of the twenty-five sub-catchments were identified as priorities for invasive alien plant removal. They comprise a total of 54,300 hectares and are the sub-catchments for Wemmershoek, Theewaterskloof, and Berg River dams.

Results show that investing R372 million ($25.5 million USD; present value) here will generate expected annual water gains of 100 billion liters (100 Mm^3) within thirty years compared to the business as usual scenario. Importantly, invasive alien plant removal would already yield up to an additional 50 billion liters (50 Mm^3) within five years. Approximately 350 job opportunities will be created in the first five years of implementation, as removing alien plant invasions is very labour intensive.

Catchment restoration is significantly more cost-effective than other water augmentation solutions, supplying water at one-tenth the unit cost of alternative options (Figure E1). It produces greater water yields than any other supply options except desalination, which is far more costly. The results of catchment restoration programmes will be evident rapidly, with improved supply showing as soon as the first winter rains. Furthermore, catchment restoration produces water yield gains into perpetuity if areas cleared of invasive alien plants are maintained.

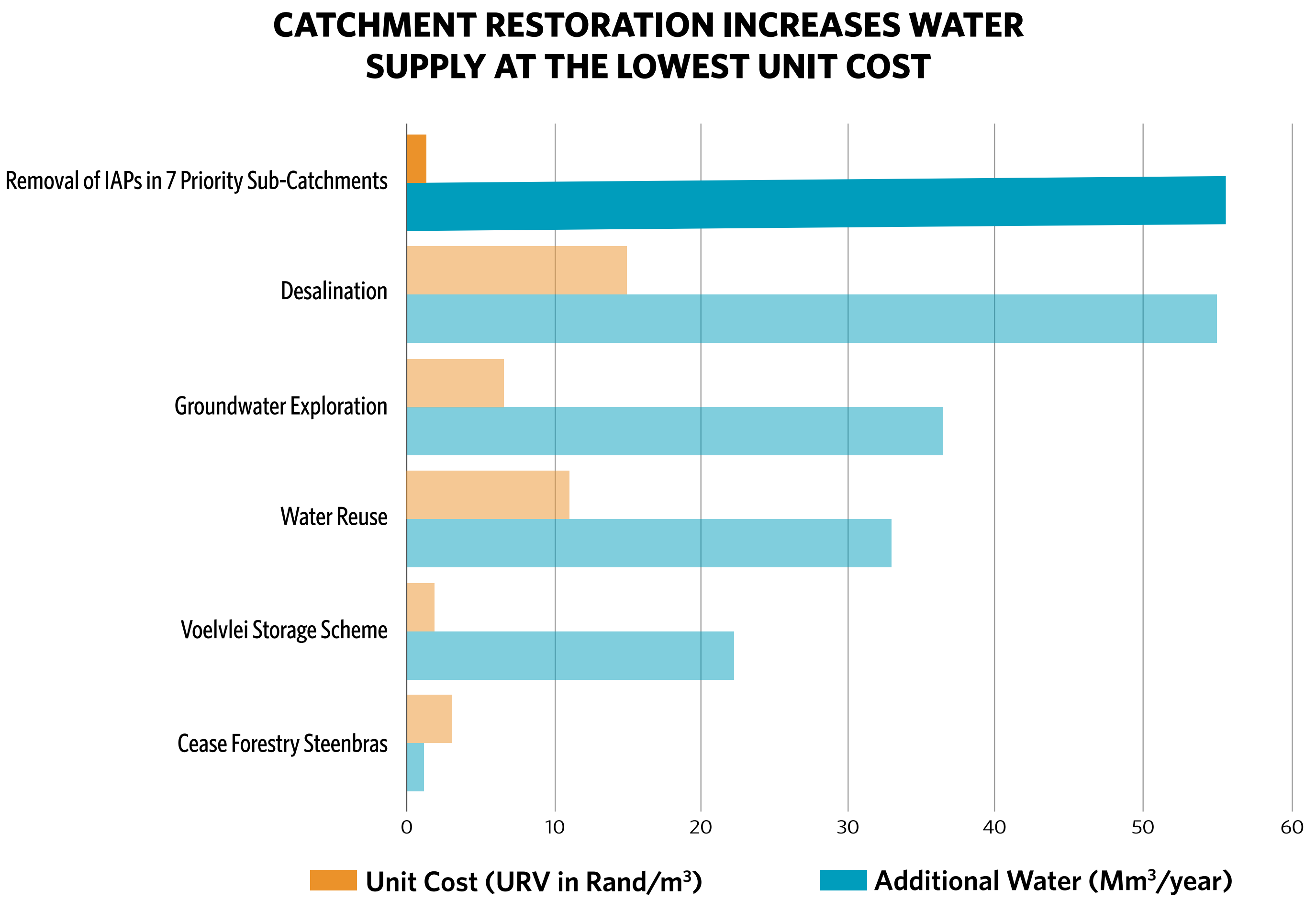

Figure E 1. Water supply gain and unit cost (URV) comparison between different catchment restoration and other supply options (costs include raw water treatment cost where applicable).

ADDITIONAL ECOLOGICAL INFRASTRUCTURE RESTORATION

While the focus of this Business Case is on invasive plant removal to restore seven priority sub-catchments supplying the WCWSS, the scope of the Water Fund will be broader in supporting additional ecological infrastructure interventions to secure water supply. The restoration of four priority wetlands would be beneficial, as well as removal of Steenbras and Wemmershoek plantations and clearing forestry exit areas, and restoration of the Atlantis Aquifer. Preliminary analysis has shown that an estimated 1.8 Mm^3 of water is lost annually due to alien plant invasions on the Atlantis Aquifer alone.

CONCLUSION

An investment of R372 million ($25.5 million USD) will generate annual water gains of over 55 billion liters (55 Mm^3) a year within five years compared to business-as-usual — equivalent to one-sixth of the city's current supply needs — increasing to 100 billion liters (100 Mm^3) a year within 30 years. Water gains are at least one-tenth the weighted unit cost of alternative supply options.

The results of this business case demonstrate that restoring the ecological infrastructure of priority sub-catchments through invasive alien plant removal is a cost-effective and sustainable means of augmenting water for the Greater Cape Town Region.

THE ROLE OF THE GREATER CAPE TOWN WATER FUND

The Greater Cape Town Water Fund is bringing together private and public sectors stakeholders alongside local communities around the common goal of restoring the surface water and aquifer catchments which supply our water. The Water Fund aims to support and align with existing government initiatives and act as a catalyst for systemic change in catchment management by cost effective use of on the ground resources, strengthened capacity, and robust monitoring and evaluation. In addition, the Water Fund will stimulate funding and implementation of catchment restoration efforts and, in the process, create jobs and momentum to protect globally important biodiversity and build more resilient communities in the face of climate change.

INTRODUCTION

Water security is a major concern globally and increasingly so in parts of the world where supply is struggling to meet demand because of climatic changes or human pressures, or both. Nowhere is this more true than for the Greater Cape Town Region, South Africa, where the City of Cape Town faced the possibility of running out of water following a three-year drought between 2015 and 2018 — which would have been a global first for as large a city. At the height of the crisis, dam levels dropped below 20% and Cape Town prepared for the day when the taps would run dry, dubbed "Day Zero."

Water demand is predicted to outstrip current supply in the Greater Cape Town Region by 2021 due to steady population growth and changing rainfall patterns even in the absence of a drought like the recent one. The City of Cape Town has had remarkable success coping with this growth through demand management schemes, most notably the reduction in losses due to leaks, and significant grey infrastructure investments are being considered. The looming Day Zero expedited the search for "new" water with exploratory investments in desalination, deep aquifer drilling in the Table Mountain Group, the Cape Flats aquifer and additional abstraction from the Atlantis Aquifer, water reuse and augmenting surface water storage.

The City of Cape Town faces rapid population growth at about 2.6% per year. Not only is Cape Town the second largest city in South Africa, it is also a popular global tourism destination and the economic hub of the Western Cape Province, accounting for 86% of the province's gross domestic product.[4] Many national and multi-national corporations have their head offices in the City or in adjacent towns serviced by the same water supply scheme. Cape Town's population is estimated to reach 4.13 million in 2018[5], making up the majority of the Western Cape Province's total population.

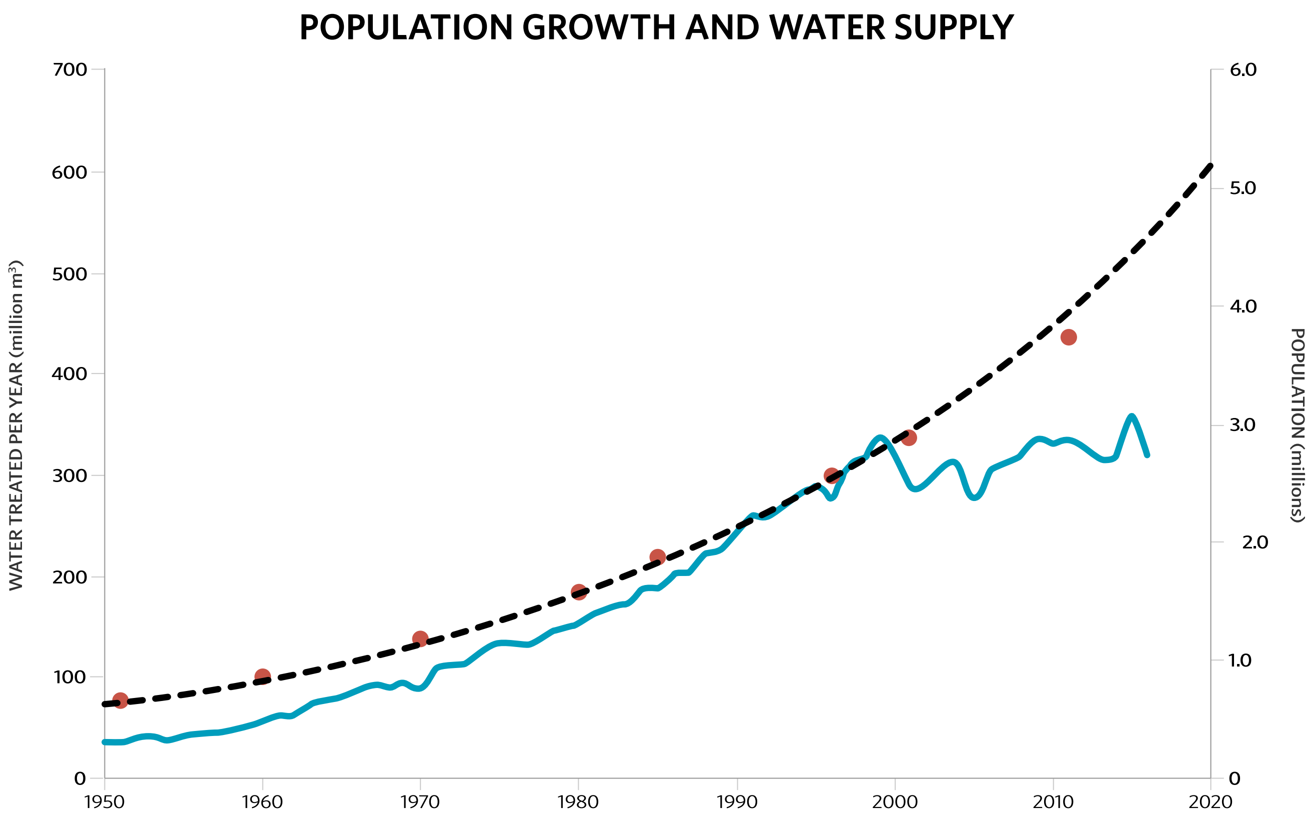

Figure 1. The population is growing while water supply is flatlining.

Figure 2. Example of black wattle tree invasion by Theewaterskloof dam.

FROM SOURCE TO TAP

Long-term water security in the Greater Cape Town Region, as elsewhere, begins at the source. Healthy water catchments naturally store, filter and transport rainfall to rivers and dams. As catchments become degraded however, water users from farmers to industry can expect treatment, pumping, and storage costs to increase.[6] In addition, in catchments where the minimum water quality and quantity necessary for sustaining aquatic ecosystems is not met, the health consequences for people and nature can be disastrous. Base flows during the dry summer seasons, for example, are critical to maintaining both aquatic health and water supply to many users.

Today many of the various sub-catchments feeding the Western Cape Water Supply System (WCWSS) are in an alarmingly unnatural state. Invasive alien plants such as pines, Australian acacias, and eucalyptus cover large areas of the landscape. These plants alter soil ecology, increase the frequency and severity of wildfires and significantly impact river flow and aquifer recharge. *Pinus radiata* and *P. pinaster* are highly invasive and have led to problems in South Africa and other countries around the world. The life-history characteristics that make *Pinus* species very suitable for commercial forestry also make them highly invasive in the areas where they have been introduced.[7] These include the size of the seeds (small and wind dispersible), the short juvenile time period (reach seed producing age quickly), and the mean interval between large seed crops (increased overall seed input into environment).[8] The wind-dispersed seeds of *Pinus* species allow them to spread easily to surrounding areas.

ECOLOGICAL INFRASTRUCTURE

The good news is that degraded catchments can be restored. Targeted investments in “ecological infrastructure” increase the hydrologic services provided naturally by a healthy catchment. Ecological infrastructure is the nature-based equivalent of grey or engineered infrastructure. It forms and supports a network of interconnected structural elements such as catchments, rivers, riparian areas and natural corridors supporting habitats and movement of animals and plants.[9]

At scale, catchment restoration programmes yield improved water availability and quality while generating multiple social, economic, and environmental co-benefits, including resilience to climate related shocks like floods and droughts.[10] Strategic investment in ecological infrastructure reduces operational costs, lengthens the life of existing water supply infrastructure and helps avoid the need for new projects — often with significant cost savings.

In the Greater Cape Town Region, as in other parts of the world, significant water security benefits can be achieved through ecological infrastructure investments in the water source areas of the WCWSS. Unfortunately, ecological infrastructure options are often overlooked. Indeed, the Greater Cape Town Region has historically lacked a comprehensive catchment restoration plan, one that major water users like the city, industry and farming community could well consider as a part of its portfolio of capital investments.[11]

The purpose of this study is to determine whether investing at scale in catchment restoration for the Greater Cape Town Region is cost competitive with other supply solutions.

The focus of this Business Case is primarily on the economics of controlling invasive plants in the surface source water areas of the WCWSS. The proposed restoration timetable is both credible and conservative and based on extensive consultation with local experts and communities. Water quantity, in particular the timing of flow or recharge, is the main focus of the benefit analysis. That said, the job creation and biodiversity impacts are also considered given the labour intensity of restoration interventions and the globally significant biodiversity of the Western Cape.

