Strategic Water Source Areas Framework for Local Municipalities

Final Report
to the Water Research Commission

by

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EXECUTIVE SUMMARY

South Africa is a water scarce country, a situation which is made more challenging by the spatial variability of rainfall and its significant annual and seasonal fluctuations. The country depends on limited water resources for its growing population and economy. Surface water must be retained in rivers and dams to maintain the ecological health of the river system and to support downstream requirements. However, South Africa's water security is threatened by the negative impacts of land degradation, mining, over-abstraction of water resources, invasive alien plants, pollution (i.e. reduced water quality) and climate change among other factors. Water security has been placed in the spotlight by severe droughts, with a growing demand exceeding the limited supply in several areas. It is within this context that South Africa's Strategic Water Source Areas (SWSAs) need to be maintained and enhanced.

South Africa, Lesotho and Eswatini together have 22 SWSAs for surface water. South Africa has 37 SWSAs for groundwater. The surface water SWSAs represent just 10% of the land surface area of South Africa, Lesotho and Eswatini, but generate 50% of the region's surface runoff. Groundwater SWSAs cover 9% of the land surface in South Africa and generate up to 42% of the baseflow in their areas. SWSAs provide many benefits to society, including water for domestic use (e.g. drinking and cleaning), industry (e.g. cooling at power stations) and agriculture (e.g. irrigation). In 2017 it was reported that SWSAs support around half of South Africa's population and about 64% of its economy. The major urban centres generally obtain a high percentage of their water from surface water SWSAs; while about 70% (2018) of water used for irrigation is directly or indirectly obtained from such sources. However, the SWSAs are generally poorly protected with only 18% of surface water SWSAs under formal protection.

Local government plays a vital role in the management and protection of surface water, groundwater, drinking water and wetlands. The management of SWSAs that are not formally protected takes place in the context of funding, skills and capacity limitations. The *Implementation of South Africa's Strategic Water Source Areas: Towards effective governance and protection* project aims to develop a framework of participatory governance and protection of SWSAs with an emphasis on municipal planning and decision making. This document provides introductory guidance around the maintenance and enhancement of SWSAs, specifically related to municipal planning and decision-making.

This report emanates from a three-year Water Research Commission project (April 2022 – March 2025) led by the Council for Scientific and Industrial Research (CSIR) in collaboration with the City of Cape Town and Witzenberg Local Municipality. Other important stakeholders also include DFFE, DWS, the South African National Biodiversity Institute (SANBI), and the World Wide Fund for Nature – South Africa (WWF-SA).

The intended outcomes and impacts of the project are:

- Awareness of the role that SWSAs play in South Africa's water and food security by decision-makers in local government;
- Improved governance of SWSAs within the local sphere – including the integration of land use, environmental and natural resource management for the effective management of SWSAs; and
- Increased capacity within local government to understand and use the outputs (i.e. SWSA Introductory Guide) in planning and decision-making processes related to urban management and infrastructure planning, water resource development and protected area expansion and management, among others.

A key success factor in this project was the co-development approach used by the project team and municipal officials to ensure active participation rather that passive exchange of information. In this way the project generated co-created solutions through interaction and analysis by the project team, municipal officials and other stakeholders. The draft Framework was developed and refined with input from municipal officials and

other stakeholders, as described in Part 2: Foundational Context and Methodology to SWSA Framework and Introductory Guide. The case study municipalities were City of Cape Town Metropolitan Municipality, a large Category A metropolitan municipality and Witzenberg Local Municipality, a small to medium Category B local municipality.

The SWSA Introductory Guide in Part 3 provides the basis for local municipalities to develop strategies for the protection and management of SWSAs. It emphasises the key steps, actions and considerations that are particularly relevant to strategy development for SWSAs at the local scale and can be incorporated into key municipal processes such as the Integrated Development Plan (IDP). The Guide is not intended as a comprehensive catalogue of all actions required, but as guidance for municipal officials involved in essential functions such as strategic planning and urban design, environmental management, conservation, water and sanitation services, social development, finance or recreation and parks.

The Guide recommends that the formulation of a municipal strategy for the management and enhancement of SWSAs be undertaken in five phases, namely: Phase 1, a situation assessment of the specific context of the municipality; Phase 2, a visioning process in which the broad aim is envisaged; Phase 3, identification of strategies or pathways to the desired vision; Phase 4, actions that will advance the implementation of the chosen strategies and Phase 5, monitoring and evaluation plans. The Guide provides generic guidance that can be customised in each municipality to inform its own planning processes. The Guide in Part 2 also includes examples of useful resources which include reports, online resources, platforms and databases that municipalities can use in the formulation of their own SWSA strategies.

The Strategic Water Source Area Spatial Mapping and Management Guidance in Part 4 provides guidance for municipalities around the maintenance and enhancement of SWSAs. It specifically illustrates how spatial data, and mapping can be used to guide municipal planning and decision-making within SWSAs at the local scale. The recommendations provided are not intended as a comprehensive outline of all management actions required to secure SWSAs but can serve as examples to other municipalities to manage the SWSAs within their jurisdiction. It is envisioned that the guidance document will assist municipal officials involved in strategic planning and urban design, environmental management, conservation, water and sanitation services, social development, finance and recreation and parks. It is also intended to be useful for local stakeholders (e.g. business representatives, Non-Governmental Organisations), civil society and other spheres of government involved in the protection and management of SWSAs. The spatial mapping and management guidance should help the user to:

1. Improve the management and protection of SWSAs within the municipal area.
2. Understand the links between key impacts, management recommendations and the identified strategies and projects for SWSAs within local government.
3. Identify and use key national spatial datasets for the protection and management of SWSAs.

The City of Cape Town (CCT) Metropolitan Municipality was used as a case study for mapping and management guidance as it provides a data-rich, complex and resource supported environment for mapping and management approaches. The guidance provided can however be applied in a local municipality context. The main impacts affecting the health and condition of SWSAs were identified through a situation assessment using existing literature and available spatial data. Based on this information and the participatory co-development process, recommendations for management are provided along with information on the responsible departments and an assessment of priority level. The City of Cape Town has three SWSAs contained within its boundaries, namely the Table Mountain surface water SWSA, Cape Peninsula and Cape Flats groundwater SWSA and the West Coast aquifer. Partially contained within the boundaries of the city are the Boland Mountains surface water SWSA and the Southwestern Cape Ranges groundwater SWSA. Management recommendations are given for key rivers, wetland and aquifers within each SWSA (e.g. Khayelitsha Wetlands located within the Cape Flats groundwater SWSA). The spatial mapping procedure consisted of interpretation of several existing ArcGIS data layers for the City of Cape Town Metropolitan Municipality.

Place-based recommendations were developed based on critical impacts identified in the situation assessment, with a focus on the most pressing threats and opportunities highlighted in the spatial analysis. Where possible, recommendations were tailored to the specific characteristics of the catchment area considering the socio-economic and environmental conditions in which the SWSAs occur. Many SWSA issues, such as water quality management or habitat restoration require collaboration across multiple departments such as Environmental Management, Public Works and Water Services. Therefore, we included a column in the management recommendation table stating which department is responsible for executing each management action. The recommendations were given a priority of high, medium or low to ensure that recommended actions are aligned with ecological urgency, resource availability, and the municipality's capacity to act.

Strategic Water Source Areas often span more than one municipality. The fostering of partnership, and collaborative governance structures are therefore important considerations. To assist municipalities to protect SWSAs, a repository of relevant spatial data on biodiversity, ecosystem services and sustainable development was created which municipal officials can use to incorporate SWSA protection into key plans, create maps and visual data, use as a shared resource between department and to justify funding proposals.

In Part 5: Conclusions and Recommendations the project team reflects on lessons learnt during this project. The SWSA Framework has been designed to be generic and applicable to municipalities throughout South Africa. Therefore, it is recommended that the SWSA Framework produced by this WRC project is refined through its application in different contexts (e.g. other municipalities within other Provinces). The key lessons learnt by the project team in undertaking the case studies described in this report will inform future work on water governance in South Africa's local authorities. These include:

- Establishing formal agreements to streamline collaboration
- Identifying specific representatives in the municipality
- Including external stakeholders in the process
- Adapting to municipal officials' time constraints
- Ensure cross-departmental participation
- Using the visioning process as a focal point
- Establishing a shared understanding of SWSAs and their spatial characteristics.

We also reflect on key factors that need to be incorporated into future research projects, identifying future research priorities that will mainstream SWSAs into municipal processes. These include:

- Refining and expanding the SWSA Framework
- Building Capacity and Awareness among municipal officials
- Integrating SWSA maintenance and enhancement into Strategic development planning
- Securing sustainable funding and resource allocation
- Integrating Green infrastructure and Nature-based Solutions
- Strengthening monitoring and evaluation
- Improving stakeholder engagement.

This work is expected to directly inform future research and the implementation of policies and legislation, strengthening collaboration between water sector researchers and municipalities. By enhancing governance and strategic decision making, it will contribute to securing the long-term sustainability of SWSAs within local authorities.

ACKNOWLEDGEMENTS

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ABBREVIATIONS AND ACRONYMS

ADEs	Aquifer Dependent Ecosystems
AFIS	Advanced Fire Information System
AMD	Acid Mine Drainage
AWRMS	Atlantis Water Resource Management Scheme
BGIS	Biodiversity GIS
BLU	Biodiversity and Land Use
CBA	Critical Biodiversity Areas
CBO	Community-Based Organisation
CCT	City of Cape Town
CDF	Conservation Development Framework
COGTA	Cooperative Governance and Traditional Affairs
CSIR	Council for Scientific and Industrial Research
DEA	Department of Environmental Affairs
DEADP	Department of Environmental Affairs and Development Planning
DFFE	Department of Forestry, Fisheries and the Environment
DWS	Department of Water and Sanitation
EIA	Environmental Impact Assessment
EMF	Environmental Management Framework
EPWP	Expanded Public Works Programme
ESA	Ecological Support Areas
FBIS	Freshwater Biodiversity Information System
GBF	Global Biodiversity Framework
GINet	Green Infrastructure Network
GIS	Geographic Information System
GVA	Gross Value Added
IDP	Integrated Development Plan
IEM	Integrated Environmental Management
LED	Local Economic Development
LUW	Liveable Urban Waterways
MFMA	Municipal Finance Management Act
MIG	Municipal Infrastructure Grant
MOA	Memorandum of Agreement
MSDF	Metropolitan Spatial Development Framework
NEMA	National Environmental Management Act
NGO	Non-Governmental Organization
NRF	National Research Foundation
NRM	Natural Resource Management
ODP	Open Data Platform
O&M	Operations and Maintenance

OECM	Other Effective Conservation Measures
SAEON	South African Environmental Observation Network
SANBI	South African National Biodiversity Institute
SCM	Supply Chain Management
SoER	State of the Environment Report
SWSAs	Strategic Water Source Areas
SWSA-sw	Strategic Water Source Area-surface water
SWSA-gw	Strategic Water Source Area-groundwater
WCDM	Water Conservation and Demand Management
WCWSS	Western Cape Water Supply System
WESSA	Wildlife and Environmental Society of South Africa
WLM	Witzenberg Local Municipality
WMA	Water Management Area
WRC	Water Research Commission
WSA	Water Service Authority
WSP	Water Service Provider
WWF	World Wide Fund for Nature
WWF-SA	World Wide Fund for Nature – South Africa