A WATER FUND FOR THE GREATER CAPE TOWN REGION

The vision of the Greater Cape Town Water Fund is to ensure healthy and resilient catchments providing sustainable water yields for current and future generations.

The current Greater Cape Town Water Fund (GCTWF) partnership includes The Nature Conservancy, National Department of Water and Sanitation, National Department of Environmental Affairs (Environmental Programmes), Provincial Department of Environmental Affairs and Development Planning, City of Cape Town, SANBI, CapeNature, Coca-Cola Peninsula Beverages, Nedbank, Remgro Ltd, and WWF. The GCTWF aims to address threats to water security at their source through targeted investments in catchment restoration and long-term management, including controlling invasive alien plants, rehabilitating wetlands and riparian areas and raising awareness about stewardship of water resources.

The Nature Conservancy (TNC) is a global non-profit with more than a million members and a network of over 3,500 staff including 600 scientists, working in over 70 countries. The TNC South Africa office was established in August 2017. The Greater Cape Town Water Fund builds upon TNC's related experience in the Upper-Tana Nairobi Water Fund, Africa's first Water Fund, and North and South America, where over 30 water funds are either operating or in development. In each case, the Water Fund serves as a governance and funding mechanism whereby public and private downstream water users contribute collectively to upstream conservation initiatives aimed at improving water quality or quantity both upstream and downstream.

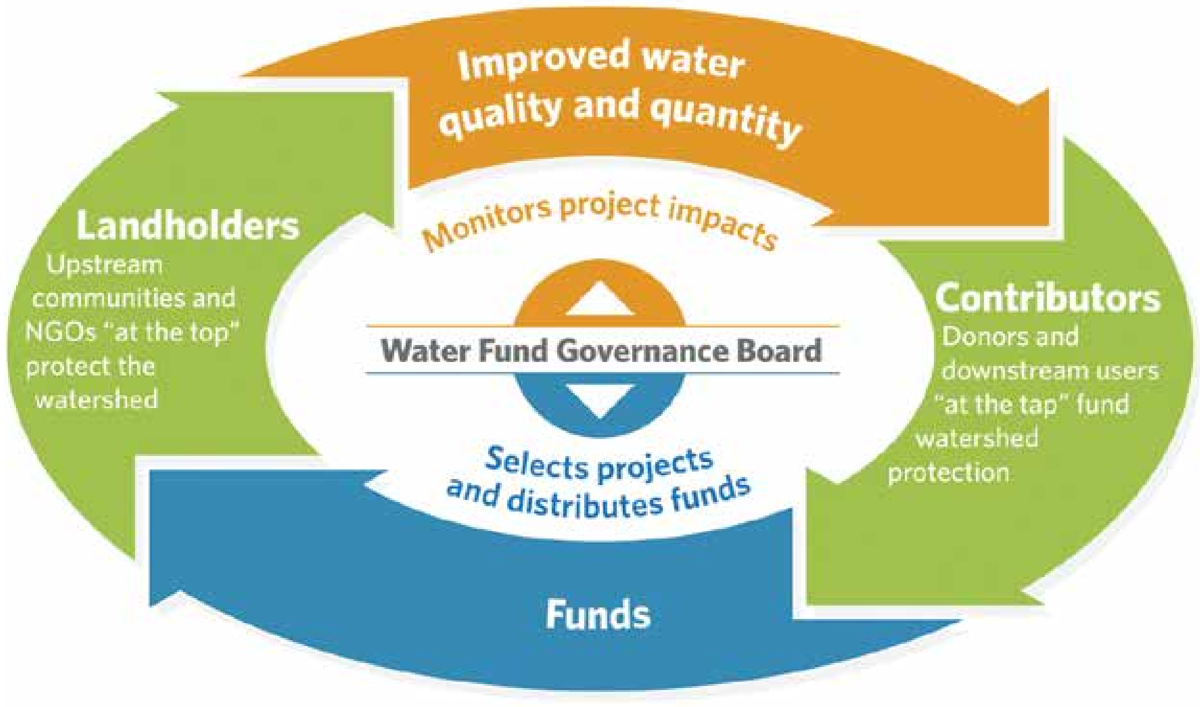

Figure 3. A Water Fund is a funding and governance mechanism that enables water users to invest collectively in catchment restoration alongside upstream communities. More information can be found at waterfundstoolbox.org.

BRIDGING THE GAP

Water Funds have typically been established where there is a market failure (i.e., the price of water does not reflect the true costs of delivering clean water, including environmental and resource costs) and where there is a need for coordination of multiple public and private sector actors through a collective platform. Even when existing water governance is linking the public and private sector relatively well, a Water Fund can be a good vehicle to pool funding and financing from various sources, including non-traditional sources of capital, and allocating those resources to priority interventions across the catchment.

A Water Fund does not replace government mandates, nor does it aim to compete for funding or duplicate efforts. TNC and the Greater Cape Town Water Fund partnership aim to significantly bolster the ongoing efforts to control invasive alien plants. These restoration efforts will go hand in hand with other existing interventions implemented by, for example, the City of Cape Town, Working for Water, and CapeNature to secure our water supply for the future. The GCTWF aims to work with relevant authorities and support the South African National Biodiversity Institute (SANBI) Global Environmental Facility (GEF) 6 project to create an enabling legal and policy environment for sustainable water resources management.

THE WESTERN CAPE WATER SUPPLY SYSTEM

The Greater Cape Town Region receives its water from sub-catchments of the Breede, Berg, and Olifants Water Management Areas (WMAs) through the Western Cape Water Supply System (WCWSS). The WCWSS is in fact made up of 14 dams, of which five are regarded as "major" dams, and three aquifers connected by an 11,600 km pipeline network, several storage reservoirs, pumping stations, and canals. The main aquifers include the Atlantis Aquifer, which is part of the West Coast Aquifer to the north of Cape Town, the Table Mountain Group Aquifer (TMG) in the Hottentots Holland mountain range beyond Cape Town, and the Cape Flats Aquifer within the urban area.

The City of Cape Town shares its water resources with the neighbouring district and local municipalities, West Coast (Swartland, Saldanha & Berg), Drakenstein (Paarl and Wellington), and augments Stellenbosch's supply, as well as the agricultural sector downstream of the Theewaterskloof, Berg River, and Voëlvlei dams. The current unrestricted daily demand for water in the WCWSS is 1.35 billion liters per day (1.35 million cubic meters per day – Mm^3) shared by The City of Cape Town, agriculture and smaller neighbouring municipalities (Figure 5).

DEMAND TO OUTSTRIP SUPPLY

Under the current planning scenario, it is predicted that demand will exceed current WCWSS capacity by 2021.[12] The planning scenario assumes that (1) The City of Cape Town meets water restriction targets; (2) Climate change or major drought does not impact water availability; and (3) Dams do not need to release additional water to meet the ecological reserve.

Day Zero refers to the point at which domestic users would be disconnected from the reticulation system and supplied from watering points. Based on consumption scenarios, the WCWSS collective dam levels for this were set at 13.5%, which would provide three months' worth of water at a greatly reduced service volume of 350 Million liters per day (MLD), less than one-third of normal deliveries. Day Zero was only narrowly avoided in the first half of 2018. A disaster management plan was implemented which involved the setting up of water collection points and finding short term alternative sources. Not only did the looming crisis compel the authorities to act, but water dependent industries, business and communities were watching the declining dam levels with anxiety. The installation of rainwater capturing capacity, grey water systems, and sinking of boreholes were some of the immediate responses by residents and businesses. The City of Cape Town implemented a Water Demand Management Strategy which involved actions such as declaring severe water restrictions, limiting individual use to 50 liters/person/day, managing the remaining water in the dams, and planning augmenting water from other sources (ground water, re-use, and desalination).[13]

The recent drought cost more than 30,000 agricultural jobs in areas serviced by the Western Cape Water Supply System and negatively impacted the tourism industry, bringing the importance of water security to the forefront. Under the predicted population growth of 2.6% per year, the City of Cape Town's population may exceed 5 million within a decade. Population growth and associated economic activities increase water demand, predicted to grow at 3% per year. An additional 300-350 MLD (110-128Mm^3 per year) would be required by 2028 to avoid a situation where demand exceeds supply.[14]

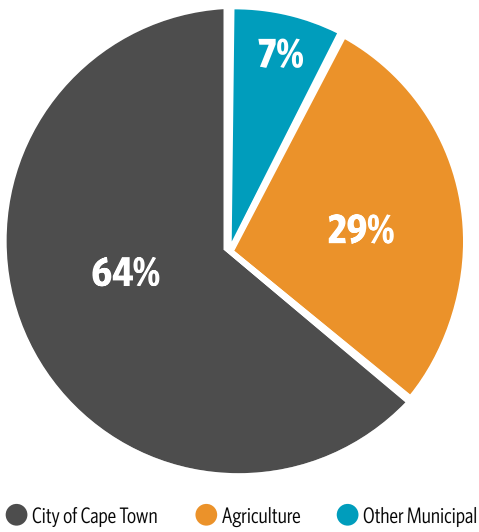

Figure 5. The City of Cape Town constitutes nearly two-thirds of water demand.

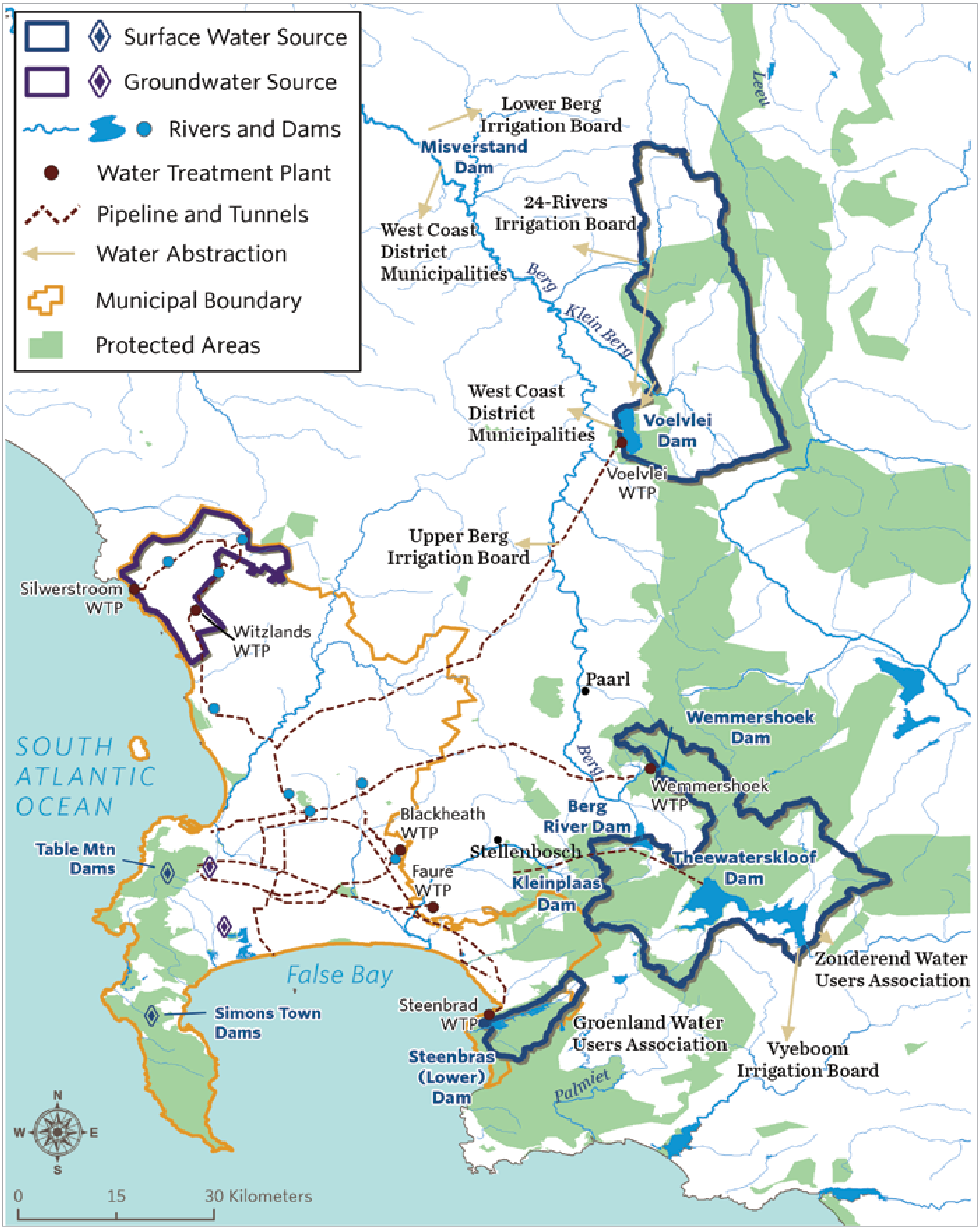

Figure 4. Western Cape Water Supply System users include the Cape Town metropolitan area, the agricultural sector, smaller municipalities, and communities.[15]

THE HIGH COST OF "NEW" WATER

Current supply augmentation solutions are estimated to cost 8 billion Rand ($540 million USD) in capital costs alone and to deliver 350-400 MLD by 2028. The City of Cape Town introduced a "New water programme" whereby the WCWSS is augmented from alternative sources to achieve the additional supply required. The new supply options are estimated to have a combined capital cost of 8 billion Rand (R) to deliver 350-400 million liters per day (MLD). Including operating cost, the estimated average unit cost (Unit Reference Value or URV) of new supply options is approximately R10 for each cubic meter of water supplied.[16]

Pumping and treating water is very energy intensive and depending on the energy source, some water supply options will lock the city onto a higher emissions path. While emission implications of water supply options are not considered here, such an assessment would further help the city make informed choices.