GLOSSARY

Aquifer	A geological formation which has structures or textures that hold water or permit appreciable water movement through them (National Water Act 1998). A saturated stratum which contains intergranular interstices, or a fissure / fracture or a system of interconnected fissures / fractures capable of transmitting groundwater rapidly enough to supply a borehole or spring directly (Colvin et al., 2007).
Baseflow	The volume of water in the stream when at its minimum or base level of flow; this is the level to which the stream flow returns between storms; in climates with seasonal rainfall it is often treated as the dry season flow; it is derived from groundwater flow or discharge (termed the groundwater contribution to baseflow), and from drainage from deep soil and weathered material (i.e. interflow); generally synonymous with the term low flow (Le Maitre et al., 2018).
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 (Stanfford et al., 2019).
Complex Adaptive Systems	Complex adaptive systems are self-organizing systems that can adjust and reorganize autonomously in response to internal and external changes (Levin et al., 2013)
Groundwater	In common usage includes all subsurface water but in this document the use of this term is restricted to water in the zone of saturation. It flows into boreholes/wells, emerges as springs, seeps out in streambeds or elsewhere in surface catchments and is not bound to rock (particle) surfaces by forces of adhesion and cohesion (Cleaver et al. 2003). Generally used for water contained in aquifers. There is consensus between the wetland and groundwater literature on the definition of groundwater in that it only includes the portion of the subsurface which is saturated and not all water that occurs underground. According to Colvin et al. (2007) underground water may occur (i) In the unsaturated zone as soil water and interflow, (ii) in the saturated zone as groundwater in aquifers (extractable), and (iii) groundwater in aquitards and aquicludes (not extractable).
Protected Areas	The Protected Areas Act No. 57 of 2003 recognises two categories: Protected Areas which are areas of land or sea that are formally protected in terms of the Protected Areas Act and managed mainly for biodiversity conservation. This includes most categories of protected government land (e.g. national parks, provincial nature reserves) as well as various forms of contractually protected private land (e.g. stewardships). Conservation areas are portions of the land or seas of land or sea that are not formally protected in terms of the Act but are nevertheless managed at least partly for biodiversity conservation (SANBI, 2023).
Mean Annual Runoff	Mean annual runoff is the amount of water flowing over the surface of the land (mainly in water courses) over the period of a year; the average (or mean) is calculated over several years (typically at least 10 years).
Siltation	Siltation refers to the pollution of water by fine particulate terrestrial material like silt and clay. This leads to increased suspended sediment concentrations and accumulation of

fine sediments in undesirable locations. Siltation is often caused by soil erosion or sediment spill.

Social-ecological system "Social-ecological systems are complex, integrated systems in which humans are part of nature" (Resilience Alliance, 2015).

Strategic Water Source Areas A subset of natural water source areas that are considered of strategic significance from a national planning perspective. Criteria for identifying strategic water source areas will be developed as part of this project (Le Maitre et al., 2018).

Unconfined aquifer Unconfined aquifers are aquifers whose upper water surface (water table) is directly open at the surface of the ground and the groundwater is directly recharged by rainfall.

Water security The capacity of a population to safeguard access to adequate quantities of water of an acceptable quality for sustaining human and ecosystem health on a watershed basis, and to ensure efficient protection of life and property against water-related hazards such as floods, landslides, land subsidence, and droughts (UNESCO, 2012).

Water source areas All natural source areas for both surface water and groundwater. From these, a subset of 'strategic water source areas' can be distinguished, depending on how 'strategic' is defined. For the purposes of this project, 'strategic' is defined according to a national planning perspective for water security. Thus, the term 'strategic water source areas' refers to a subset of water source areas that are considered of strategic significance from a national planning perspective, and it may include groundwater and surface water source areas (Nel et al., 2017).

PART 1: INTRODUCTION

1.1 INTRODUCTION AND BACKGROUND

The water resources on which South Africa depends to meet the needs of its population and economy are severely limited (DWS, 2022). In addition, these resources are threatened by factors such as urbanisation, inefficient water use, over-abstraction of water resources, decreasing water quality, severe droughts and the effects of climate change, among others (DWS, 2022; Maze et al., 2019). This context increases the importance of maintaining and enhancing the country's Strategic Water Source Areas (SWSAs), which are areas of high rainfall that either "(a) supply a disproportionate amount of mean annual surface water runoff in relation to their size and are considered nationally important; or (b) have high groundwater recharge or where the groundwater forms a nationally important resource or both; or (c) areas that meet both criteria (a) and (b)" (Le Maitre, 2018: iv). Surface water SWSAs make up just 10% of the land area of South Africa, Lesotho and Eswatini, but supply 50% of the surface water runoff to these countries (Le Maitre et al., 2018). In 2017 it was reported that SWSAs support around half of South Africa's population and about 64% of its economy (Nel et al., 2017). The major urban centres generally obtain a high percentage of their water from surface water SWSAs; while about 70% of water used for irrigation is directly or indirectly obtained from these water sources (Le Maitre, 2018). The protection and management of these areas is therefore critical for South Africa's water, food and energy security (Figure 1.1).

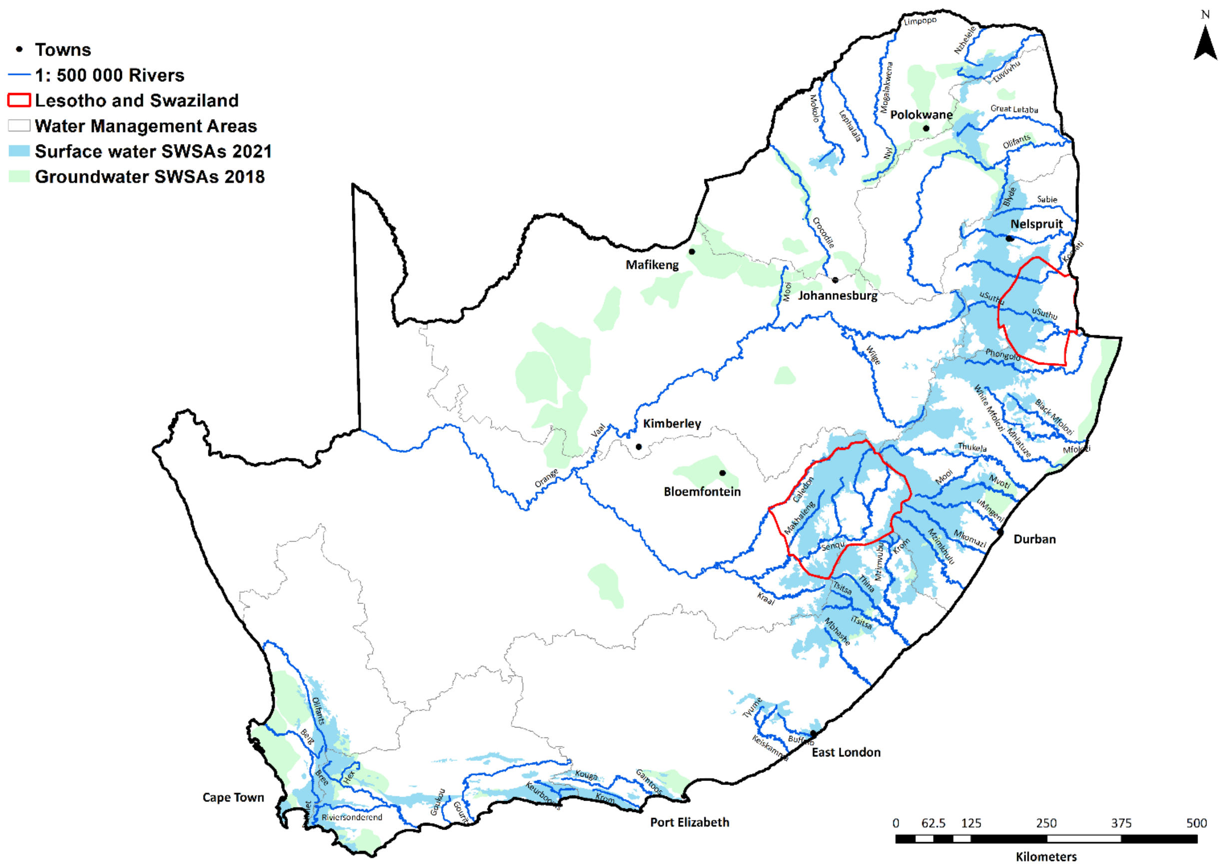

Figure 1.1. SWSAs for groundwater (Le Maitre et al., 2018) and surface water (Lötter and Le Maitre, 2021)

The governance of SWSAs falls under a range of government departments and extends across all spheres from national to local and includes land under private ownership. On the ground, local municipal implementation of restoration and protection measures is a critical gap identified in previous work that needs to be addressed (Le Maitre et al., 2018). While there are increasing expectations on local government to take custodianship of the environment, this is within a municipal context of severe shortages of funding, skills and capacity (Middleton, 2011). Local government plays a vital role in the protection of surface water, groundwater, drinking water and wetlands, often filling in the gaps in provincial and national government regulations (Koma, 2010; Middleton, 2011). The development of an Integrated Development Plan (IDP) is one of several tools local governments can use in addressing these gaps.

1.2 PROJECT AIMS AND OUTCOMES

This report emanates from a three-year Water Research Commission project (April 2022 – March 2025) led by the Council for Scientific and Industrial Research (CSIR) in collaboration with the City of Cape Town and Witzenberg Local Municipality. Other important stakeholders also include DFFE, DWS, the South African National Biodiversity Institute (SANBI), and the World Wide Fund for Nature – South Africa (WWF-SA).

This project focuses on the development of a municipal-specific Framework to guide municipalities in developing a strategy for improved governance and protection of SWSAs in their areas of jurisdiction. An Introductory Guide has been developed (Part 3) around the effective management of SWSAs in local municipalities in South Africa, contributing to securing SWSAs in line with the Department of Forestry, Fisheries and the Environment's (DFFE) identified mechanisms for securing SWSAs (DFFE, 2024). The work undertaken in this project also relates to the Kunming-Montreal Global Biodiversity Framework (GBF) Target 3 "Ensure and enable that by 2030 at least 30 per cent of terrestrial, inland water, and of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem functions and services, are effectively conserved and managed through ecologically representative, well-connected and equitably governed systems of protected areas and other effective area-based conservation measures, recognizing indigenous and traditional territories where applicable, and integrated into wider landscapes, seascapes and the ocean, while ensuring that any sustainable use, where appropriate in such areas, is fully consistent with conservation outcomes, recognizing and respecting the rights of indigenous peoples and local communities, including over their traditional territories." (https://www.cbd.int/gbf/targets/3).

"Securing" SWSAs is defined in this report as "the progressive, collaborative and adaptive implementation of a range of mechanisms that aim to enhance the ability of SWSAs to deliver the maximum quantity of good quality water for people, economic activities and ecosystems, both within and downstream of the SWSA, in a way that helps assure efficient, equitable and sustainable water supply and access to water for all" (DFFE, 2022).

The aims of this WRC project are to:

1. Develop a framework for participatory governance and enhancing the protection of SWSAs within municipalities in South Africa;
2. Develop a system for effective protection of the water quality and quantity within and flowing from SWSAs. This system involves delineating different levels of protection as determined by land use and land management activities and water production potential, among other factors; and
3. Identify monitoring approaches to assess the effects of interventions aimed at protecting and restoring SWSAs in municipalities.

The specific approach adopted to achieving these broad aims is described in Section 1.4.

Outcomes and expected impacts of the project are:

- Awareness of the role that SWSAs play in South Africa's water and food security by decision-makers in local government;
- Improved governance of SWSAs within the local sphere – including the integration of land use, environmental and natural resource management for the effective management of SWSAs; and
- Increased capacity within local government to understand and use the outputs (i.e. SWSA Introductory Guide) in planning and decision-making processes related to urban management and infrastructure planning, water resource development and protected area expansion and management, among others.

It is recommended that opportunities are sought to apply approaches developed in this project to additional pilot municipalities, thereby further developing the Framework in other, particularly rural, municipal contexts.

1.3 STRUCTURE OF THIS REPORT

This Technical Report consists of two main outputs which have been written up as two stand-alone parts of the report. Following this introduction (Part 1), the foundational context and methodology of the project are described in Part 2. This section describes the approach and method used to develop the SWSA Framework and the Introductory Guide and should be read in conjunction with Part 2 to provide foundation and context to the Guide. The Strategic Water Source Area Introductory Guide (Part 3) provides a framework for municipalities to develop their strategies for SWSA protection and management. It is presented in user-oriented steps along with recommendations and key actions for each phase of the framework development process. The Spatial Mapping and Management Guidance Document (Part 4) demonstrates practical application of spatial data using a metropolitan municipality as a case study. Recommendations for land use practices and municipal planning are also provided. In Part 5 we provide our conclusions and lessons learnt, with recommendations for future studies from this development process.