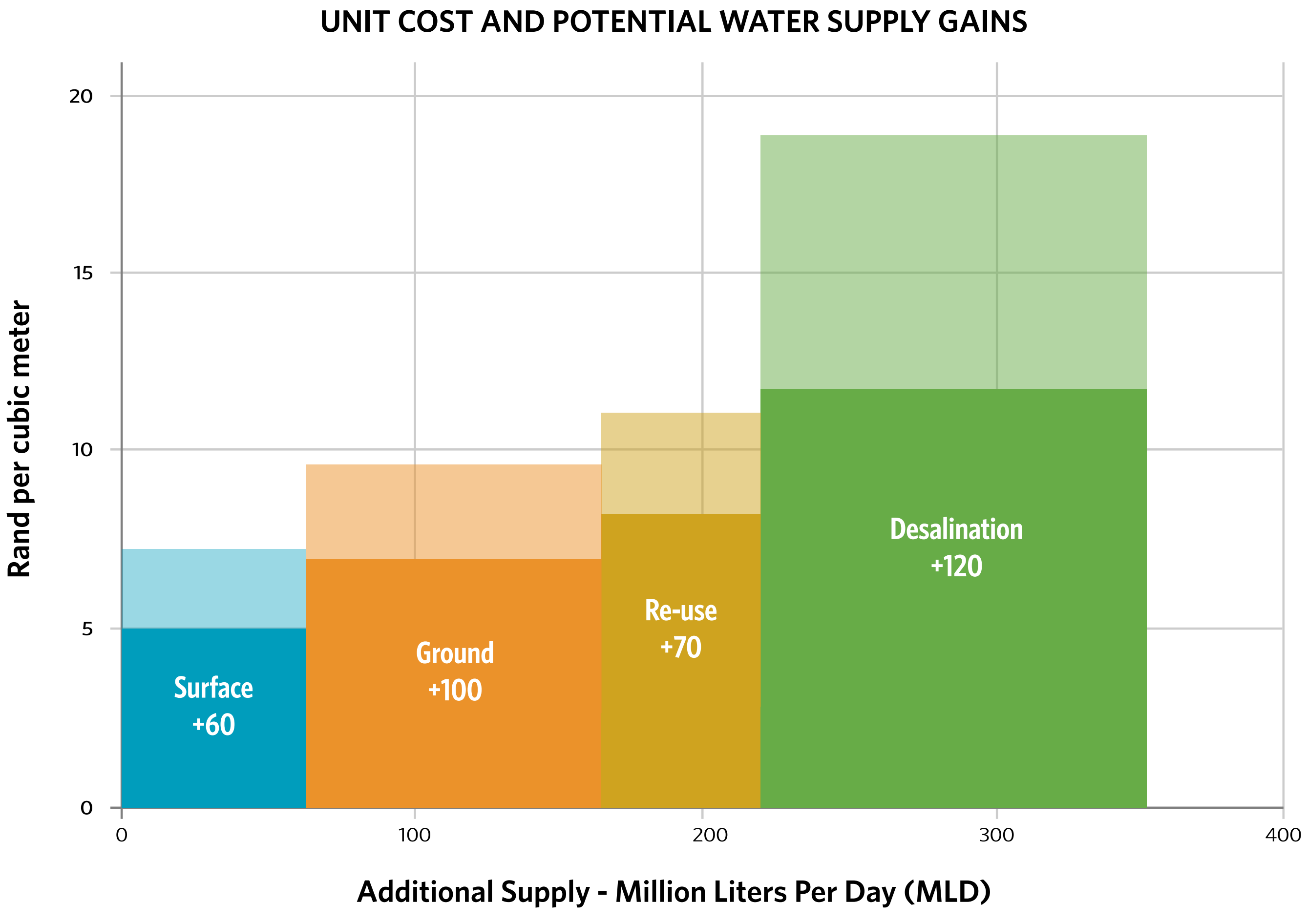

Figure 6. Unit cost comparison and estimated water yield potential of grey infrastructure solutions under consideration by the city. Significant uncertainty remains around the unit costs (shaded sections in chart).[17]

WCWSS SOURCE WATER AREAS

The Greater Cape Town Region's water comes from an area spanning over 170,000 hectares which drain into five major dams and the Atlantis aquifer. The majority (85%) of the areas upon which the Cape Town metropolitan area depends for its water are located outside municipal boundaries. The National Department of Water and Sanitation (DWS) manages three, and the City of Cape Town two, of the major dams.

The 25 source water areas of the WCWSS include the catchments upstream of the surface water dams, Voëlvlei, Theewaterskloof, Wemmershoek, Berg River, and Steenbras and the groundwater source, Atlantis Aquifer. Only 42% of these source water catchment areas are under formal protection, 15% occur in privately owned mountain catchment areas and 43% on other land — agriculture, government, private ownership and plantations.

The health of these catchments has been negatively affected by several factors, including the degradation of wetland and riparian areas, altered fire regimes — resulting in more frequent and intense fires — water pollution, and invasive alien plants.

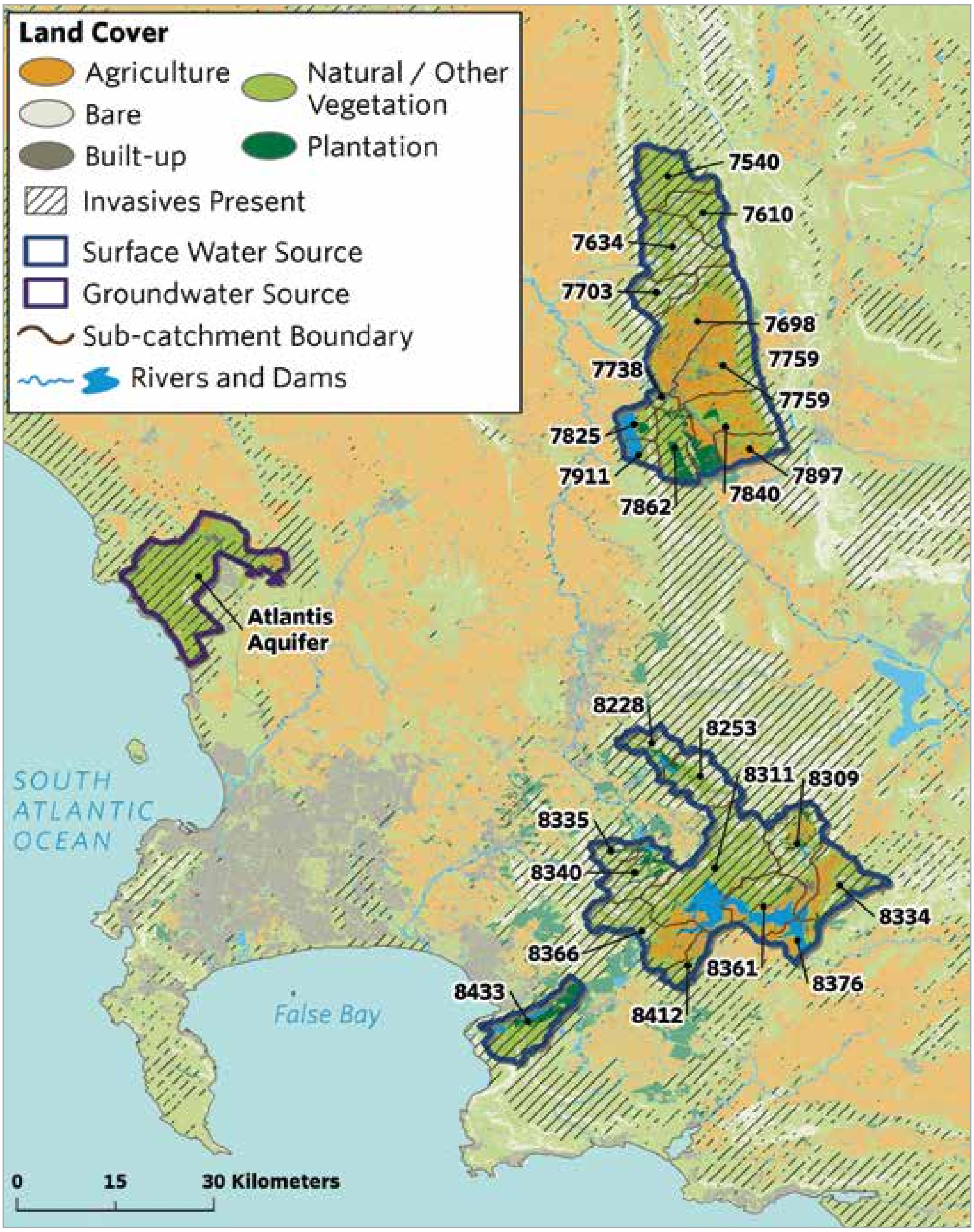

Figure 7. Over two-thirds of sub-catchments are invaded by alien plants.

Figure 8. Pine tree invasion.

ALIEN PLANT INVASION

Over two-thirds of sub-catchments are invaded by alien plants. The state of many of the source water sub-catchments feeding the WCWSS is being heavily degraded by invasive alien plants. These plants, which unlike the native fine-leaf fynbos vegetation are trees, quickly replace native species if unmanaged. They alter soil ecology, increase the frequency and severity of wildfires and significantly impact river flow and aquifer recharge.

Invasive alien plants threaten the diversity of native plant life in the Cape Floral Region, **where 70% of plants are found nowhere else on the planet,** and alter the habitat of native fauna.

The impact that invasive alien plants have on modifying catchment hydrology, and therefore water availability, is significantly determined by the species type and the density of the invasion.[18 19] Woody plant species, such as Australian acacia, pine and eucalyptus, which dominate invasives cover in these source catchments, have higher evapotranspiration rates and use up to 20% more water than the region's native fynbos vegetation. This leads to attendant decreases in surface water run-off as well as a reduction in infiltration or deep percolation to aquifers. Because woody plant species have deeper rooting systems than herbaceous landcover, they are also able to access and extract more groundwater even in times of low rainfall, allowing their growth cycles to persist. Over time, these species become more established as they can outcompete herbaceous native species and their density increases. This increased density magnifies their influence on water partitioning among evapotranspiration, surface water run-off, and groundwater and aquifer recharge leading to an overall reduction in water availability.

Figure 9 illustrates overall invasive alien plant presence in sub-catchments alongside what the percentage of coverage would be if those alien species were condensed to their equivalent 100% density within a sub-catchment (for a definition of density categories, see Box 1, P26).[20] For example, a sub-catchment may have widespread coverage of invasive plants, but at a low density. The influence of plants in such a catchment will be potentially much lower than in a catchment where invasive alien plants occur at a high density particularly when these woody species establish themselves in riparian zones. In catchments with widespread high density invasive alien plants, removal of these species will result in an immediate and significant response in local hydrology, specifically increased surface water run-off.

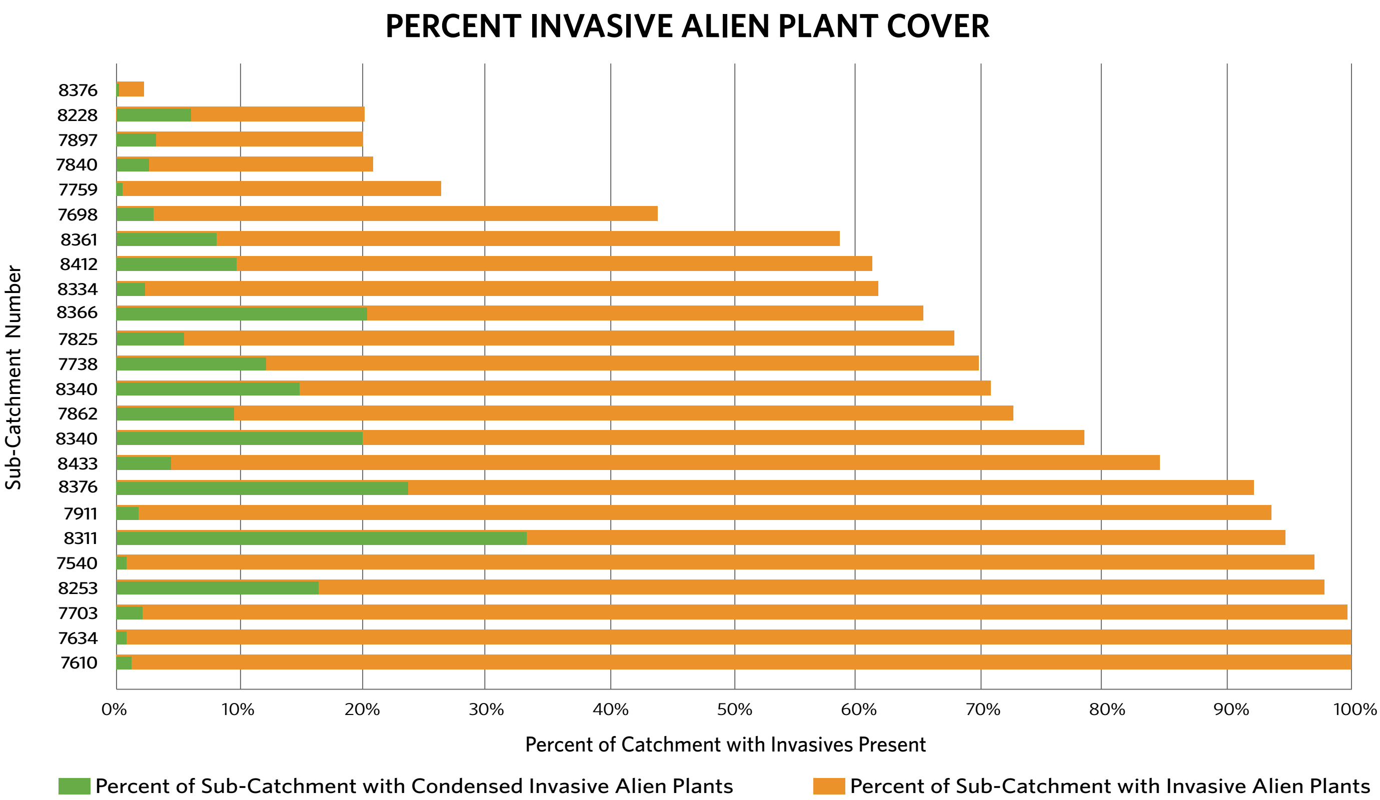

Figure 9. Invasive alien plant coverage of surface water sub-catchments, showing percentage of sub-catchment where invasive plants are present and the percentage of sub-catchment with condensed invasive plants.

CURRENT INITIATIVES TO CONTROL INVASIVE ALIEN PLANTS IN THE WCWSS

The National Department of Environmental Affairs Environmental Programmes (DEA-EP) is the largest funder of ecological infrastructure restoration projects in the WCWSS area. The Department's Land User Incentive Programme enables private landowners and Non-Government Organisations (NGOs) to apply for funding to control invasive alien plants on their land under certain conditions. The Working for Water (WFW) programme was introduced in 1995 to control invasive plants in catchments using labour intensive methods. By 2012, 2.5 million hectares across the country had received initial treatments and an average of 2.7 follow-up treatments.[21] This and the more localised clearing efforts of other players complement the progress made with biological control. Biological control is the use of natural enemies, predators or pathogens sourced from their areas of origin and subjected to stringent host specificity tests before they are released to control invasive plants. Biological control has been released to deal with over 50 invasive plant species in South Africa, resulting in the complete cessation of spreading for almost a quarter of them.[22]

By 2014/15 the WFW Programme implemented over 300 individual projects with an annual budget of R1.5 billion.[23] However, invasive alien plants remain a serious environmental problem in the WCWSS despite these programmes being in place, even with landowners being compelled to control invasive plants on their lands under the National Biodiversity Act 10, 2004 (Alien and Invasive Species Regulations (2014)). Some of the main reasons for the persisting problem of alien plant invasion in catchments were identified through stakeholder engagement conducted by the GCTWF (Table 1). It is clear from the factors identified that a new coordinated approach is need to tackle the problem of invasive alien plants, one that aligns stakeholders around shared goals and focuses funding on interventions which demonstrate the highest return on investment.