1.4 APPROACH TO THE SWSA FRAMEWORK AND GUIDE FOR LOCAL MUNICIPALITIES

1.4.1 Background to WRC Project: focus on municipalities

A WRC Reference Group was established to assist and guide the project, as well as to evaluate progress and the final outputs. The inaugural WRC reference group meeting took place on 2 June 2022, and the project Inception workshop took place on 20 September 2022. At these meetings much discussion took place about the challenges facing agencies that engage in water source conservation and management. The reference group members agreed that local-level governance effectiveness is a major challenge in the management of SWSAs, as evidenced by international experience (e.g. Eledi et al., 2017) and local projects such as the Southern Drakensberg State of the Sources study (Quayle et al., 2021). It was agreed that the project would have to engage very closely with municipalities in order to address these challenges.

Because the focus of the project was on local-level implementation of action towards SWSA conservation and management, the project team and reference group agreed to focus on these two municipalities. Limited resources provided by the project budget meant that further case studies could not be pursued, but the reference group felt that the two selected areas were representative of a range of municipalities in South Africa. Across the country there are different drivers of change in Strategic Water Source Areas and a variety of mechanisms can be employed to ensure resilience or protection of strategic water sources. It was resolved to produce a framework and Introductory Guide for participatory governance for the protection of SWSAs in municipalities. The framework is aimed at helping municipalities develop their strategies for the protection of SWSAs through the use of the Guide.

The City of Cape Town was selected as a case study due to ongoing and completed work on water source protection in the municipality and the overlap in surface water and groundwater source areas in the greater City of Cape Town area. The inclusion of Witzenberg local municipality as a second case study area was suggested because of its active participation in environmental management and sustainable water resource initiatives as well as the partnerships formed between the municipality and businesses which can serve as an example of how public and private entities can collaborate to improve water security and ecosystem resilience. Therefore, the CSIR decided to focus on the City of Cape Town (MOU already in place), and the Witzenberg Local Municipality as case studies for the project.

1.4.2 Link to DFFE Framework

The Department Forestry Fisheries and the Environment (DFFE) has recently published a report detailing a framework and toolbox of mechanisms and measures to secure South Africa's surface water Strategic Water Source Areas (DFFE, 2024). As the DFFE framework is well aligned with the work proposed in this project, the three broad DFFE mechanism types have been aligned with the strategies and projects included in the SWSA framework in this report (Part 2 and Part 5). The DFFE (2024: 8) mechanisms refer "….to a wide range of interventions consisting of different processes, techniques and tools that can be used to secure South Africa's SWSAs". These mechanisms are divided into three groups as follows (DFFE, 2024):

- **Enabling mechanisms** (e.g. funding, building human resources and strengthening legislation) are foundational, directing decision-making and enabling the application of the implementation and adaptative mechanisms;
- **Implementation mechanisms** (e.g. restoration, avoiding loss and degradation of biodiversity and protection of land and water) are operational actions which have quantitative impacts in practice; and
- **Adaptive mechanisms** (e.g. research, data collection, evaluation and learning and communication) enable reflection by all stakeholders on the effectiveness of the mechanisms that have been implemented for the management of SWSAs-sw.

The DFFE (2024) reports that the DWS has started a parallel initiative to ensure the protection and sustainable use of groundwater SWSAs; and that it is also foreseen that future revisions of the DFFE Framework will include mechanisms specifically for securing groundwater SWSAs. In Table 3.4, the strategies and projects for both surface- and groundwater SWSAs have been linked to the DFFE mechanisms.

1.5 APPROACH TO THE CO-DEVELOPMENT OF THE FRAMEWORK

1.5.1 Case studies

A case study approach was employed to co-develop the Framework for the development of municipal strategies to manage, protect and monitor key freshwater sources in SWSAs at the local government level. This approach allows in depth, multi-faceted explorations of complex issues in their real-life settings (Avery et al., 2011).

Municipal officials were active participants rather than passive recipients of information, and knowledge and information were generated through the interactions between researchers and practitioners (Roux et.al., 2006). In this way we were able to develop and refine the Framework being formulated with input from municipal officials. Two case study areas were selected to represent different municipal structures and levels of complexity within the local sphere. These case study municipalities were as follows:

- A large Category A metropolitan municipality (City of Cape Town Metropolitan Municipality (CCT)), and
- A small to medium, Category B local municipality (Witzenberg Local Municipality).

The third category of municipalities in South Africa, Category C District municipalities, are not represented in our case study sample, due to time and budgetary constraints. As is standard practice in a WRC project, a reference group was appointed to provide input, support and guidance for the research undertaken. For a detailed outline of case study approach and method see Part 2.

1.5.2 Phases used in developing the SWSA framework

The Framework aims to guide local municipalities in formulating their own strategy for the protection and management of SWSAs. The process proposed to undertake this - and followed in the case studies- is a generic one, adapted from those often used in strategic planning, such as the IDP process (Coetzee, et al, 2000). The proposed Framework therefore includes five procedural phases (Figure 1.2). Each municipality would need to adapt the implementation of these phases to their specific circumstances. It is important that stakeholder engagement occurs throughout the process. In this project, however, due to budgetary and time constraints the case study processes were focused on participation by the relevant municipalities.

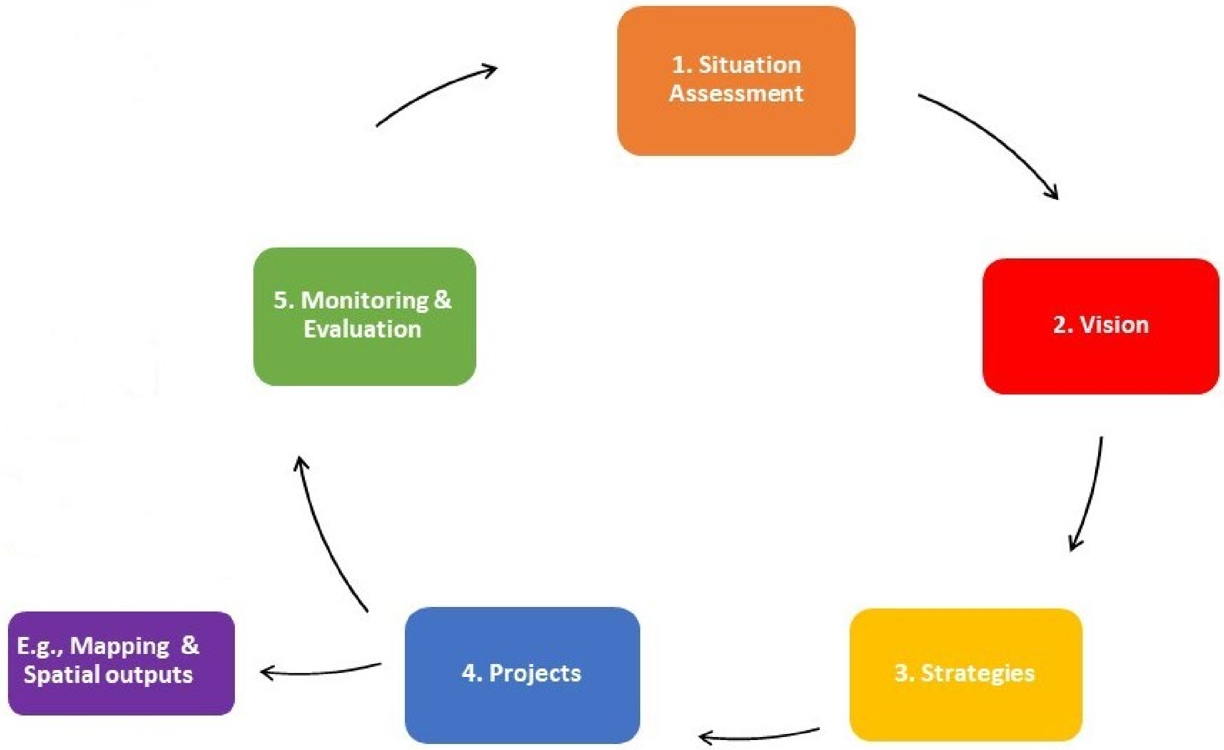

Figure 1.2. Process flow diagram illustrating the proposed process and approach followed in the case studies, to be included in the SWSA framework and Guide

The aspects, related to each of the phases shown in Figure 1.2, are briefly described in the first column of Table 1.1 below. In the second column the aspects of the draft Framework that were developed through the first case study (the City of Cape Town) are broadly outlined. The third column outlines the aspects of the Framework developed through the Witzenberg case study. For a more detailed description of this process see Part 2.

Table 1.1. Phases of the process to be included in the SWSA Framework

Aspects outlined in the Framework to guide local municipalities in formulating a strategy for the protection and management of SWSAs	Aspects of the Framework developed through City of Cape Town case study	Aspects of the Framework developed through Witzenberg case study presented in this report
Phase 1: Situation Assessment Key factors that should be included when undertaking a situation assessment for the protection and management of SWSAs in local municipalities (e.g. socio-economic trends, water quality and climate change). Guidance on useful information sources for this assessment are also provided.	Overview of the situation assessment undertaken for the City of Cape Town case study presented and discussed at the workshop. The opportunities and constraints to maintaining and enhancing SWSAs in Cape Town, identified by the project team, which were refined in the in-person workshop.	A situation assessment for Witzenberg municipal area. Summary of key trends. The situation assessment was presented and discussed at a workshop with the Municipality
Phase 2: Vision Description of the importance of the visioning process. Examples of two visions related to SWSA management in local municipalities (i.e. City of Cape Town and Witzenberg visions developed).	Description of the visioning process for the protection and management of SWSAs in Cape Town, undertaken in the workshop with the City of Cape Town. Finalisation of the vision at the online meeting with the City of Cape Town mentioned below.	Description of the visioning process for the protection and management of SWSAs in Witzenberg, undertaken in the workshop with the Municipality. Presentation of final vision that was developed. Opportunities and constraints to the achievement of the vision, identified in the Witzenberg workshop.
Phase 3: Strategies Outline of the purpose of strategies and their importance in local government protection and management of SWSAs. List of strategies for the protection and management of SWSAs by local municipalities.	Version 1 of a list of generic strategies for the protection and maintenance of SWSAs by municipalities was developed. These are based on inputs from participants at the City of Cape Town workshop, a review of relevant literature and an online meeting with the City of Cape Town. It is important to note that these strategies were formulated as Version 1 of the generic strategies that are included in this technical report (and not strategies only for the City of Cape Town).	A second version of the generic strategies, which were refined and integrated in light of the in-person workshop, and online meeting with Witzenberg, as well as the CSIR team discussions.
Phase 4: Projects Examples of projects for the protection and management of SWSAs by local municipalities.	Version 1 of a list of *examples* of generic projects for the protection and maintenance of SWSAs by municipalities were developed. These are examples of the projects and actions that can be implemented to achieve the strategies mentioned above	A second version of the list of *examples* of generic projects for the protection and maintenance of SWSAs by municipalities. The projects were refined and integrated based on the in-person workshop and an online meeting with Witzenberg, as

Aspects outlined in the Framework to guide local municipalities in formulating a strategy for the protection and management of SWSAs	Aspects of the Framework developed through City of Cape Town case study	Aspects of the Framework developed through Witzenberg case study presented in this report
	and are informed by the online meeting with the City of Cape Town, online literature and the CSIR project team's experience.	well as the CSIR team discussions.
Phase 5: Monitoring Short outline of the importance of monitoring Examples of monitoring indicators for the protection and management of SWSAs	Indicators were identified for the strategies formulated in the case studies. These provide examples for municipalities when they are compiling monitoring programmes for the protection and management of SWSAs.	

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PART 2: FOUNDATIONAL CONTEXT AND METHODOLOGY TO SWSA FRAMEWORK AND INTRODUCTORY GUIDE

2.1 INTRODUCTION

This technical support material provides an overview of the method used to develop the SWSA Framework for local municipalities and the Introductory Guide in which this Framework is presented (Part 3). This supporting information should be read in conjunction with the Guide.

2.2 STRUCTURE OF THIS SECTION

Section 2.3 outlines the approach and methods used in the City of Cape Town Metropolitan Municipality case study. In Section 2.4, the Witzenberg Local Municipality case study is described. Section 2.5 provides the integrated generic strategies and examples of projects and indicators for monitoring of progress towards enhanced SWSA conservation and management that are also described in the Guide. Section 2.6 provides a monitoring and evaluation plans with generic indicators for tracking progress towards improved SWSA conservation and management. In Part 5 we provide our conclusions and lessons learnt from this development process.

2.3 CASE STUDY: CITY OF CAPE TOWN METROPOLITAN MUNICIPALITY

2.3.1 Background to case study

The City of Cape Town Metropolitan Municipality is situated in the southern peninsula of the Western Cape Province (Figure 2.1). It lies in the Berg-Olifants Water Management Area which extends north to include both the Berg and the Olifants river catchments, as well as the smaller natural catchments within the City's boundaries. It has a coastline of 294km and stretches from Gordon's Bay to Atlantis and includes the suburbs of Khayelitsha and Mitchells Plain.

The oldest geological formations in the area belong to the Malmesbury Group of rocks that make up the basement of the area. Around 540 million years (Ma) ago, the Cape Granite Suite, formed by solidification of cooled magma (molten rock) from below the surface of the earth, pushed through the Malmesbury Group rocks along a roughly north-northwest orientation (Brown and Magoba, 2009). These intrusions are called plutons and are responsible for the higher areas of the Cape Peninsula, Kuilsriver-Helderberg, Stellenbosch and Paardeberg.

On average, the area experiences a Mediterranean-type climate with warm, dry summers and mild, wet winters with strong winds. Rainfall decreases dramatically from the east (approximately 1 700 millimetres per annum), across the Cape Flats to the west coast, where the mean annual precipitation is around 400 mm. River flows mirror the rainfall pattern; flow is strongly seasonal, with most of the flow occurring in the winter months (June to September). It is also highest in the east and lowest in the west (Brown and Magoba, 2009).

The CCT Metropole and its neighbouring towns obtain their water from a combination of the Western Cape Water Supply System (WCWSS) and their own sources, including groundwater. This system includes the Theewaterskloof Dam in the Breede River system, five other major storage dams and the use of groundwater by Saldanha and Atlantis, among others (DWS, 2018). The three SWSA-sw which supply the dams are the Boland, which supply 79% of the water, Groot Winterhoek which supplies about 18% and Table Mountain, which supplies 1% of the water (Le Maitre, 2018).

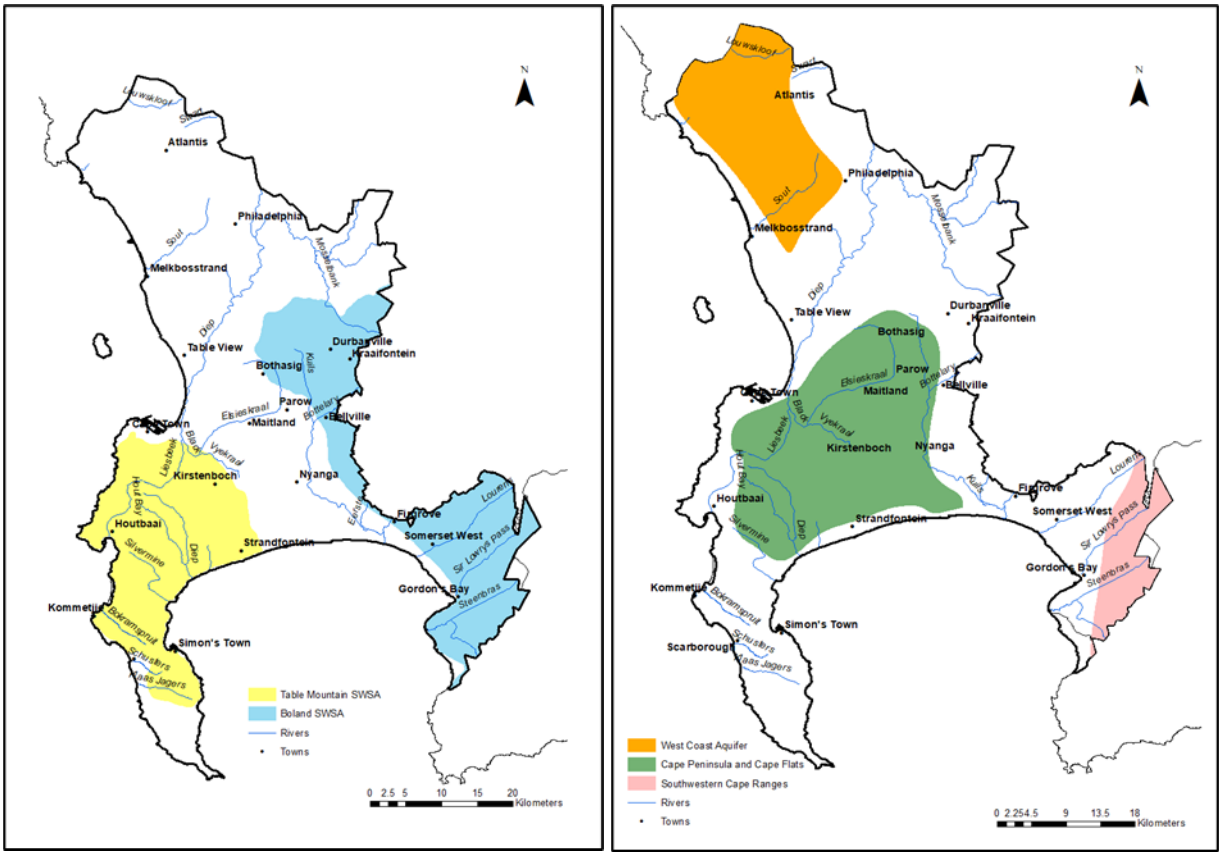

Figure 2.1. Surface water SWSAs on left (Lötter and Le Maitre, 2021) and groundwater SWSAs on right (Le Maitre et al., 2018), City of Cape Town. The location of the study area within the southern peninsula of the Western Cape Province, South Africa is also indicated.

The CCT is a large urban area with a high population density, an intense movement of people, goods and services, extensive development and multiple business districts and industrial areas. It is one of four coastal metropolitan municipalities in South Africa together with eThekwini, Nelson Mandela and Buffalo City, and the only Category A Metropolitan Municipality in the Western Cape province. The City of Cape Town is South Africa's second largest economic centre and second most populous city after Johannesburg. It is the legislative capital city of South Africa where the national parliament is located. It is also the provincial capital of the Western Cape Province.

2.3.2 Summary of key engagements with the City of Cape Town

In this section a brief summary of the engagements held with the City of Cape Town are described. These are presented in further detail in Sections 2.4.3 and 2.4.4 of the report.

An in-person workshop was held at the Water and Sanitation Head Office in Bellville on 10 October 2023 where several municipal officials from different directorates and departments/branches were present. These included Bulk Water, Spatial planning, Legal Services, Catchment, Stormwater and River Management, Environmental Management, Water and Waste, Scientific Services Branch and Communication and Partnership Departments. At this workshop the CCT participants engaged with the project team members in three groups around the objectives of the workshop, a vision for City's SWSAs, opportunities and constraints to the effective management of SWSAs and the strategies for such management. Group report backs informed this iterative process.

An extended online follow-up meeting with the City of Cape Town also took place on 24 October 2023 where the vision and strategic objectives were reworked and finalised by the participants. Thereafter, the project team followed up with several telephone and email discussions with key stakeholders to inform the evolving Framework.

A final hybrid workshop was held with senior management representatives on the 11 July 2024. In this session a brief background to the SWSAs project was presented and participants were given the opportunity to provide written (on worksheets) and verbal feedback on the draft strategies presented.

2.3.3 Phases 1 and 2: Situation assessment, vision, opportunities & constraints

Situation assessment

In the development of the situation assessment a process of organising, analysing, and sharing data using a mixed methods approach was followed. This included targeted site visits, and the review of relevant policy and planning documents, available studies and programme reports. It was important to have a clear view of the social and ecological aspects of the system to facilitate a better understanding of the relationships between ecosystem wellbeing and human development. The analysis also provided an opportunity to describe the current conditions and trends from available data and to include the observations of stakeholders who have lived and worked in the area for many years.

Site visit

A two-day site visit was undertaken of the Diep/Sand River and Kuils River systems on 13 and 14 April 2023. On the first day the Diep/Sand River catchment was covered, the sites visited included the Spaanschemat river, the Keysers River, Grootboschkloof, Prinskasteel, Prinseskasteel, Westlake River and Zandvlei Estuary. On the second day the Kuils River system was covered and included the Kuils River, Bottelary River and the Eerste River/Kuils River confluence (see Figure 2.2).

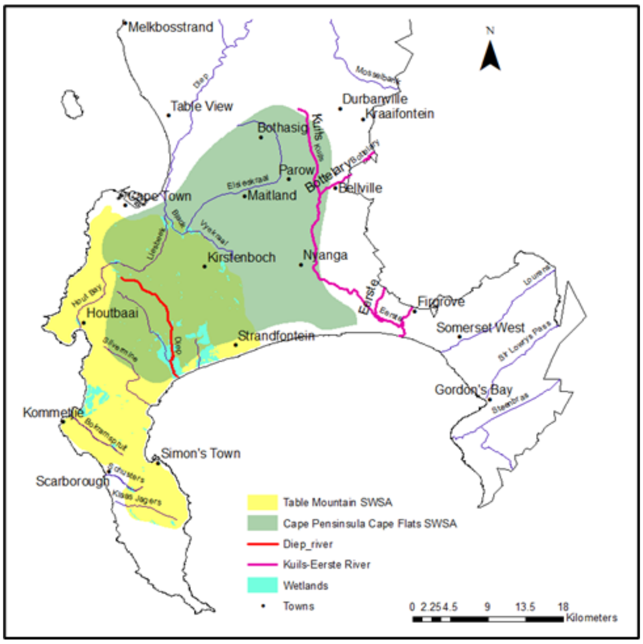

Figure 2.2. The Diep River and Kuils River location, City of Cape Town (left) and field trip participants mapping out the field visits on Day 1 (right)

The objective of the site visit was to inform the situation assessment for this case study, as well as PhD project methodology for a post-graduate student working on the SWSA project. The site visits allowed participants to observe the present state of the two rivers as they transverse the highly urbanised catchments from source to sea. It also provided an opportunity to view sites along the river reaches where the city has rehabilitation and monitoring programs. The site visit was led by a Senior Ecologist at the City of Cape Town, with participants from the CSIR and the City, including the PhD student on this SWSA project; as well as the student's supervisor from the University of the Western Cape.

The sites visited on the first day form part of the City's Liveable Urban Waterways (LUW) programme. This programme aims to develop a systematic approach to waterway rehabilitation and provide a more natural state of waterways, focusing on improving the quality and function of aquatic, riparian and wetlands environments. Project work is primarily focused on the watercourses themselves, involving reshaping of riverbanks, planting indigenous riparian species, rehabilitating wetland areas, constructing gabions and natural stone weirs, and installing stormwater swales and sediment traps (Matthews, 2023).

The Diep River originates in Table Mountain National Park, joins the Sand River, and flows through a series of suburbs via the Constantia Valley Greenbelt and public open spaces, feeding into Klein Princess Vlei, Zandvlei estuary and ultimately into the Atlantic Ocean at Muizenberg beach (Brown and Magoba, 2009). All these streams have been affected by urban development and agriculture and are highly modified (Figure 2.3 d-f). The Kuils River and Eerste River are two important rivers that run through the eastern part of the Cape Town Metropolitan Area. The Kuils River flows through highly urbanized and some agricultural areas and the river has been degraded to a great extent in both water quality and aesthetic value (Thomas et al., 2010). The Kuils River has its source in the Durbanville Hills near Kanonkop and runs south through the industrial and residential areas of Bellville and Kuilsriver (**Figure** 2.3 a-c). In the lower course the river has some wetlands, which are of high significance, but over 80% of these have been transformed due to rapid urban growth and the development of industrial parks and residential areas over the last 40 years (Brown and Magoba, 2009). The Kuils River joins the Eerste River near Macassar and runs into the Atlantic Ocean shortly thereafter.