Table 1. Factors listed as main reasons for the persistence of the IAP problem in the Western Cape Water Supply System (WCWSS) catchments.

Factor	Result	Recommendation
Absence of a coherent long-term WCWSS-scale integrated ecological infrastructure restoration strategy and implementation plan	Duplication and gaps in efforts, lack of continuity and inadequate progress	Develop an integrated, long-term ecological infrastructure strategy for source water protection in the WCWSS
Lack of prioritisation and focus	Ongoing catchment degradation, gaps in implementation, important areas for source water protection not cleared, waste of resources	Prioritise sub-catchments for water resource protection, align control efforts to clear and maintain priority areas while maintaining previously cleared areas
Restrictive bureaucratic processes and red-tape, lack of flexibility to respond in a timely manner e.g. follow up after fire events	Re-invasion of cleared areas, ongoing spread of invasive alien plants leading to further degradation of catchments and water losses	Additional funding streams to supplement government funding, implement demonstration projects, flexibility to respond by following up after fires
Lack of monitoring, evaluation and reporting on progress against clear set of Specific, Measurable, Achievable, Realistic, Timebound objectives and targets	Ongoing degradation and water losses, poor quality work not detected and corrected on time, outcomes are not measured in ecological or water terms, but rather in terms of hectares treated, and job creation, results in wasteful expenditure and increase in spread of invasive plants	Develop and implement a Monitoring and Evaluation framework, analyse results against set objectives and targets, assess impact, report progress, adapt management where required
Information management inadequate, fragmented and not at the appropriate scale, the data is not readily available for decision-making. Inconsistencies and data gaps. Reliance on National Invasive Alien Plant data set that is not readily available and outdated in some instances when eventually made available.	Strategic, landscape-scale planning not possible due to data inconsistencies and gaps. Data not readily available for planning or tracking progress at scale involving all relevant stakeholders	Develop a strategic spatially explicit, web-based, accessible information management system for the source water areas of the WCWSS
Lack on integration of control methods such as fire. A key factor here is concerns about legal liability when doing prescribed burns and also the cost of doing them — so almost no prescribed burning	Inability to address alien plant invasions at scale, ongoing spread and increase in water losses	Integrate fire and biological control with conventional control methods, monitor impacts and adapt management approach
Legislative limitations preventing the City of Cape Town's to play a more active role and taking ownership of its water resources	City prioritises costly augmentation options, over cost effective long-term nature-based solutions such as controlling invasive plants in its water source areas	Legislative changes and/or changes in interpretation, enable the City of Cape Town to play and active role and invest in controlling invasive plants and maintaining priority sub-catchments outside municipal boundaries, conditionally to water allocation security
Institutional failure and fragmentation	Inadequate resources for source water protection	Support institutional capacity building, and build an inclusive effective governance structure for the WCWSS

EVALUATING THE COST COMPETITIVENESS OF CATCHMENT RESTORATION

It is often challenging to compare the cost-effectiveness of catchment restoration with that of conventional water supply infrastructure. The latter benefits from decades of track record, which makes estimating costs and predicting impact straightforward and reliable. Predicting the cost and impact of most ecological infrastructure in contrast can be very challenging. Invasive alien plant control is a notable exception, especially in South Africa where long-standing programmes like Working for Water provide a strong basis for estimating costs and operational considerations. Likewise, there is a strong scientific evidence base for the water yield impacts of catchment restoration through controlling alien plant invasions, which greatly reduces the uncertainty of water supply impacts. In short, there exists a solid foundation upon which to base investment decisions about controlling invasive alien plants.

Nevertheless, investing in a catchment restoration programme at scale — one that would largely take place outside of municipal boundaries — requires a predictable impact and a strong financial case. For Cape Town, this financial case depends on how the cost to control alien plant invasions and maintaining cleared and uninvaded areas and the resulting water impact compare to those of alternative water supply options.

The spatial scope of this study is limited to solely those 25 sub-catchments that flow into five main surface water dams — Theewaterskloof, Wemmershoek, Berg River, Voëlvlei, and Steenbras.

SIX-STEP PROCESS FOR ANALYSIS

This section details the analytical steps implemented to allow a comparison of the cost-effectiveness of invasive alien plant control and other water supply options. As illustrated in Figure 10, the analysis involved six main steps:

1. Map the current and future extent of alien plant invasion in sub-catchments
2. Model current and future water loss due to invasive alien plant invasion
3. Estimate the costs per hectare of invasive alien plant control based on local conditions
4. Rank areas by highest ROI, i.e., greatest water yield per unit cost
5. Build discounted restoration timeline for priority sub-catchments, including full maintenance costs
6. Compare cost per cubic meter, expressed as Unit Reference Value (URV) and potential yield gains of restoration programme to alternative water supply options

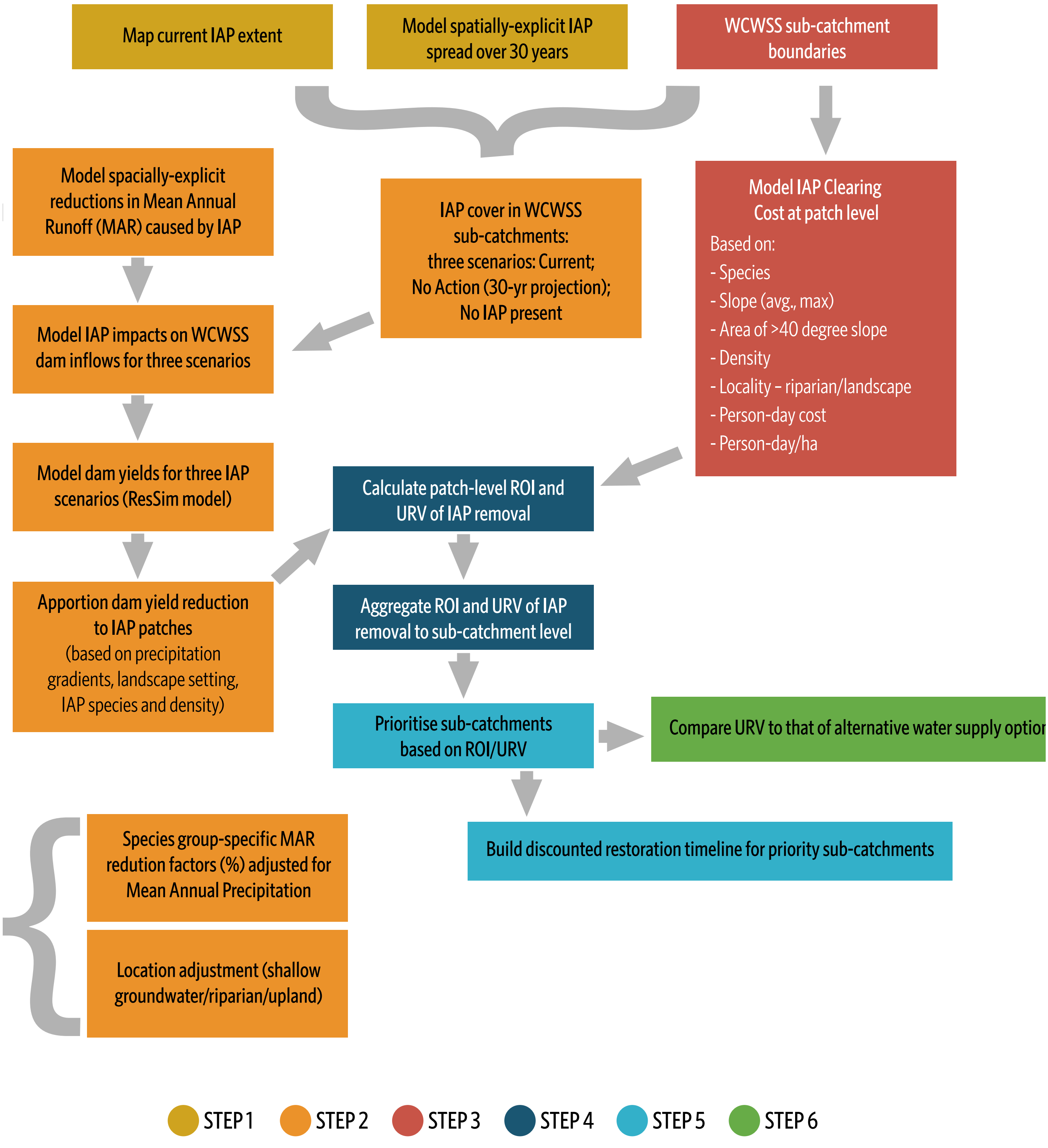

Figure 10. Estimating the cost competitiveness of catchment restoration by controlling invasive alien plants (IAPs) removal involved a series of analyses.

Mapping the current extent of alien plant invasion

Over two-thirds of the Greater Cape Town Region's sub-catchments have some degree of invasion and 14,400 ha (9%) are heavily invaded. Mapping the current extent involved compiling an inventory of alien plant invasions and producing Geographic Information Systems (GIS) maps (Figure 11) of the source water sub-catchments. The Görgens *et al*. (2016)[24] dataset was used as the primary source and updated using distribution data obtained from existing datasets from CapeNature, Landcare, City of Cape Town and the National Invasive Alien Plant Survey[25] where no other data existed.

More than two-thirds of the water source catchments has been invaded by introduced tree species, and some 14,400 hectares (9%) are densely invaded (Box 1). Most invasions are in the 5-25% density category followed by 25-50% (Figure 11). Deciding which densities to address first is part of strategic planning and control tactics. The densest areas (75-100% IAP cover) have significant impacts on water yields, whereas the occasional trees occurring in the landscape (often on steep cliffs) are crucial to clear to reduce seed dispersal and prevent alien plant invasion. A two-pronged approach is therefore recommended, assigning resources to the dense patches within a management unit, while also clearing the sparse invasions.

Box 1. Density Categories

Density categories

For strategic landscape scale planning purposes alien plant invasions are clustered in seven density categories based on the plant canopy cover in percent.

For the purpose of a single contract, when the sub-catchments are divided into management units for the purposes of assigning a contract, the densities are listed for each species occurring within the management unit ranging between 1 – 100%.

Condensed hectares: Represents the equivalent area that the invasive plants would take up if they occurred at 100% density cover.

Condensed Hectares = $(c/100) \times a$, where c is the % cover and a is the area in hectares.

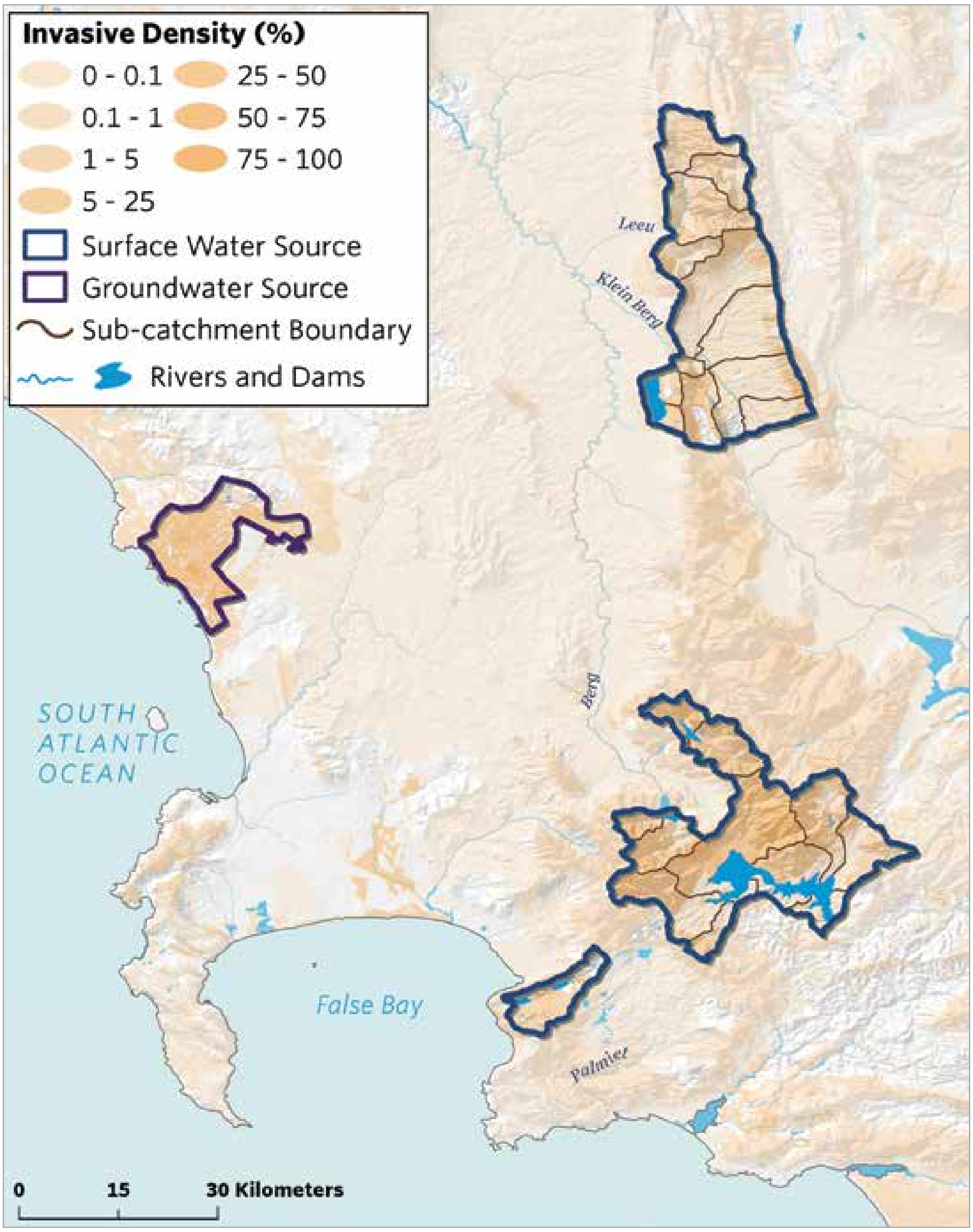

Figure 11. Invasive alien plant density distribution across the sub-catchments.