Figure 2.3. Sand River Catchment (a) Spaanschemat river, (b) Westlake River and (c) Zandvlei Estuary; Kuils River Catchment (d) Kuils River source in Durbanville, (d) canalised reach in Kuils River and (f) river reach in Driftsands Nature Reserve after passing through the Khayelitsha wetlands

Assessment of key trends

A rapid assessment of key trends that are applicable to the management of SWSAs in the City of Cape Town Metropolitan Municipality was undertaken. In the assessment the current state and condition of the freshwater ecosystems and the communities in the Cape Town Metropolitan area was researched and described. The situation assessment focused on:

- The diversity and quality of inland water;
- The effect of land use modification, pollution, and water withdrawal on waterways;
- The diversity and quality of land ecosystems including their modification, conversion, and degradation;
- Resource use in terms of water demand and supply; and
- Water-related climate change predictions.

- In terms of social aspects, the main areas investigated include:
- Population growth;
- Level of education;
- Economy and income; and
- Ecosystem health.

Examples of key trends include those listed below (a list of the key data sources used in the situation assessment can be found in Section 2.7.3):

1. The urban rivers which transverse the Table Mountain SWSA (i.e. Diep, Hout Bay, Liesbeek and Black River) suffer from pollution due to untreated wastewater, discharge, industrial runoff, and agricultural effluent.
2. The biggest water quality issue experienced in most of the routinely monitored systems is elevated phosphorus, which drives eutrophic and hypertrophic conditions.
3. The groundwater quality of the Cape Flats Aquifer is at risk of contamination from urban and industrial sources, with saline intrusion a concern in some areas.
4. The upper parts of the Lourens river, Steenbras and Sir Lowry's Pass Rivers which occur in the Boland SWSA are protected by their location in largely natural areas but are impacted by agricultural and urban activities in their lower reaches.
5. The groundwater quality of the West Coast Aquifer is generally good, though localized contamination from agricultural activities and brackish intrusion is a threat to groundwater quality.
6. According to the Census 2022 the population of Cape Town shows a growing trend. Currently, Cape Town is home to an estimated 4 772 846 people, which is nearly 36% more than in the previous census in 2011.
7. Western Cape Provincial Government's socio-economic profile of the city reports that, out of 1 135 000 households in 2021, 185 000 people (14%) live in informal settlements.
8. The current average annual rainfall for the City of Cape Town is between 400mm to 1200mm per annum. In future, rainfall is expected to decrease by 55-174 mm per annum. This means that the future will be substantially drier in the region.
9. Economic growth at both a national and city level has not managed to keep pace with population growth, which may increase further due to internal migration.
10. On average, all economic sectors in Cape Town have shrunk between 2017 and 2021, except for agriculture, finance, and community services.

Development of the Vision

The development of a draft vision statement was a central part of the workshop held with representatives from the City of Cape Town on 10 October 2023 (mentioned in Section 2.3.2. above). The vision was developed through providing each participant with three cards on which to write words/phrases that they thought were important to include. Example contributions from participants are shown below:

- "Holistic management of SWSAs that recognizes necessary trade-offs for the overall improvement of ecosystem services."
- "Protected and restored to optimize water quality or quantity."

- “Communities and partnerships work together with legal frameworks to protect our SWSA.”
- “Overcoming imminent effects of climate change in relation to water resources.”
- “Preserve the cultural use of SWSAs.”

The CSIR team then grouped these phrases and drafted a preliminary vision statement which was then discussed with the participants and edited through until a final draft vision statement was reached. The vision was finalized in an online meeting with representatives from the City of Cape Town on the 24 October 2023 (mentioned in Section 2.3.2 above) and is shown in the Box below.

Vision for the City of Cape Town Metropolitan Municipality

We, the City of Cape Town, are working together with partners and communities to identify risks, monitor and improve the green infrastructure of our Strategic Water Source Areas (SWSAs), biodiversity and social wellbeing, enhancing the future value of SWSAs and advancing the City’s vision to become a water sensitive city by 2040.

Opportunities and constraints

Draft opportunities and constraints were developed by the project team prior to the first City of Cape Town workshop (10 October 2024) at which they were presented. Following the presentation, the participants were divided into three groups based on the departments in which they work (see Figure 2.4).

Figure 2.4. City of Cape Town officials discussing opportunities and constraints in group sessions

- **Group 1:** Participants from the Bulk Water Department.
- **Group 2:** Participants from the Scientific Services Branch and Catchment, Stormwater and River Management Department.
- **Group 3:** Participants from Environmental Management Department, Spatial Planning Department and Water and Sanitation Communication and Partnership Branch.

Each group was provided with a print-out of the draft opportunities and constraints and asked to discuss, add and/or edit these as they see fit. Additional opportunities and constraints were written down on cards. These were grouped and summarized by the CSIR team in the workshop and presented back to the participants. Participants were asked to expand or clarify points that were not clear. The cards provided a basis for interesting and engaging discussion around each theme identified.

Opportunities, constraints and strategies identified at the in-person workshop

Opportunities:

- Rich biodiversity in the City of Cape Town Metropolitan Area attracts tourism and associated socio-economic income, as well as (in some instances), funding for environmental protection.
- There are several active DFFE "Working For" programmes being undertaken in the City of Cape Town (e.g., Working for Water, Working on Wetlands, Working on Fire and Working for Ecosystems).
- There are numerous NGOs undertaking awareness campaigns and/or environmental education initiatives that relate to the maintenance and enhancement of water source areas (e.g., WESSA, WWF, Table Mountain Water Source partnership).
- Initiatives exist in the City of Cape Town:
- To protect, restore and manage the natural environment, which will assist in maintaining not only the SWSAs themselves, but also the ecosystem functioning and processes on which they depend (e.g., Local Biodiversity Strategy and Action Plan and Biodiversity Network, biodiversity management initiative Maintain sustainability (maintaining recharge area: protecting recharge area to maintain yields).
- Maintain healthy and functional waterways through removing blockages, clearing litter and preventing pollution, among other aspects (e.g., water quality improvement project) will assist in improving water quality.
- Remove invasive alien plants (e.g., in partnership with the Greater Cape Town Water Fund) and expand land under conservation (e.g., biodiversity management initiative), will assist in the management and protection of SWSAs (e.g., through reducing water losses).
- Implement water conservation and demand management program (incl. leak repairs, upgrading of infrastructure, recycling, water restrictions,) – focus is on water demand management; inclusion for water sensitive urban design principles in key policies to manage stormwater while capturing water for future supply needs.
- Respond to climate change through, for example: joining the 100 Resilient Cities Network (2016), adopting the Climate Change Policy (2017), joining the C40 SA Buildings Program (Net Zero Carbon Buildings) (2018), approving the Resilience Strategy (2019), and adoption of the Cape Town Climate Change Strategy (2021).
- Monitor water quality: related to both surface water and groundwater. The city has an extensive network of monitoring boreholes and surface water monitoring stations.
- Manage and protect groundwater: monitoring has been undertaken to identify baseline conditions; yield assessments have been done to determine aquifer storage and maximum possible abstraction rates; groundwater monitoring committees being developed (already established for Cape Flats Managed Aquifer Re-Charge, Steenbras TMG Schemes); groundwater protection plans developed; City is involved in community outreach initiatives for groundwater management (e.g. partner in the Table Mountain Water Source Partnership).
- Engage with stakeholders to build understanding – and trust – around water reuse plans.
- Share information used to determine alter levels for water restrictions (e.g., rainfall trends and seasonal weather forecasts, among other factors).
- Consideration of water demand is included in strategic spatial planning (SDF, 2023). Scenario planning also informs the City's operational – and long-term- resource planning.
- The City has developed important spatial tools, such as BioNet (Biodiversity Network) and GINet (Green Infrastructure Network).
- City of Cape Town is investigating diversifying sources of water, which would increase the resilience of the City to drought and other climate impacts, placing less demand on current sources (e.g., desalination, use of groundwater sources, water re-use).
- The City plans change to the delivery model for water and sanitation - in support of the 2020 Water Strategy (e.g., use of advanced technology, reducing costs of asset failure, targeting maintenance, and improving the revenue model and tariff structure). The City also aims to collaborate with other spheres of government and other users for improved management of the water supply system.
- Participation in catchment forums: there are numerous catchment forums being developed and this presents an

opportunity for involvement (or to be led) by the City around SWSAs.
- Water treatment costs can be reduced through improving water quality in SWSAs.
- Introduce innovation to improve efficiency in water and sanitation provision.
- Opportunities exist for the City to form partnerships around SWSA education and awareness.

Constraints:

- Increasing population places greater pressure on water quality and quantity (increase in water demand).
- Increasing urbanisation results in increased water demand and reduced infiltration and groundwater re-charge.
- Ecosystem services provided by SWSAs (e.g., water purification by wetlands) are threatened by, for example: unplanned development (including escalating illegal land invasions); development in areas of high environmental sensitivity (e.g. because of a lack of land for housing); and/or by environmental degradation (e.g., from pollution or the spread of invasive alien plants (IAPs).
- Climate change: leads to increase in temperatures, decrease in rainfall and change in seasonality of such rainfall. Also, more extreme events (e.g., storms, droughts, and wildfires) will reduce surface water and groundwater recharge, increase evaporation and decrease mean annual runoff. These factors likely to contribute to threatening water supply.
- Continued water losses due to increases in the spread of invasive alien plants (IAPs). In addition, IAPs in SWSAs decrease runoff and recharge and degrade the ecosystem's ability to maintain its integrity and ability to deliver ecosystem services.
- Most of the City's watercourses have poor water quality, being affected particularly by phosphorus enrichment.
- The current primary source of water in the City of Cape Town is surface water. A lack of diversification of water sources, raises the City's vulnerability to increased demand and climate change, among other factors.
- Loadshedding (especially extended higher stages) poses a direct - and indirect - risk to Cape Town's water supply (e.g., most water treatment plants rely on grid power). This can affect the quality of water in SWSAs.
-
- High percentage of people living in poverty and without access to basic services and essential resources, increases direct dependency on the natural environment (e.g., water for cleaning and washing, wood for fires) which can compromise water quality and human – and ecosystem- health.
- Increase in the amount of indigent population results in a decrease in municipal revenue available for the delivery and maintenance of services (e.g., water and sanitation infrastructure and refuse removal services) which can result in water losses (e.g., water leaks) and a decrease in water quality.
- Increase in population, particularly the number of people living in poverty and without access to basic services, results in an increase in the conflict faced by stakeholders (e.g., the City of Cape Town) between conserving the natural environment and enabling urban growth.
- Lack of integration across sectors (e.g. across government departments) required for the protection of water resources (e.g. when considering development applications); and across administrative boundaries.
- Lack of access to private land for environmental monitoring (e.g. water quality) and/or protection.
- Gaps in water quality monitoring, including determining the impacts of water quality on biology (outside reserves); monitoring outside of the City boundaries.
- Meeting increasing legislative requirements (e.g. Resource Quality Objectives) that may become even more complex.
- Public perceptions (as a result of historical injustices): alternative services (e.g. water recycling options for certain uses) may be seen, in some instances, as 'inferior'; and/or some legal environmental requirements may be perceived as unfair.
- Existing Supply Chain Mechanism Framework (can restrict innovation in some instances).
- Human capacity, financial and administrative (e.g. varying budgetary cycles between spheres of government) constraints.

2.3.4 Phases 3 and 4: Strategies and projects

At the end of the first City of Cape Town workshop described above (10 October 2023), the agenda included the identification of strategies to achieve the vision - in a manner that maximises the opportunities and addresses the constraints. However, given the productive and fruitful engagement of the participants in the development of the vision and the opportunities and constraints, these discussions were given more time to continue. This meant that there was limited time for the identification of strategies. A short session was, however, held where the participants discussed potential strategies in groups and the CSIR team reported back those which were identified to the participants in a plenary session.

Following the workshop, the team reflected on the workshop outputs, particularly the limitations of the session on strategy development. The insufficient time available for this session meant that the strategies provided by the participants required further clarification and elucidation, which was not possible on the day. A decision was therefore made to supplement the existing strategies from the workshop; with a review of national and international literature relevant to the management and protection of SWSAs. A list of 'generic' strategies (including the inputs from the workshop) was compiled and grouped into 11 themes. These are:

1. Protection of SWSAs
2. Pollution control (Water Quality)
3. Clearing Alien Invasive Plants
4. Water Conservation and Demand
5. Delivery of Basic Services
6. Effective municipal planning, policy and legislation
7. Stakeholder engagement and awareness raising
8. Development of partnerships
9. Ensure comprehensive, and accessible knowledge and information
10. Technical innovation
11. Adequate financial support

The online session on the 24 October 2023 was held with City of Cape Town officials. Although it was a small group that attended this session, the discussions were engaging and informative. The original intention was to refine the generic strategies developed, related to each theme, in terms of the City of Cape Town context (i.e. how would the strategies be applied in the City context?). However, the 'strategies discussion' gained momentum once the conversation focused on practical projects and actions, rather than broader strategies.

After the online session, the CSIR team integrated and reduced the 11 themes into five and identified examples of associated projects (incorporating ideas from the discussions with the City). The five themes were as follows:

- Protection and management of SWSAs and ecosystems on which they depend;
- Management of water quality and quantity;
- Water conservation and demand management;
- Stakeholder engagement, partnerships, and communication in the management of SWSAs; and
- Adequate financial support for the management of SWSAs.

In summary, the draft strategies and projects were derived from:

- Discussions at the workshop with the City of Cape Town (described above) which were held on the 10 October 2023;
- The online meeting with officials from the City of Cape Town (described above), held on the 24 October 2023;
- The literature which is listed in the references at the end of this report, separated in this list under the heading Section 2.7.2;
- The knowledge and experience of the CSIR team.

A hybrid workshop was organised for 11 July 2024 (after the Witzenberg case study work) specifically to allow an opportunity for senior managers to provide input to the draft Framework by reviewing and refining outcomes and commenting on their relevance. In this session a brief background to the SWSAs project was given, followed by a description of the Draft Framework (including the process being followed for its development); as well as the draft themes and strategies developed to date. Participants were provided with worksheets on which they could give written feedback on each of the themes and strategies presented. They were also given an opportunity to provide verbal feedback. These written and verbal comments were considered in a review and finalisation of the draft strategies that occurred subsequent to the Witzenberg case study work described in the Part that follows. The SWSA Introductory Guide: Draft Report was also distributed for written comments, inputs and feedback to all those who attended the in-person and online City of Cape Town workshops.

2.4 CASE STUDY: WITZENBERG LOCAL MUNICIPALITY

2.4.1 Background to case study

Witzenberg Municipality (WC022) is a Category B local authority. It borders on the Northern Cape Province to the north and north-east, while the Laingsburg Municipality forms the eastern boundary. To the west it is bounded by the West Coast District Municipality and to the south-east by the Drakenstein Municipality and Breede Valley Municipality. The Olifants/Doorn Water Management Area (WMA) covers most of the Witzenberg Municipality, while Berg WMA, Breede WMA and Gouritz WMA covers the western, southern, and south-eastern parts of the area. Most of the perennial and non-perennial rivers located in the Tankwa and Ceres Karoo as well as the northern Koue Bokkeveld are intact and able to contribute towards river ecosystem targets, whereas rivers located in more intensively cultivated and built-up areas are seriously modified (Van Deventer et al. 2019; Witzenberg SDF, 2012).

The Witzenberg Municipality covers four main catchment areas: The Olifants/Doorn, Berg, Breede and Gouritz Water Management Areas. The majority of the towns of the Witzenberg Municipality fall within the Upper Breede sub-area. The main rivers draining into the Upper Breede sub- area are the Upper Breede River and its tributary the Witels (Figure 2.5). Most of the area is intensively cultivated with stone fruit orchards and irrigation from more than 60 dams (Witzenberg SDF, 2012).

The Witzenberg Municipality contains two of the surface water SWSAs, namely the Boland Mountains and Groot Winterhoek SWSAs. The Groot Winterhoek SWSA forms part of the Cape Fold Belt, and supplies water to Atlantis, Ceres and Saldanha (CER, 2023). The main rivers flowing from this water source area are the Olifants, Klein Berg, and Doring rivers. This SWSA is well protected and includes five mountain catchment areas, seven forest protected areas, two provincial nature reserves and two local nature reserves (Witzenberg SDF, 2012). The Boland Mountains Strategic water source area supplies the City of Cape Town with 97.1% of its water (Le Maitre et al., 2018). It also provides water to Worcester, Robertson, Swellendam, Overberg and the Winelands Municipality. The Klein Berg River has its source in the Groot Winterhoek and Witzenberg Mountains and joins the Berg River near the town of Saron (River Health Programme, 2004). The Berg River is one of the main rivers which flow from the Boland Mountains water source area the Groot Winterhoek.

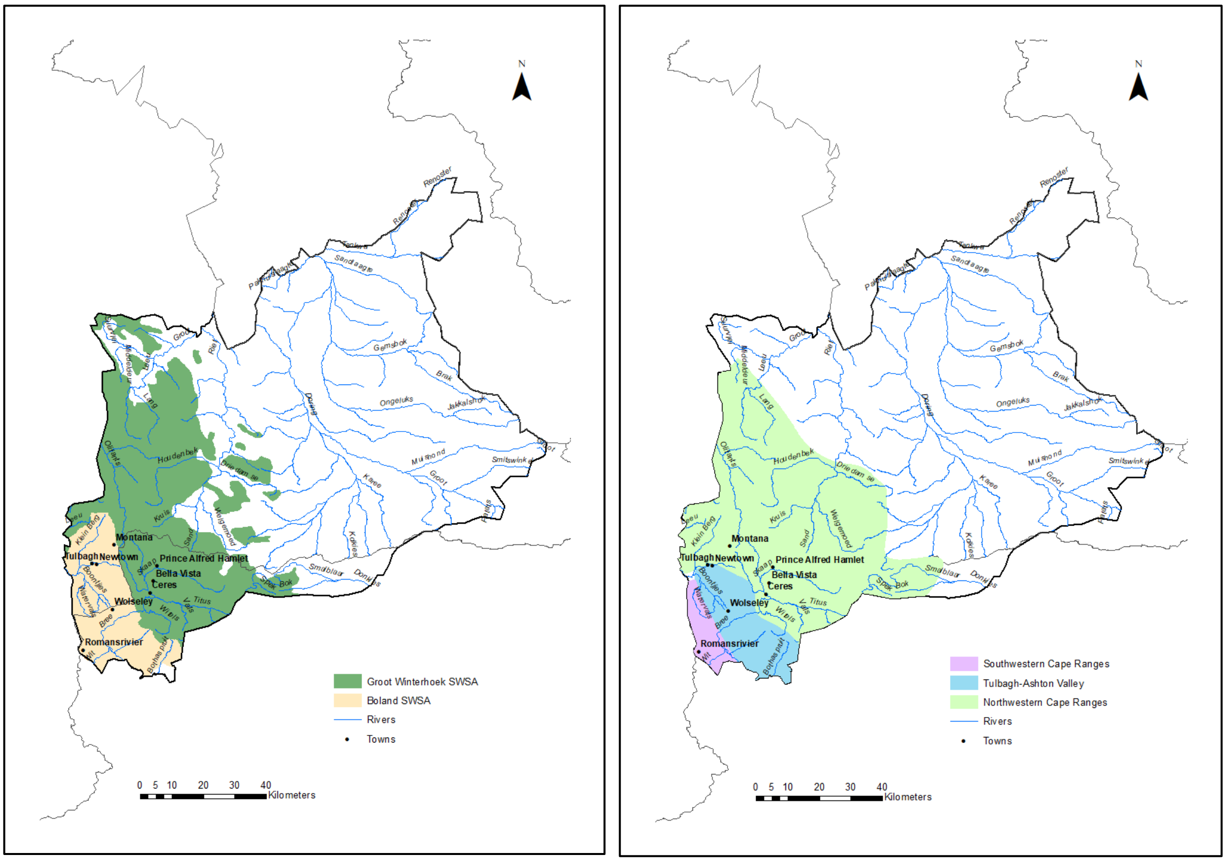

Figure 2.5. (a) Surface water SWSAs (Lötter and Le Maitre, 2021) and (b) groundwater (Le Maitre et al., 2018) SWSAs within the Witzenberg local municipality. Note also the Present Ecological State of the rivers that transverse the municipality. A – near natural, B – largely natural, C– moderately modified, D – largely modified, E – seriously modified, F - critically modified (Van Deventer et al., 2019).

The Witzenberg Municipality is both the Water Services Authority (WSA) and Water Services Provider (WSP) (Witzenberg IDP, 2023). There are five water supply and wastewater systems, each centred around one of the five towns, that deliver water and sanitation services in the municipal area (Witzenberg IDP, 2023). The Western Cape drought which developed over a period of three years from June 2015 to June 2018 highlighted the gaps in water availability in the municipality, especially in the town of Tulbagh.

2.4.2 Summary of key engagements with Witzenberg Municipality

The work was initiated with a letter of collaboration sent to the Municipal Manager of Witzenberg Municipality on 21 September 2023 requesting that the municipality be part of the case studies in this WRC project. This was followed by an introductory meeting held on 31 October 2023 with municipal officials, Director Technical Water and Sanitation as well as the Manager for Water and Sanitation.

After buy-in from municipal counterparts was established an in-person workshop was held in Tulbagh on 30 November 2023 where several municipal officials from different directorates and departments (as well as a representative from the Tulbagh Water Users Association were present). These included Technical Services, Water and Sanitation, Environmental Management and the Housing Department. The purpose of this workshop was to inform the participants of the steps related to the Framework development process. The formation of a shared vision for the protection and management of SWSAs in Witzenberg was facilitated, as well as the identification of opportunities and constraints to achieving this vision and finally related strategies were discussed by participants.

A follow up online meeting took place on 14 December 2023 where proposed generic strategies were presented to participants and further discussed with a view of identifying related activities and/or projects. These strategies included those formulated through the City of Cape Town case study, with the addition of new strategies based on the Witzenberg in-person workshop. Thereafter, on the 23 July a meeting was held with a Town and Regional Planner from the Municipality and the project team, at which the development planning process was discussed, including possible avenues for the incorporation of SWSAs in development decision-making.

2.4.3 Phases 1 and 2: Situation assessment, vision, opportunities & constraints

Situation assessment

A rapid situation assessment of the water quality, quantity and ecosystem health of the surface water and groundwater, as well as the key socio-economic trends in the Witzenberg Local Municipality was undertaken. In the development of the situation assessment a mixed methods approach was followed. This included targeted site visits, the review of relevant policy and planning documents, as well as available studies and programme reports and observations from municipal officials. It was important to have a clear view of the social and ecological aspects of the system to facilitate better understanding of the relationships between ecosystem wellbeing and human development. The analysis also provided an opportunity to describe the current conditions and trends from available data and to include the observations of stakeholders who have lived and worked in the area for many years.

Site visits

A site visit of the Tulbagh area in Witzenberg Municipality was undertaken on 29 November 2023. Tulbagh is one of the main towns in the Witzenberg Municipality. Land use activities in Tulbagh are essentially agricultural, with the town serving as an agricultural service centre for the region, with agri-processing related to wine, fruit, vegetables (Witzenberg IDP, 2023-2024). In the past Tulbagh has suffered from insufficient water storage capacity which resulted in the trucking in of water and the implementation of water restrictions (Witzenberg IDP, 2023-2024).

The visit was led by the water bailiff for the Tulbagh Water Users Association and attended by the CSIR project team, as well as an official from Witzenberg Municipality. Several sites were visited, including the Moordenaarskloof Dam and the Waverenskloof Dam. The Moordenaarskloof Dam is the main dam supplying the town of Tulbagh and is situated just outside the town. The Moordenaarskloof River and local springs are the main water supply sources for the dam. The Waverenskloof Dam was completed in 2023 to alleviate water shortages experienced during summer (Figure 2.6 a-b).