Modeling current and future water loss due to invasive alien plants

Alien plant invasions in the Greater Cape Town Region's water source catchments result in an estimated annual reduction in water yield of 55 billion liters (55 Mm^3). If no action is taken, water loss could double within 30 years. The analysis built on modelling work done in earlier studies [26] to estimate the water yield reduction at 10% system assurance resulting from alien plant invasion in the WCWSS source water sub-catchments. The water losses for the sub-catchments were estimated using the Water Resources Yield Model (WRYM), the WR2005 Model, the stand-alone reservoir simulation ResSim Model, and a scenario-based approach (see Appendix A: Description of the models used for the study).

The loss in yield was calculated for each sub-catchment by subtracting current and future yields from the natural (i.e., under native species land cover)

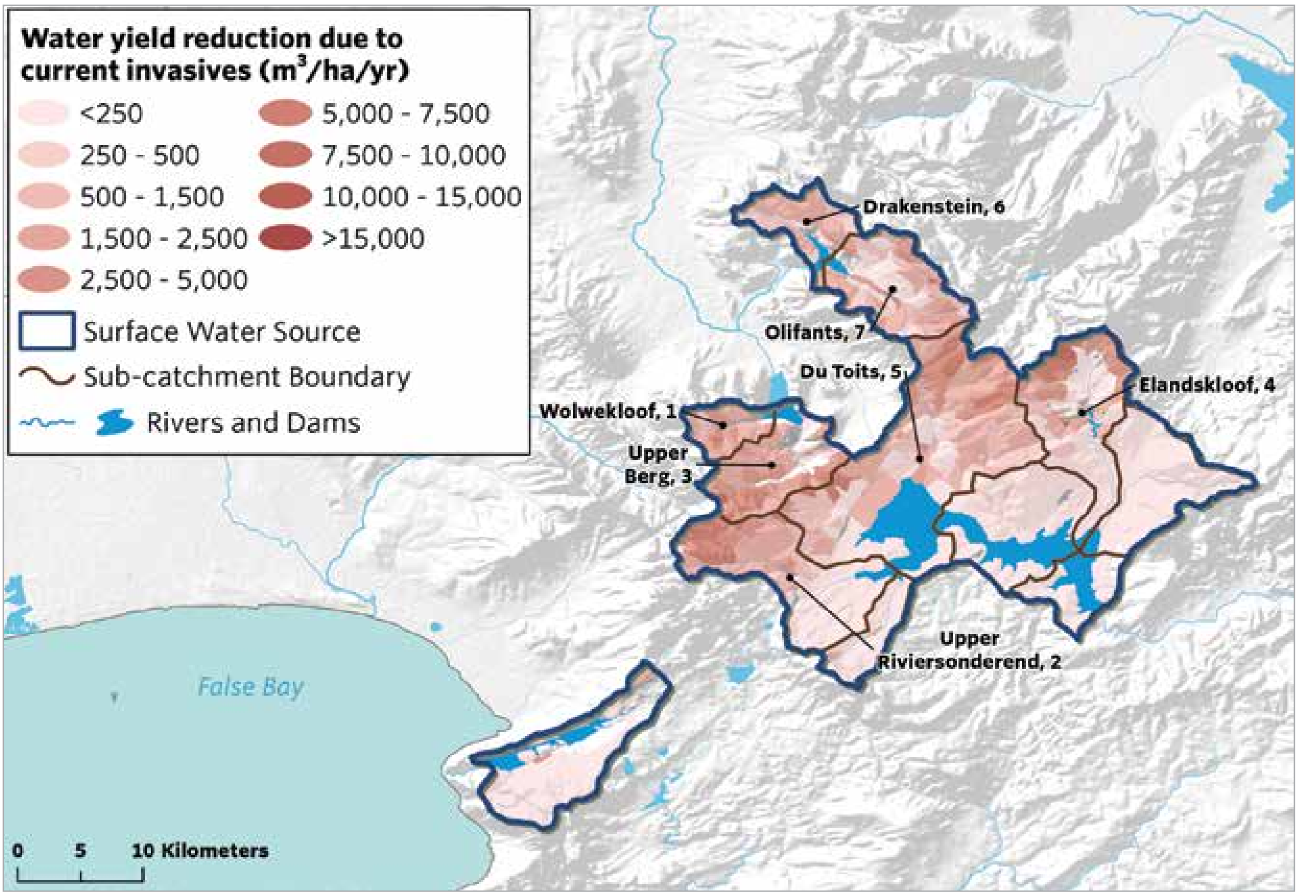

Figure 12. Current water yield reduction as a result of alien plant invasion in the sub-catchments.

yield and the incremental reductions in yield were then proportioned back to individual invasive plant patches based on four factors:

- Mean annual run-off (MAR)
- Landscape setting — e.g., altitude
- Invasive alien plant species presence
- Invasive alien plant density

The results were mapped as a reduction in 10% failure yield per hectare across the study area for both current invasion (Figure 12) and probable future invasion in 30 years' time. (Figure 13).

The expected increase in water supply impacts is particularly evident in the more natural catchments that have greater potential for alien plant invasion. Total current water yield reduction due to alien plant invasion is estimated at 55 billion liters (55 Mm^3) per year. Overall, if no action is taken, the loss of water within the study area due to invasive alien plants would roughly double within 30 years.

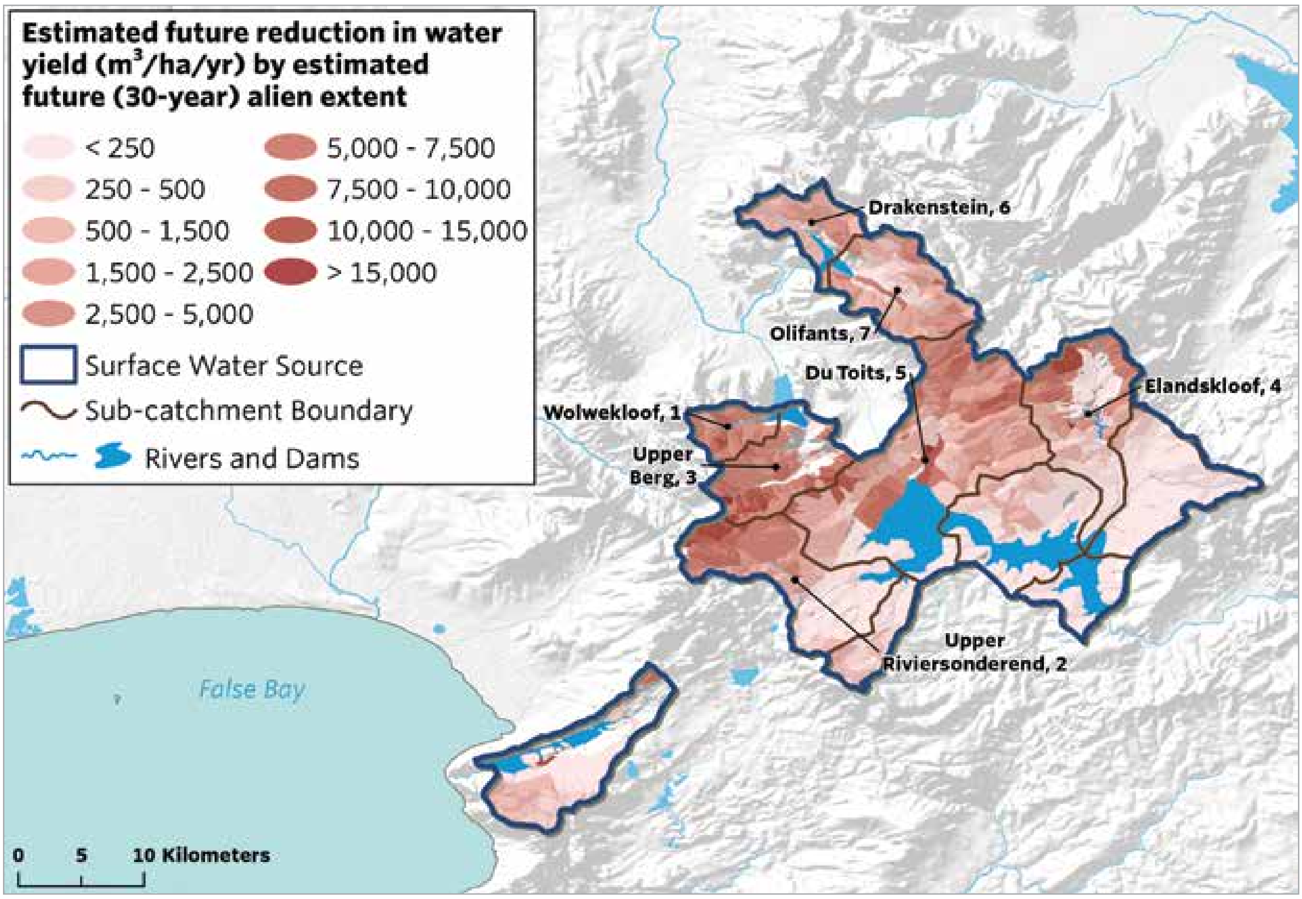

Figure 13. Estimated water yield reduction could double within 30 years without the modeled invasives control programme.

STEP 3

Estimating the costs per hectare of invasive alien plant control based on local conditions

The initial clearing cost in priority areas can be as high as R40,000 ($2,700 USD) for a densely invaded hectare

The cost to clear invasive plants and to maintain a sub-catchment over a 30-year period was calculated by extracting the relationship between invasive alien plant species, density and initial/follow-up clearing and person-days required from Working for Water's water data.[27] An existing model[28] was modified that incorporated ecosystem dynamics of regrowth and response to fire. The model takes into account the fact that invasive alien plant clearing is not a once-off intervention and can be influenced by stochastic events like fire, which are hard to predict but can increase invasive plants spread and densification. This model uses the density of invasive plant patches in successive years following clearing and adding in the stochastic events of fire and the consequence this would have on re-invasion and future clearing.

Current cost per person-day was used as the baseline and expressed as rand per person-day (R/PD).

The cost per hectare is multiplied with the hectares to give a total clearing cost per intervention over a period of 30 years (present value). Initial control operations are the most costly, up to R40,000/ha in very dense invasions in rugged terrain and riparian areas. Thereafter the cost gradually declines over time as invasive plant density and size decline following each intervention. Factoring in costs for long-term maintenance and management is essential to ensure areas or catchments are kept free of invasions and water gains are maintained in perpetuity.

Figure 14. Invasive plants are already established over expansive areas in the WCWSS.

FACTORS INFLUENCING THE PERSON-DAY COST

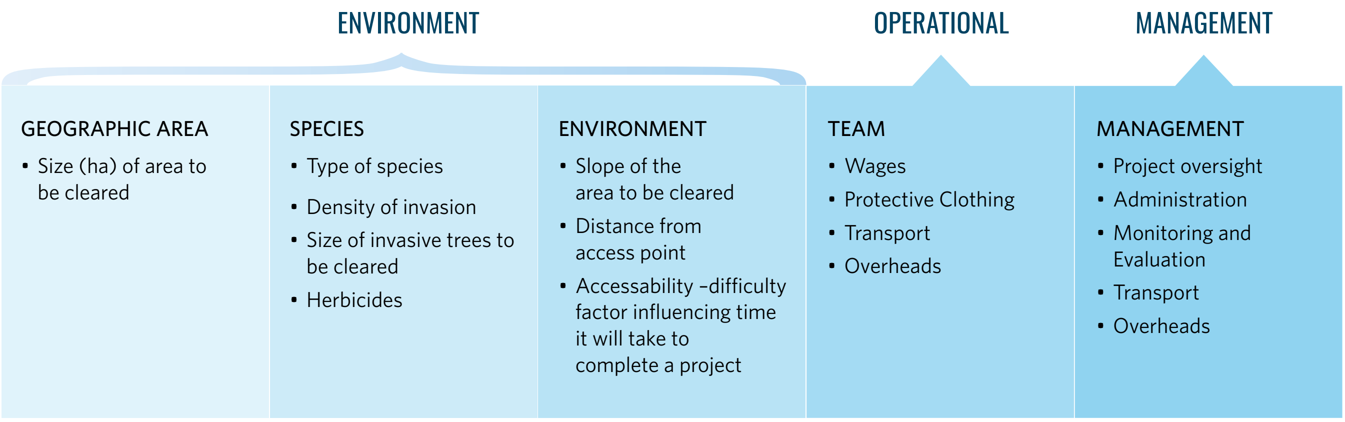

Figure 15. Clearing cost is made up of different components.

Factors influencing person-day cost:

- **Geographic area** — extent or size (hectares) of the area to be cleared.
- **Species information** information such as the **type** of species, whether it is re-sprouting (e.g. Australian acacia or eucalyptus) or non-sprouting (e.g. pine or hakea), the **density** (expressed as % of the sub-catchment covered in invasive trees) and the **size** (young, mature, seedlings).
- **Environmental conditions** — also referred to as difficulty factor. Includes steep **slopes**, rocky **terrain** with **indigenous vegetation** exceeding a meter in height, the **drive time and walk time** per day from the nearest access point.
    - Areas with 30% of their area over 40° slope are classified as High-Altitude Area requiring specialized High-Altitude Area Teams (HAAT) using rope access to reach the target plants. Intermediate areas are steep, but rope work is not required. General work is flat and gentle slopes.
    - Working in remote areas require teams to be transported to the work areas by helicopter and camping (lodging cost) and thus increases costs.
- **Management** refers to the management cost for project management, office and transport cost, monitoring and evaluation.

The workload is expressed as person-days/hectare (PD/ha) and refers to the number of people required for one full workday to clear one hectare, described as person-day cost or also known as person-day rate. Person-day cost (R/PD) is the key “currency” used in South Africa for determining the cost of clearing invasive plants

Rank sub-catchments by highest ROI, i.e., greatest water yield per unit cost

Seven sub-catchments were identified for control in the water source areas of the WCWSS with an average URV of R1.2 per m^3

Given the importance of augmenting water supply for the Greater Cape Town Region in a cost-effective manner, return on investment (ROI) was considered the most important criterion for prioritising sub-catchments for interventions. Sub-catchments were ranked in terms of their return on investment (ROI), that is, the number of cubic meters of water generated per rand invested in invasive plant removal over a 30-year period. The ROI estimates shown in Figure 17 are conservative, because they assume that current water loss due to invasive alien plants remains constant. The final ROI estimates used in this business case are up to 50% higher because they account for the fact that overall water loss from invasive alien plant invasions is expected to double within 30 years without interventions.

Based on estimated near-term water supply changes (by year six of the programme, when initial clearing of priority sub-catchments is completed) and estimated invasive alien plant control cost as calculated by the clearing cost model, the potential return on investment (ROI), expressed in physical terms as cubic meter per rand (m^3/R), was estimated and mapped for each patch of invasive alien plants in the sub-catchments. Return on Investment (ROI) is calculated as the present value (PV) 30-year system yield (calculated at a 10% failure yield — 90% assurance) divided by 30-year PV costs. Conversely, the Unit Reference Value (URV) is calculated by dividing the PV 30-year stream of invasive alien plant control costs by the PV total gains in water yield over the 30-year analysis period (Box 2). A 6% discount rate was used to calculate PVs of future streams of water gains and costs.