The team visited one of the sites along the Klein Berg River which forms part of the Berg and Breede Riparian Rehabilitation Programme (Figure 2.6 c). This Programme was established in 2013 and is one of the largest actively planted riparian rehabilitation projects in South Africa. (Figure 2.6 c). The Klein Berg River (Figure 2.6 d-e) is the main source supplying water to the Voëlvlei dam, a major water supply for City of Cape Town Metropolitan Municipality. The town's water distribution chamber which directs the flow of potable water from the source to consumers is shown in Figure 2.6 f. The NRM programme of DFFE has removed much of the alien vegetation (Figure 2.6 i), mainly Black Wattle, along the upper reaches of the river, the lower reaches of the river are however still infested with River Gum and Black Wattle. The team also visited a local wine farm where they gained insights around the use of surface water and groundwater for agricultural activities and the challenges experienced from climate change impacts.

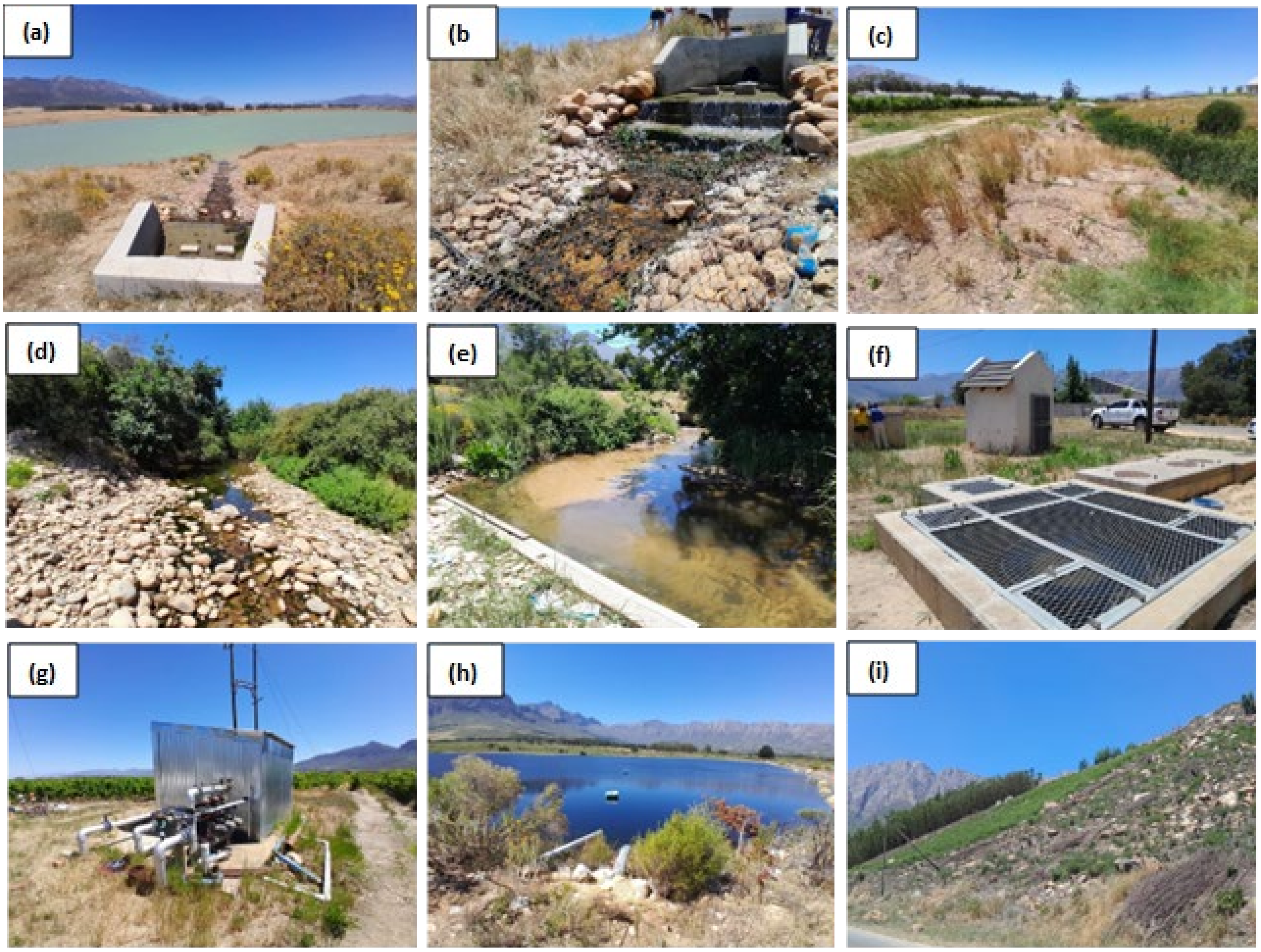

Figure 2.6. Sites visited during Tulbagh, Witzenberg Municipality site visit. The newly completed Waverenskroon dam (a) showing inlet from a local mountain stream (b). Seedlings planted along dripper lines as part of Berg and Breede Riparian Rehabilitation River Programme (c). Upper and lower reaches of the Klein Berg River (d-e). Water distribution chamber for the town of Tulbagh (f). Groundwater pump station (g) local farm dam (h) Alien invasive clearing in the Tulbagh Valley(i).

Assessment of key trends

The Witzenberg Municipality situation assessment, which included information on trends, pressures and driving forces, was presented and discussed at the in-person workshop held with Witzenberg municipal officials on the 30 November 2023 (mentioned in Section 2.4.2 above) (Figure 2.7). Following the presentation participants were given cards and requested to write down two or more changes they have seen in the municipality over the past five to seven years. Each participant had a chance to read their observation to the group which provided an opportunity to discuss the most significant issues to be addressed in the protection of SWSAs and improvement of the condition of the ecosystem and lives of the people.

The situation assessment focused on:

- The diversity and quality of inland water.
- The effect of land use modification, pollution, and water withdrawal on waterways.
- The diversity and quality of land ecosystems including their modification, conversion, and degradation.
- Resource use in terms of water demand and supply; and
- Water-related climate change predictions.

Figure 2.7. Workshop participants, Witzenberg Municipality case study

In terms of the human dimension, the main areas investigated include:

- Population growth.
- Level of education.
- Economy and income; and
- Ecological status

Key trends identified in the situation assessment include that (a list of the key data sources used in the situation assessment can be found in Section 2.7.4):

1. Urban growth and agricultural expansion, including irrigation practices and return flows, is a significant contributor to declining water quality in the Klein Berg River, Skaap and Titus rivers which flow across the Groot Winterhoek SWSA.
2. The aquifers which make up the groundwater SWSAs in the Witzenberg Municipality have generally low vulnerability to contamination with highest vulnerability in the intergranular aquifers around Tulbagh and Wolseley.
3. Almost all bulk water supply for towns in the Witzenberg Municipality comes from local surface water sources, with groundwater used exclusively for irrigation.
4. High reliance on surface water sources makes the municipality vulnerable to droughts and climate variability.
5. High demand for irrigation during summer coincides with the period of least water availability, increasing pressure on water sources.
6. Steady population growth (16.5% growth over two decades) indicates ongoing urbanization and potential pressures on infrastructure and services.
7. Although access to basic services and formal housing is generally high, there are still gaps in access to piped water and opportunities to improve education.
8. The agricultural sector accounts for 33.54% of total employment in Witzenberg, the main commodities are deciduous fruit (apples and pears) and wheat.
9. The Witzenberg Municipality faces a hotter, drier future with more extreme and unpredictable weather patterns predicted.
10. Rising temperatures reduced winter chill and intensified water demand will severely impact agriculture, particularly fruit and wheat production in future.

Development of the Vision

The first key activity at the workshop was to develop a draft vision statement with the participants to guide the identification of opportunities and constraints. The vision was developed through providing each participant with three cards on which to write words/phrases that they think are important to include in the vision. The contributions from participants are shown below:

- "Forming Partnerships, funding and municipalities".
- "Partnerships for water security"
- "Municipality and community work together"
- "Effective and efficient service delivery"
- "Protection and conservation of water"
- "Equal access"
- "Balancing economy and ecology"
- "Identify risk or threats to water security".
- "Esurance of adequate supply and equitable access".

The CSIR team then grouped these phrases and drafted a preliminary vision statement which was then discussed with the participants and edited until a final vision statement was reached.

Vision for SWSAs in the Witzenberg Local Municipality

Working with the community and forming partnerships to ensure adequate supply, protection and conservation of SWSAs for water security, while ensuring equitable access to effective and efficient services, balancing the economy and ecology.

Opportunities and constraints

At the workshop mentioned above (30 November 2023), participants were requested to write down (again, through the use of cards) any existing opportunities and constraints they could identify to achieving the vision. Each participant was then requested to read their cards and to expand or clarify points that were not clear (the cards were then grouped by the CSIR team and verbally summarised - Figure 2.8).

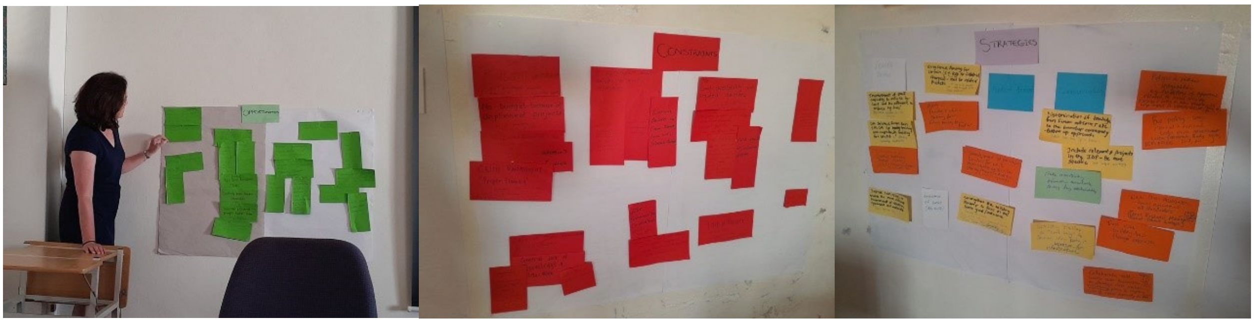

Figure 2.8. Witzenberg Municipal Workshop in Tulbagh: identification of opportunities (left), constraints (centre) and strategies (right). 30 November 2023

Following the workshop, the CSIR team summarised and interpreted the cards into the list of opportunities and constraints shown below.

Opportunities, constraints and strategies identified at the in-person workshop

Opportunities:

- Current environmental maintenance programmes through the Expanded Public Works Programme (EPWP), which create employment opportunities (e.g. alien clearing).
- There are existing alien clearing projects successfully run in the Witzenberg area (e.g. by the Water Users Association).
- Training and/or awareness raising opportunities exist from organisations outside the municipal environment (e.g. the Water Research Commission (WRC).
- Open access resources exist (e.g. the Green Book Platform) that the municipality can utilise in their strategic planning, thereby minimising their own expenditure in obtaining such data/information.
- External funding is available from external organisations (e.g. WWF Nedbank Green Trust) and/or other spheres of government (e.g. Municipal Infrastructure Grant (MIG) through the Cooperative Governance and Traditional Affairs (COGTA) Department).
- Investment mechanisms exist such as the contractual commitment of Independent Power Producers (IPPs) to invest in local communities.
- Various legally required processes are in place that assist with management of the water reticulation system (e.g. water balance reporting and No Drop Assessments)
- A River Management Maintenance Plan is being developed in terms of legislation (e.g. the Water Act No.36 of 1998; and the National Environmental Management Act (No. 107 of 1998)
- There are several water resilience initiatives in the area, including water quality monitoring and restoration, and stewardship programmes (e.g. Breede Catchment Water Stewardship Programme).
- The Municipality has environmental management inspectors for the enforcement of environment legislation (Green Scorpions also responsible for enforcement).
- Good water quality supply from sources (e.g. rivers and springs).
- Regular community information sessions (around housing consumer education) and active community committees already exist and could possibly include awareness-raising related to SWSAs.
- There is good co-operation between the Municipality and the Water Users' Association.
- In Ceres a multi-stakeholder forum around water exists to enable co-operation between business, local government and commercial agriculture. This forum could be expanded to include the whole of Witzenberg.
- A large proportion of the Witzenberg municipal area is already formally protected.
- A drought management team (including internal and external partners) exists and meets if needed (e.g. when droughts occur).