Figure 16. Environmental conditions such as rugged terrain and steep cliffs impact alien invasive plant control costs.

Seven of the twenty-five sub-catchments were identified as priorities for invasive alien plant removal (Figure 17). They comprise a total of 54,300 hectares and are the sub-catchments for Wemmershoek, Theewaterskloof, and Berg River dams — which supply 73% of the surface water contribution to the WCWSS. Catchment restoration here will deliver the highest ROI and lowest unit reference value. The priority sub-catchments have a low combined average URV of R1.2 per m^3 including water treatment cost.

$$\text{URV (R per m}^3\text{)} = \frac{\text{PV of lifecycle costs (Rands)}}{\text{PV of quantity of water supplied (m}^3\text{)}}$$

Box 2. URV formula

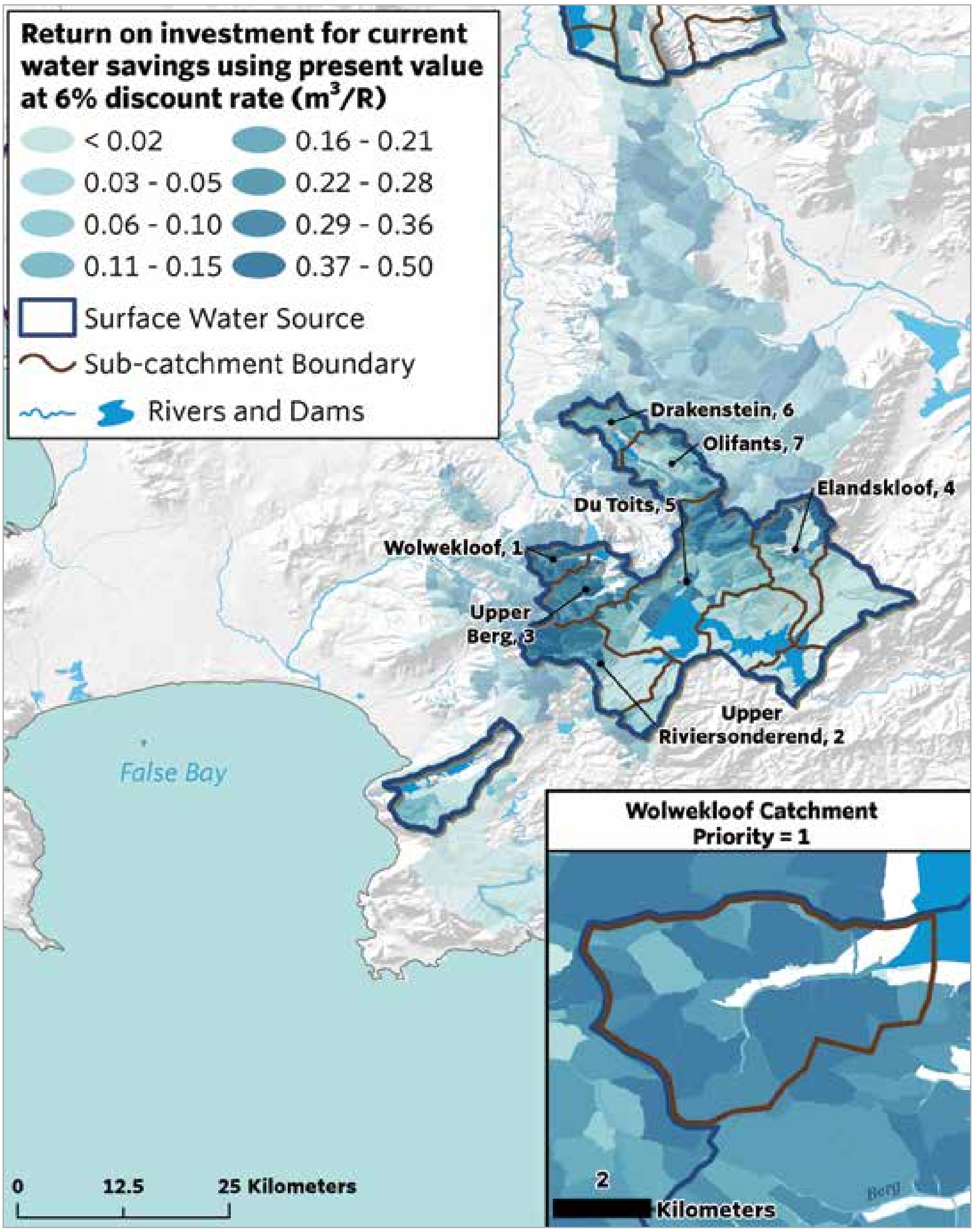

Figure 17. Priority sub-catchments identified for delivering the highest ROI.

STEP 5

Build discounted restoration timeline for priority sub-catchments, including full maintenance costs

Results show that investing R372 million ($25.5 million USD; present value) will generate expected annual water gains of 100 billion liters (100 Mm³) within thirty years compared to the business as usual scenario. It is infeasible to clear all seven priority sub-catchments in one year due to the magnitude of the problem, the cost involved and limited availability of high-altitude teams. This study recommends spreading the initial clearing over a period of five years, starting with the highest-priority Wolwekloof catchment in year one, moving on to priority two and so on, conducting follow up in each catchment every second year. Invasive alien plant removal would yield up to an additional 55.6 billion liters (55.6 Mm³) per year after initial treatment is completed in year six (Figure 18). Expected gains increase to 100 Mm³/year in year 30 of the programme, due to the avoided further spread of invasive alien plants and associated water losses.

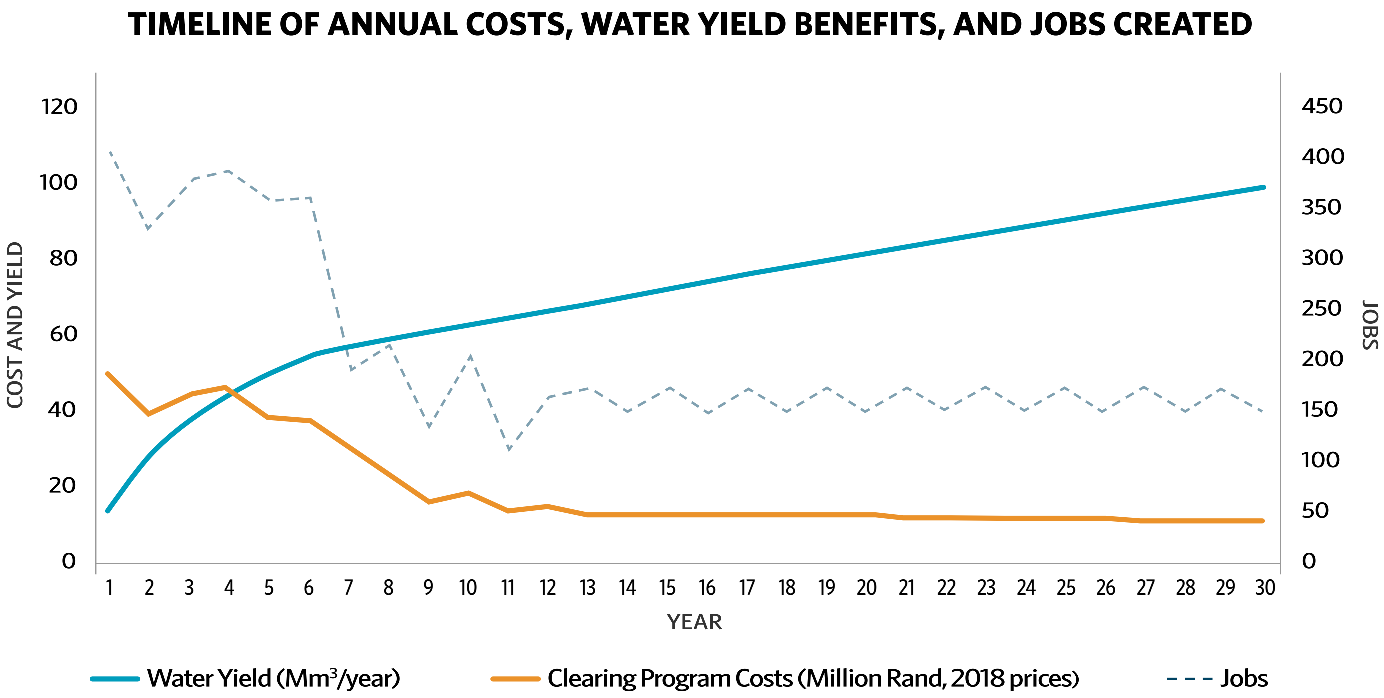

Figure 18. Discounted restoration timeline for priority sub-catchments.

There is also an opportunity to demonstrate the effectiveness of integrating prescribed fires as a control method.

An investment of R372 million (PV; $25.5 million USD) is required to clear and maintain the seven top priority catchments over 30 years. The cost of initial clearing is estimated at R225 million (PV; $15.4 million USD). A further R147 million (PV; USD $10.1 million) is then required over the remaining period to ensure lands are kept free of new invasions. Factoring in costs for long-term maintenance and management is essential to ensure water gains are maintained in perpetuity.

The top seven priority sub-catchments require specialised High Altitude Area Teams (HAAT), skilled in rope work and operating in rugged terrain, far from the closest access points. So, it will be necessary to transport teams by helicopter and set up camp at a suitable area in the sub-catchments to reduce the walking time and improve accessibility. The availability of teams with specialised skills is a limiting factor. According to WFW, 457 HAAT workers were available across the country with approximately 150 available for the Western Cape.[29] The water gains were calculated assuming the clearing will be conducted faster than the rate of spread. The optimal clearing scenario can only be achieved if there is appropriate number of trained HAAT workers available to conduct the clearing. Additional teams will therefore have to be trained to reach the required total number of 350 clearing personnel (HAAT and non-HAAT), creating new specialised jobs in the process.

Table 2. Seven priority sub catchments hectares, clearing cost and URV.

Sub-catchment	Total area with IAPs present (ha)	Condensed area of IAPs (ha)	IAP removal cost (RM, PV)	Water gain year 6 (Mm^3)	Water gain year 30 (Mm^3)	URV R/m^3 *	Priority order (ROI or URV)
Wolwekloof	1903	443	25	3.7	8.0	1.2	1
Upper-Riviersonderend	7500	1527	87	12.7	19.4	1.2	2
Upper Berg	4782	957	48	8	14.7	1.2	3
Elandskloof	6840	1023	38	6.7	11.3	1.2	4
Du Toits	14447	4816	111	16.9	32.7	1.2	5
Drakenstein	13514	840	29	3.4	6.9	1.4	6
Olifants	5359	882	32	4.1	7.8	1.4	7
Total	54345	10488	372	55.6	100.4	1.2*	

* Includes water treatment cost of R0.8/m^3.

Comparing cost per cubic meter (URV) and potential yield gains of restoration programme to alternative water supply options

Catchment restoration is significantly more cost-effective than other augmentation solutions, supplying water at one-tenth the average unit cost of alternative options.

The main water supply options under consideration in the WCWSS to respond to the growing demands and scarcity include desalination, water reuse, groundwater exploration and augmenting the Voëlvlei dam. The cost of future water within the WCWSS can be grouped in surface water and groundwater schemes with URVs ranging from approximately R2/m³ to R15/m³ based on current analyses.

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Table 3. Comparisons between different water supply options

Option	Additional water (Mm³/yr)	URV (R/m³)
Removal of IAPs from top 7 priority catchments	55.6	1.2
Voelvlei Augmentation Scheme	21.9	1.9
Cease forestry Steenbras	1.2	3
Groundwater exploration	36.5	6.7
Water reuse	32.9	11.1
Desalination	55	14.9

Notes: Water supply from IAP removal represents volume after initial treatment of all seven priority catchments; this supply will increase over time due to avoided further spread of IAPs and associated water losses. URVs include raw water treatment costs of R0.8 per m³ where applicable.

The analysis demonstrates that, including the raw water treatment cost of R0.8 per cubic meter, catchment restoration would supply water at two-thirds to less than one-tenth the cost per cubic meter as the other supply alternatives considered in Cape Town, with a URV only one-eighth that of the combined alternatives (Figure 19). Importantly, invasive alien plant removal from the seven priority sub-catchments delivers a larger water yield than any of the alternative supply options except for expensive desalination, which produces a similar yield but at twelve times the cost. The results of catchment restoration programmes will also be evident more rapidly than some of the engineering-intensive, grey infrastructure options, with improved supply showing as soon as the first winter rains. Furthermore, unlike some of the alternatives whose infrastructure requires periodic replacement at the end of its lifetime, catchment restoration produces water yield gains in perpetuity if areas cleared of invasive alien plants are maintained.

In addition to demonstrating a high return on investment, there are a number of non-monetary benefits that should be taken into consideration when evaluating the effectiveness of catchment restoration. The added values associated with greener technologies and more environmentally-friendly water supply options can be significant. Removing invasive alien plants will help restore native biodiversity and provide additional ecosystem services such as improved soil quality and reduced severity of wildfires. Fires in alien plant invaded areas are more difficult to control and increase fire intensity up to 10% of that in a fynbos area. Investing in comparatively low-cost catchment restoration efforts now may delay the need for other more costly options, whose cost may decrease in the future as technologies develop.

CATCHMENT RESTORATION INCREASES WATER SUPPLY AT THE LOWEST UNIT COST

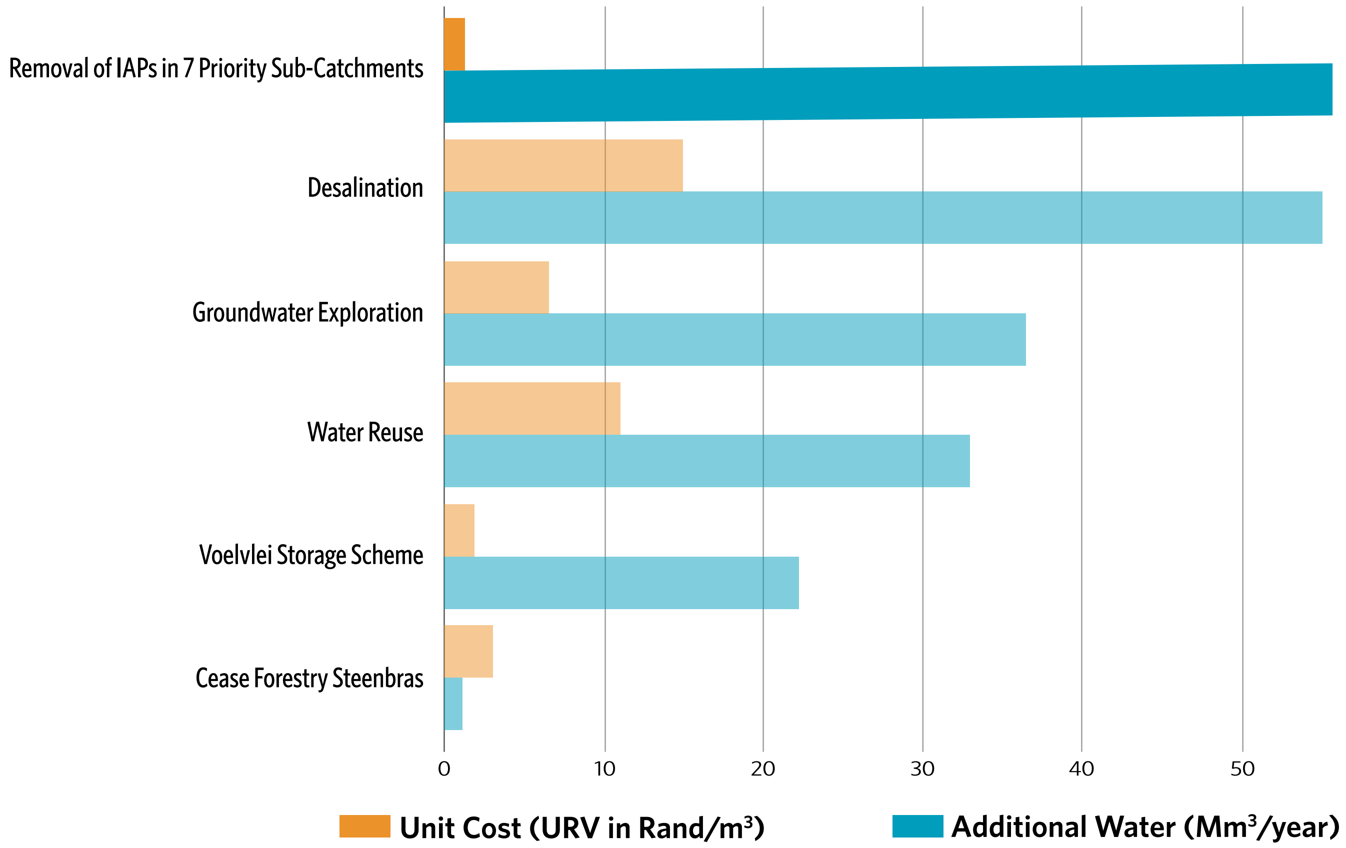

Figure 19. Water supply gain and unit cost (URV) comparison between different catchment restoration and other supply options (costs include raw water treatment cost where applicable).

SUMMARY

These results demonstrate that restoring the ecological infrastructure of priority sub-catchments though invasive alien plant removal is a cost-effective and sustainable means of augmenting water for the Greater Cape Town Region. An investment of R372 million (PV, $25.5 million USD) in catchment restoration over thirty years will generate annual water gains of 55 billion liters (55 Mm^3) a year within five years compared to business as usual — equivalent to one-sixth of the city's current supply needs — increasing to 100 billion liters (100 Mm^3) annually within 30 years. Catchment restoration is significantly more cost-effective than other water augmentation solutions, supplying water at one-tenth the unit cost of these alternative options.

ADDITIONAL ECOLOGICAL INFRASTRUCTURE INTERVENTIONS TO SECURE WATER

While the focus of this Business Case is on invasive plant removal to restore seven priority sub-catchments supplying the WCWSS, the scope of the Water Fund will be broader in supporting additional ecological infrastructure interventions to secure water supply. Efforts under consideration include the restoration of four priority wetlands, controlling invasive alien plants in former forestry areas, and restoration of natural vegetation on the Atlantis Aquifer.

Controlling alien plant invasions in the catchments were prioritised because of the body of evidence existing about their impacts on water security and the short-term gains to be derived from restoring the top seven priority sub-catchments.

WETLAND RESTORATION

Wetlands help to naturally store and filter scarce water resources in the WCWSS. Wetlands are important for catchment hydrology, increasing groundwater infiltration and attenuating surface flows and sediment loads, and reducing downstream damages during storm events. By retaining nutrients and removing pathogens, wetlands also prevent the development of algal growth that deteriorate downstream water quality and thereby reduce additional water treatment cost.

Today, invasive alien plants, agricultural discharge, and draining are some of the threats to the wetlands in the WCWSS. It is therefore necessary to include

Figure 20. Wetlands play an important role in catchment hydrology.

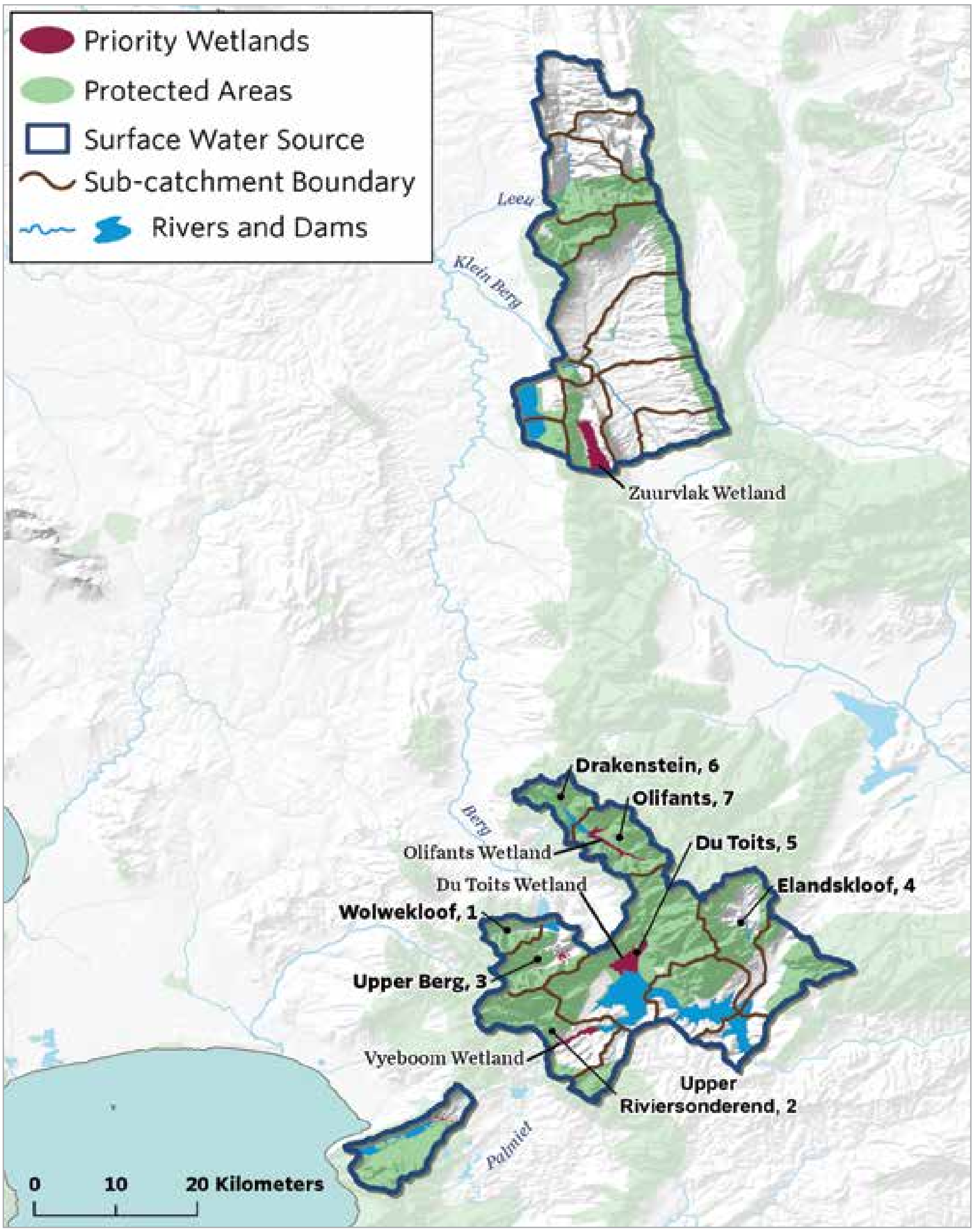

Figure 21. Priority wetlands in the WCWSS.

wetland restoration and protection in the suite of ecological infrastructure interventions of a Greater Cape Town Water Fund.

Four wetlands in the WCWSS — Vyeboom, Du Toits, Olifants and Zuurvlak — were identified as of strategic importance by applying a set of criteria considering their position in the catchments and their hydrological and geomorphological characteristics (Figure 21).

A preliminary analysis of the water storage and nutrient removal services provided by these four wetlands that used avoided replacement costs for water storage and treatment costs (using a 30-year time horizon and 6% discount rate) estimated that wetland rehabilitation would generate values of **R280,000-R560,000** per year (water storage provided by all four wetlands) and **R472,000-R937,000** per year (nutrient removal by the Zuurvlak wetland), respectively, for a combined net economic benefit estimated at **R0.81-R1.35 million/year** (Appendix G).

In terms of organic content, run-off potential of soils, and catchment rainfall intensity, the Vyeboom wetland upstream of the Theewaterskloof dam emerged as the most critical wetland for the supply of important wetland functions relating to water security. The Vyeboom area where the wetland is located is an area of intense agriculture, vulnerable to point and non-point sources of nutrients and other pollutants. This wetland's functioning is limited as a result of degradation of the buffer zone, leading to sedimentation and impacting its ability to filter out nutrients and pollutants before the water enters the dam.

The GCTWF implementation strategy will take wetland restoration into account and further studies to refine wetlands role and the economic and ecological importance of wetland restoration will continue.

MANAGING DECOMMISSIONED FORESTRY AREAS

The GCTWF can play an important role in supporting the decommissioning of forestry in target areas of the WCWSS sub-catchments.

Non-native timber tree species were introduced into South Africa to help supply timber products and lessen the pressure on indigenous forests. Forestry has since grown to become an important economic activity within South Africa. Across the country, pines and Eucalypts (*Pinus* and *Eucalyptus* species) make up over 90% of the species grown in plantations. Approximately 1.2 million hectares (~1% of total area) of South Africa was under forestry plantation in 2016, most of which falls in the eastern parts of the country.[30]

Pinus species are highly invasive and have led to problems in several countries worldwide. It has been estimated that approximately 51% of the invasions within the Cape Floristic Region's protected areas have been a direct result of active commercial plantations as opposed to abandoned plantations or escapees from ornamental or other stands.[31]

The impact of these non-native species on hydrology when planted for forestry is the same as for when they invade other parts of the fynbos biome. Forestry plantations intercept rainfall, decrease infiltration, and increase the transpiration of water from soil, riparian areas, and shallow groundwater areas. Research has since shown that plantations reduce the total annual run-off from catchments in proportion to the level of afforestation[32] and that the effect of commercial plantations on flows is much higher in the dry season than the rainy season. Commercial plantations in South Africa are potentially reducing high flows by up to 3.2% (11,147 Mm^3/year) and low flows by 7.8% (1,101 Mm^3/year) (average annual reduction of 9.8 mm/year in planted areas). Estimates from the Western Cape are lower than these national averages, amounting to 1.96% of total flow and 6.02% of low flows.[33]

In 2000 the national government decided to phase out forestry in marginal areas. This decision was known as the Western Cape Exit Policy.[34] It was planned to decommission plantations in 45,000 ha of the 70,000 ha across the Western Cape.

The decision to phase out marginal forestry areas was revisited based on increasing profitability of the sector through market improvements and timber shortages (partially due to large-scale fires in some plantations across South Africa). A report re-examining the viability of these Western Cape plantations[35] suggested that 22,500 ha of the 45,000 ha to be exited in the Western Cape be replanted. This was approved by Cabinet in 2008. However, the new policy has yet to be fully implemented. There has been limited replanting in these areas, although some natural re-generation has taken place, and there is little clarity on their future management. Many of these abandoned forestry areas have been reinvaded because follow up and maintenance did not take place, posing a fire threat and impacting negatively on water resources.

The City of Cape Town owns and manages plantations of about 595 ha in the Steenbras Dam catchment and around 100 ha in the Wemmershoek Dam catchment. Decommissioning has commenced on both these plantations.

OPPORTUNITY COST OF DECOMMISSIONING THE PLANTATIONS

Case Study – Steenbras a City of Cape Town Owned plantation

Clearing the 595 ha Steenbras plantation and maintaining it free of invasive plants will yield 1.2 billion liters (1.2 Mm^3) into the Greater Cape Town's water supply each year at a cost of R0.94 - R2.22 per m^3

Figure 22. The Steenbras plantation causes water yield reduction of 1.2 Mm^3.

The 595 ha Steenbras plantation is mostly under mature *Pines*. As part of the GCTWF Business Case analysis, the impact of this plantation on stream flows and water yield was modeled using the Pitman hydrological model. This suggested that 1.2 Mm^3/year of yield (at 90% assurance level) was being lost to forestry each year.

In order to determine whether the cessation of forestry in the Steenbras catchment would be a justifiable in terms of water delivery, the water returns were compared with the forestry benefits that would be foregone, also taking maintenance into account. The estimated URV of R2.22/m^3 falls between the costs of removal of Voëlvlei Augmentation and groundwater exploration and is therefore more cost effective than some alternative water supply options under consideration. If the externalities caused by forestry activities in the rest of the catchment are also taken into account and the external costs avoided through cessation of operations are subtracted from implementing cessation, the URV drops to R0.94/m^3, making this intervention even more cost-effective. While the potential water yield gains are limited in terms of absolute amounts, cessation of forestry in Steenbras should still be prioritised as a cost-effective solution to augmenting water supply to the Greater Cape Town Region, and also in minimising risk of invasive alien pine spread (and associated water losses) in the rest of the catchment. Jobs lost due to cession of forestry can be offset in the near to medium term by the jobs created through catchment restoration efforts, including ensuring new plant invasions do not occur after harvesting is completed.

NEXT STEPS FOR THE GREATER CAPE TOWN WATER FUND

The Greater Cape Town Water Fund Steering Committee will use the results of this study to co-develop with stakeholders an ecological infrastructure restoration strategic plan for the WCWSS focused around the seven priority sub-catchments. This strategic plan will be designed to set near term and long term objectives, create clarity, focus, and a shared roadmap for action at scale. The Water Fund will use the strategic plan to guide implementation and associated monitoring and evaluation, in partnership with the landowners and land managers of the priority sub-catchments. Putting the strategic plan in place will include building the institutional capacity of the Greater Cape Town Water Fund to lead or support restoration efforts and creating mechanisms such as an endowment fund to help ensure sustained funding.

The Water Fund will support the development of differentiated employment models for the various components of ecological infrastructure restoration to maximise efficiency and effectiveness, especially the clearing of rugged terrain. In addition, the integration of fire as a control method will be implemented at scale and the results monitored. Operational flexibility will ensure timely follow up and maintenance of burned areas to avoid densification following unplanned fire events. Robust monitoring and evaluation, in collaboration with academic and other scientific partners, will be critical to demonstrate impact against agreed upon restoration and water yield targets, as well as clarifying ecological and socio-economic uncertainties that have been highlighted through the development of this Business Case. In the coming years, based on the experience of Water Funds around the world including in Nairobi, Kenya, it is expected that the Greater Cape Town Water Fund will evolve into a stand-alone organisation. This will likely take the form of a Non Profit Company under South African law with a strong public-private governance board which will support implementation of the strategic plan, and successor plans, using a sustainable financing mechanism.

Although the near-term priorities of the Greater Cape Town Water Fund will be focused on strategic removal of invasive alien plants, and the maintenance of restored native vegetation, there is a wider range of ecological interventions that the Water Fund plans to deploy over time in WCWSS source water areas. These proposed interventions include riparian restoration, the restoration and protection of wetlands, and agricultural land use improvements. Implementation of a broader set of ecological infrastructure interventions will continue the collaborative, science-based approach demonstrated by this Business Case.

CONCLUSION

The results of this business case demonstrate that restoring the ecological infrastructure of priority sub-catchments though invasive alien plant removal is a cost-effective and sustainable means of augmenting water supply for the Greater Cape Town Region. An investment of R372 million (PV, $25.5 million USD) over thirty years on catchment restoration will generate estimated annual water gains of 55 billion liters (55 Mm^3) a year within five years compared to business as usual — equivalent to one-sixth of the city's current supply needs — increasing to 100 billion liters (100 Mm^3) a year within 30 years. Catchment restoration is significantly more cost-effective than other water augmentation solutions, supplying water at one-tenth the unit cost of other alternatives.

The results of catchment restoration programmes will be evident more rapidly than some of the engineering-intensive, built infrastructure options, with improved supply showing as soon as the first post-restoration winter rains. Furthermore, catchment restoration produces water yield gains in perpetuity if areas cleared of invasive alien plants are maintained. This Business Case analysis fully accounts for long-term maintenance and management, which are essential investments to ensure water gains are secured for generations to come.

The Water Fund will also invest in catchment restoration efforts beyond the seven priority sub-catchments, which will bring additional water yields at a low URV. Clearing the Steenbras plantation and maintaining the land free of invasive trees would yield an additional 1.2 billion liters of water a year. The combined net economic benefit of restoring four priority wetlands is estimated at R0.81-R1.35 million/year. In addition to security in water supply, catchment restoration brings wider benefits in terms of job creation, community empowerment, reduced fire risk, the restoration of native fynbos biodiversity and climate change resilience.

Water Funds are a tried and tested mechanism in bringing together a coalition of private and public stakeholders alongside local communities to achieve sustainable catchment management. The Greater Cape Town Water Fund will be the catalyst for the funding and implementation of catchment restoration that will help secure the future of Greater Cape Town's water supply.





APPENDICES

A. RETURN ON INVESTMENT METHODOLOGY

Three economic arguments are commonly advanced to support investments in ecological infrastructure: (1) cost-effectiveness, (2) co-benefits, and (3) the precautionary principle.[36]

With the exception of the precautionary principle, assessing the economic rationale for investing in ecological infrastructure requires sufficiently reliable quantitative information about both the benefits or "returns" a particular ecological infrastructure solution delivers in a given place for a given level of investment, as well as its total implementation costs.

- Investing in ecological infrastructure is a cost-effective alternative to "grey" or built-infrastructure if it is at least cost-competitive with conventional engineering-based solutions in producing a specific target service or bundle of services.
- Ecological infrastructure is the preferred alternative on economic grounds if it generates larger total net benefits (i.e., benefits minus costs) than grey alternatives once the co-benefits that ecological infrastructure produces are accounted for. These co-benefits, that is, the additional benefits beyond the target benefit the infrastructure is designed to provide, result from the additional ecosystem services any ecological infrastructure provides beyond the specific target service(s), and that competing grey infrastructure generally does not provide.

  The precautionary principle can support conservation of ecological infrastructure because of the latter's option value: more intact catchments can increase resilience to climate change and sustain higher hydrological service flows, which is important in the face of uncertainty about the size and value of reductions in future service flows due to ecosystem degradation coupled with the potential irreversibility of that degradation. The precautionary principle can also justify conservation or restoration of natural systems based on the recognition that such systems have worked well so far.

B. WATER MANAGEMENT LEGISLATIVE AND REGULATORY ENVIRONMENT

The Department for Water and Sanitation (DWS) is the mandated authority responsible for water resource management in South Africa, which includes raw water supply and allocation, allocations to instream flows for basic human needs, and the environment. The City of Cape Town as the water utility manages the water treatment and reticulation of the raw water and is responsible for ensuring long-term supply through water conservation and water demand management for the Cape Town metropolitan area.

There is no shortage of legislation relating to water resource management in South Africa, however, the legislative and regulatory environment falls short at the implementation stage and faces several challenges such as:

- nstitutional arrangements are currently fragmented at national and provincial levels and among many water boards, catchment management agencies, and municipalities
- Lack of capacity and resources
- Lack of a single cohesive legislative framework which addresses the entire value chain in the water sector as a result of the current legislative split between water resources and water services, and which severs the link between end-user charges and investments in water sources
- Mandates seem to be unclear for the multiple functions of managing catchments and, specifically, a municipal water service authority's role upstream of water works (i.e. the supply system's ecological infrastructure) is especially unclear or unnecessarily constrained
- Administering and financing water resource management

Sustainable water resources management requires the active participation of government at different levels. The GCTWF aims to work with relevant authorities and support the South African National Biodiversity Institute (SANBI) Global Environmental Facility (GEF) 6 project to create an enabling legal and policy environment for sustainable water resources management.

C. TECHNICAL STUDIES

The Greater Cape Town Water Fund Steering Committee commissioned studies to evaluate the impact of ecological infrastructure on water supply, beginning with targeted removals of alien plant invasions, and determine whether investing at scale in ecological infrastructure restoration is in fact cost competitive with other supply-side solutions. Four technical studies informed this business case:

- *Priority interventions for restoration of the Greater Cape Town's water supply catchment areas*, prepared by Anchor Environmental Consultants (reviewed by Professor Brian van Wilgen)[37];
- *Prioritization of wetlands for water security in priority dam catchments in the Western Cape Water Supply System*, prepared by Freshwater Research Center (reviewed by TNC); and
- *Preliminary economic analysis of wetland restoration* by Anchor Environmental Consultants.
- *An analysis of legislation and policies supporting water resource protection in South Africa, with specific focus on municipalities*, prepared by Mark Botha (reviewed by TNC).

A research project by the Council for Scientific and Industrial Research (CSIR) to determine the impact of Acacia species (*Acacia saligna* and *A. cyclops*) on groundwater Case Study Atlantis Aquifer results is underway. Results will be available in May 2019.

D: MODELS USED FOR ANALYSING WATER LOSSES DUE TO INVASIVE PLANTS

Description of WR2005 software

The WR2005 Model consists of a suite of programmes that operate on a monthly time step and is centered on the Pitman rainfall-runoff model which estimates runoff from hydrological processes such as rainfall. The monthly rainfall over the catchment is determined in a separate process whereby the monthly point rainfall at rainfall stations located in or near the catchment are averaged to determine catchment rainfall. This monthly catchment rainfall is expressed as a percentage of MAP. The Pitman Model then uses additional data to simulate streamflow. This includes catchment MAP (which converts rainfall from % to mm), catchment area which is required to convert the rainfall (in mm/month) to a flow (in cubic meters/month) as well as mean monthly S-pan evaporation to determine the evaporation from the soil. Additional inputs to the Pitman model consist of parameters that define the ability of a catchment to produce runoff (such as soil depth, soil texture, infiltration rate, interflow, and groundwater contributions to streamflow). The Pitman Model then simulates which component of rainfall results in immediate streamflow as well as delayed contributions to streamflow from the soil and groundwater.

The calibrated Pitman Model and associated data sets are available for all quaternary catchments in South Africa and were developed as part of the national water resource assessments. The Pitman Model was included in the WR2005 Model which consists of a suite of models designed to determine water-use in the catchment. This includes software modules that determine flow reductions due to afforestation, irrigation and domestic demands, wetlands, groundwater, and the impacts of mining areas. In addition, the WR2005 Model includes a reservoir routine that simulates reservoir operation.

Once a catchment flow has been generated (or simulated) the model is then calibrated using a monthly observed record that is obtained from a flow gauge. This is achieved by changing the Pitman Model parameters until a satisfactory calibration is achieved. Several statistical measures (mean, standard deviation etc.) are used to determine the accuracy of the calibration. The calibrated model may then be used to generate longer simulated runoff sequences. This is possible because the model is driven by rainfall which is generally available from about 1920 to present day, whereas observed or gauged flows are generally much shorter and are therefore only used for calibration. Longer flow sequences are desirable in hydrological studies as they are more likely to contain extreme events such as floods and droughts. In addition, a calibrated model enables the generation of flows at any location within the catchment. Models are also useful as they provide a method to quantify the effect of changing land-use on flow and yield.

Description of ResSim model

The ResSim Model is a stand-alone reservoir simulation which is an in-house model created by Aurecon to determine the yield of a dam at a desired level of assurance. This model requires several inputs such as the monthly inflow to the dam as well as climatic data such as the monthly rainfall and evaporation and a surface area vs. capacity relationship so that the rainfall and evaporation directly affecting dam storage can be determined. A monthly demand distribution is also specified which reflects the nature of demand on the dam. A domestic demand may be similar in each month whereas an irrigation demand will require more supply in summer than winter.

The ResSim model is then run to determine a failure yield. A desired failure is specified and the model begins an iteration process and increases demand until the demand is unable to be fully met the desired number of times. So, for a 10% failure yield and using a 70 year inflow record, the model will determine the annual supply from the dam in the 8th driest period (the dam will not fully meet the required annual demand for 7 years in a 70 year period).

E: UNIT REFERENCE VALUE

The URV allocates a unit value to each water supply intervention as a cost per m^3 (or kiloliter) of water supplied over the total lifecycle of the project. Therefore the URV of a project is calculated by dividing the present value of the total cost of the infrastructure (construction, maintenance, operational) by the projected total volume of water supplied over the economic life of the project.[38]

$$URV\ (R\ per\ m^3) = \frac{PV\ of\ lifecycle\ costs\ (Rands)}{PV\ of\ quantity\ of\ water\ supplied\ (m^3)}$$

For calculating the URV, the capital, operating and maintenance costs are summed per annum (C_t) and the NPV determined over the analysis period (*t*) for a specified discount rate (*r*), usually 8%. It is standard practice to also do a sensitivity analysis, typically using alternative discount rates. Similarly the NPV of the water supplied (W_t) from the project is determined by projecting over the same time period (*t*) and discounting at the same rate (*r*) to derive a present value of water supplied in cubic metres (Blersch & du Plessis 2017):

$$\text{URV (R per m}^3\text{)} = \frac{\sum\left(\frac{C_t}{(1+r)^t}\right)}{\sum\left(\frac{W_t}{(1+r)^t}\right)}$$

Where:

C_t = the costs incurred in year *t*

W_t = the volume of water supplied in year *t*

r = chosen discount rate

t = analysis period

F: SCENARIOS

1. Business as usual

Current clearing is fragmented, inconsistent, under resourced and carried out at varying levels of efficiency (Appendix B Specialist review).

Outcome: Increase in alien plant invasions, wetland and riparian degradation, continued water and biodiversity losses.

2. Increase in funding and efficiency,

Consolidate, adopt the WCWSS Ecological Infrastructure Restoration Strategy (Appendix C), scale up and get the problem under control through impact investment to clear top 7 priority catchments and the Atlantis Aquifer recharge zones to reach maintenance within 7 years, secure long-term funding commitments to maintain the gain over the next 30 years.

Outcome: Additional 55 billion liters at R1.2 per m^3 into the WCWSS, ROI of average 820m^3 per R 1000, systematic clearing of other priorities as identified resulting in direct and indirect benefits to a range of stakeholders.

3. Do nothing

No action, leave invasive plants to spread, wetlands and riparian areas to degrade, rely exclusively on grey infrastructure interventions and TMG aquifer.

Outcome: Price of water increases, water losses escalates from the current 157.31 Mm^3 per year to 321.42 Mm^3 per year within 30 years with associated biodiversity losses, increase in biomass resulting in larger and hotter fires more costly to control and associated loss of livelihoods, infrastructure damage, erosion, sedimentation, negative economic impacts and catchment degradation.

G. WETLAND PRIORITISATION CRITERIA

Table 4. Wetland characteristics that were used to prioritise individual wetlands for water security indicating wetlands that met the criteria

Characteristic	Selection criteria	Upper RSE	Du Toits River	Wemmershoek (Olifantskloof)	Zuurvlak
Wetland size	Area > 50 ha (upper two categories of Macfarlane et al., 2014)	222	679	323	925
Hydrogeomorphic type	Seeps or valley-bottom wetlands	Yes	Yes	Yes	Yes
Fluvial connectivity	Connected to rivers	Sonderend	Du Toits	Olifantskloof	Waterval
Presence of important water resource downstream	Immediately upstream of dams	Theewaterskloof	Theewaterskloof	Wemmershoek	Voelvlei
Runoff potential of the soils – sand vs clay, and soil depth	Located on moderately deep to deep sandy loams and sandy soils	Yes	No	No	No
Soil type – especially presence of soils high in organic content, such as peat	Permanently saturated palmiet peat wetlands in the Cape Fold Mountains	Yes	Yes		Partially
Slope	Slope category of < 9%	Yes	Yes	Yes	Yes
Total rainfall (mm/y)	Total rainfall	2141 mm/y	1241 mm/y	1306 mm/y	754 mm
Rainfall intensity	High rainfall intensity areas (Maximum for South Africa – 140 mm)	112 mm	86mm	72mm	55 mm

H. DEA ENVIRONMENTAL PROGRAMMES AND LINKS

Working for Water

Working for Water https://www.environment.gov.za/projectsprogrammemes/wfw

Working for Wetlands

https://www.environment.gov.za/projectsprogrammemes/workingfowetlands

Working on Fire

https://workingonfire.org/

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