Constraints:

- A lack of education and awareness among various stakeholders of the importance of effective water management.
- Increasing population leads to a lack of land and insufficient services, resulting in negative impacts on water quality and quantity (e.g. environmental degradation due to settlements in sensitive areas, erosion resulting from overgrazing, pollution of rivers due to animal waste).
- Greater cooperation required between formal structures for water management between different spheres of governance; as well as across sectors (i.e. across municipal departments).

- Capacity shortages (e.g. skills) within the Municipality in key areas related to SWSAs.
- Increase in the amount of indigent population results in a decrease in municipal revenue available for the delivery and maintenance of services (e.g., water and sanitation infrastructure and refuse removal services) which can result in water losses (e.g., water leaks) and a decrease in water quality.
- Lack of policies and by-laws related to water, planning and illegal settlements, and inadequate enforcement of existing legislation.
- There are municipal budgetary constraints that lead to a focus on immediate needs (e.g. addressing burst pipes), limiting the amount of proactive maintenance and upgrading of water infrastructure that can occur.
- Insufficient participation of the community in the Integrated Development Planning (IDP) process.
- Inequalities because of historical spatial injustice increases the number of people living in poverty and without access to basic services and resources. This can increase direct dependencies on the natural environment (e.g. rivers for washing clothes, wood for fires), which can compromise human – and/or ecosystem- health.
- Improved communication and cooperation required between the various stakeholders in Witzenberg.

2.4.4 Phases 3 and 4: Strategies and projects

Following the identification of opportunities and constraints, participants were divided into two groups and asked to discuss possible strategies to enhance the opportunities and address the constraints. They were provided with copies of draft generic strategies identified through the City of Cape Town case study and requested to add and/or amend as needed. Each group then reported back in plenary. The next steps in the project were outlined by the project manager and the workshop was concluded.

An online workshop was held on 30 November 2023 to which the same officials (and a representative from the Water Users Association) were invited. In this session, a list of strategies was presented which comprised an integration of the first version which was developed through the City of Cape Town case study and those strategies which were raised at the Witzenberg workshop. This presentation was used as a basis for discussion around projects and/or actions that could be taken for the protection and management of SWSAs in Witzenberg.

An online meeting was held with a Town and Regional Planner from the Municipality on 23 July 2023. At this meeting, background to this project was provided and the discussion centred around possible “entry points” at which information around SWSAs could influence development planning decisions.

2.5 INTEGRATED STRATEGIES AND PROJECTS

2.5.1 Introduction

After concluding the engagements with the two case study municipalities the strategies and projects were revised, refined and further developed by the CSIR team: with the main themes evolving to those shown in Figure 2.9.

Figure 2.9. Main themes of the proposed strategies and projects for local government protection and management of SWSAs

In summary an integrated list of strategies and project ideas was produced from both case studies. This list was presented to City of Cape Town senior management representatives (11 July 2024) and provided to the WRC Reference Group for comment. The final version forms a key component of the Introductory Guide (Part 3).

These generic strategies and projects (shown in Part 3: Table 3.3) were informed by the following:

- Discussions at the workshop with the City of Cape Town on the 10 October 2023 (described in Section 2.3.4).
- An online meeting with officials from the City of Cape Town, held on the 24 October 2023 (described in Section 2.3.4);
- Inputs and comments received during a hybrid workshop with City of Cape Town senior management held on 11 July 2024 (described in Section 2.3.4);
- Discussions at the Witzenberg workshop on the 30 November 2023 (described in Section 2.4.4);
- An online meeting with officials from Witzenberg Municipality on 14 December 2023 (described in Section 2.4.4);

- Meeting with a Witzenberg Municipality Town and Regional Planner held on 23 July 2024 (described in Section 2.4.4);
- Written comments and inputs received on the Draft Framework Report from WRC Reference Group;
- A review of the literature which is listed separately in the references list at the end of this report (under the Section 2.7.2); and
- The project team's knowledge and experience.

The version of the strategies and projects presented in Part 3: Table 3.3 represent generic strategies and examples of projects or actions for the municipal maintenance and rehabilitation of SWSAs.

2.6 PHASE 5: MONITORING AND EVALUATION

2.6.1 Introduction

Monitoring is an important part of the Framework developed and the Introductory Guide that was drafted (Part 3:), as it is essential for understanding the effectiveness of any program or project. Regular assessment allows not only for the identification of successes and failures, but also areas for improvement, promoting accountability and guiding future action. to be identified. In this WRC project, monitoring (Phase 5) is aimed at assessing the extent to which the vision (Phase 2) and strategies (Phase 3) are being achieved through project implementation (Phase 4). Based on the strategies in Part 3: Table 3.3, generic examples of indicators were identified for municipalities to consider and/or adapt when measuring progress towards their SWSA vision.

2.6.2 Indicator development

Indicator development was initiated with a review of standards and existing indicator frameworks relevant to the field of SWSAs from which lessons and best practices were drawn (Allen et al. 2012; Bertule et al. 2017; Quayle et al. 2021, Dzino-Silajdzic, 2022). Although there are several types of indicators that can be used in monitoring and evaluation (Bertule et al. 2017), the CSIR team focused on developing **output indicators** able to measure the direct outcomes of a program as well **outcome indicators** which are able to measure the changes or impacts that result from a program or project developed (Kareemulla, 2017; Dzino-Silajdzic, 2022).

Draft indicators that address each of the strategies under the five themes identified for local government protection and management of SWSAs were developed. This was undertaken by dividing the five themes among the CSIR team members and tasking them with the development of indicators for their respective theme. Indicators were developed to, as far as possible match the examples of projects and/or activities listed in Table 3.3. These indicators were then reviewed by the CSIR project team in plenary. Where applicable the tools to be used for data collection were defined (e.g. questionnaires, field assessments, water meters) and the frequency with which each indicator should be monitored (e.g. monthly, quarterly, annually) was stated.

The draft indicators were further refined in a workshop held with the City of Cape Town project team members. Both team members are in the Technical Services Department under the Scientific Services Research and Development branch responsible for ensuring that the municipal water quality complies with water quality checks prescribed by DWS. In this workshop the indicators under each of the five themes were reviewed in detail with worksheets provided for written comments and edits.

Input was also obtained from a senior specialist at the CSIR related to Theme 3: Water Conservation and Demand Management: Strategy Two (Part 3: Table 3.3). Indicators then underwent a final review by an independent internal reviewer. All comments and edits received during the refinement process were incorporated to produce the final indicators shown in Part 3: Table 3.5).

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PART 3: STRATEGIC WATER SOURCE AREA INTRODUCTORY GUIDE

3.1 INTRODUCTION

South Africa is a water scarce country, a situation that is exacerbated by the spatial variability and seasonal fluctuations in the distribution of water (Hedden and Cilliers, 2014; DWS, 2022). The country depends on finite water resources for its growing economy and population (DWS, 2022). Also, surface water must be retained in rivers and dams to maintain the ecological health of the water system or to support downstream requirements (Hughes et al., 2014; Makanda et al., 2022). However, South Africa's water security is threatened by the potential negative impacts of climate change, the degradation of rivers and wetlands, urbanisation, inefficient water use and the over-abstraction of water resources, among other factors (DWS, 2022). Water quality is also an increasing concern with many rivers and dams being over-loaded with nutrients and other pollutants (Nel et al., 2013).

Over the last decade, South Africa's tenuous water security has been placed in the spotlight by severe droughts, with growing demand exceeding the limited supply in several areas (Maze et al. 2019). It is within this context that South Africa's Strategic Water Source Areas (SWSAs) need to be maintained and enhanced. In 2017, it was found that SWSAs support around half of South Africa's population and two-thirds of its economy; with the major urban centres generally obtaining a high percentage of their water from surface water SWSAs; while about 70% of water used for irrigation is directly or indirectly obtained from these water sources (Nel et al., 2017; Le Maitre et al., 2018; SANBI 2023). However, SWSAs are generally poorly protected with only 18% of surface water SWSAs under formal protection (Stats SA, 2023). In this document the term "protection" includes targeted intervention, management and formal protection. At a local level, municipal implementation of strategies to maintain and enhance SWSAs is a critical gap that needs to be addressed (Le Maitre et al., 2018). This document therefore provides introductory guidance around the maintenance and enhancement of SWSAs, specifically related to municipal planning and decision-making.

3.1.1 Purpose and structure of this guide

The purpose of this Guide is to provide a Framework for local municipalities to develop their own strategies for the protection and management of SWSAs. In this Guide, basic steps to follow in developing such a strategy are outlined. The process followed is a generic one commonly used in strategic planning, such as the Integrated Development Planning (IDP) process (Coetzee, et al., 2000), as well as in environmental management, such as in objectives-led Strategic Environmental Assessment (DEAT, 2000). The Guide emphasises the key steps, actions and considerations that are particularly relevant to strategy development for SWSAs at the local scale.

This Guide will help the user to:

1. Understand the role of, and threats to, SWSAs in water supply in South Africa;
2. Understand and implement key steps for the development of a strategy for SWSAs within local government, which can be integrated into other municipal processes; and
3. Improve the protection and management of SWSAs within the municipal area, through a cross-departmental approach.

The Guide is structured as follows:

- Section 3.1.5 and 3.2 explain what SWSAs are, the benefits they provide, and the key threats to SWSAs in South Africa;
- Section 3.3 provides a Framework for developing a strategy for SWSAs management for local government outlining the 5 phases of the strategic process along with examples of recommendations and key actions for each phase;
- Section 3.4 provides useful resources that can assist in the strategy development process.

3.1.2 Who should use this Guide?

The document is intended to guide municipal officials in South Africa involved in strategic planning and urban design, environmental management, conservation, water and sanitation services, social development, finance, recreation and parks, as well as other relevant departments. The Guide is also intended to be used by local stakeholders (e.g. business representatives, Non-Government Organisations (NGOs) and Civil Society Organisations (CSOs). Officials from other spheres of government (e.g. provincial and national) who are involved in the protection and management of SWSAs may also find specific sections of the Guide useful for informing policies and actions.

3.1.3 How should the Guide be used?

This Guide should be used as a *basis* for the development of municipal strategies for the protection and management of SWSAs and not as a comprehensive outline of all actions required. It is important to note that the limitations of the Guide include the following:

- The Guide does not address the legislative aspects related to strategy development or the implementation of the strategies and projects presented; and
- The strategies and projects presented need to be adapted to the context of each municipality, which should decide how to apply the guidance in this document.

3.1.4 How was the Guide developed?

This Guide forms part of the deliverables of a three-year WRC project (April 2022 – March 2025) titled *Implementation of South Africa's Strategic Water Source Areas: Towards Effective Governance and Protection,* led by the Council for Scientific and Industrial Research (CSIR) in collaboration with the City of Cape Town Metropolitan Municipality (CCT) and Witzenberg Local Municipality (WLM), including a representative from the Water Users Association. Two representatives from the Technical Services Department of CCT are part of the project team. The project Reference Group included individuals from DFFE, DWS, SANBI, Stellenbosch University, MTPA, SALGA, CER and WWF-SA (see Acknowledgements).

The overarching objectives of the WRC project are to:

- Provide introductory guidance around the effective management of SWSAs in local municipalities in South Africa;
- Contribute to securing SWSAs in line with the DFFE’s identified mechanisms for securing SWSAs and
- Support the Kunming-Montreal Global Biodiversity Framework (GBF) Target 3 to secure 30% of ecosystems by 2030.

The SWSA framework for local municipalities was developed using a case study approach which allowed for its co-development and increased its applicability to the management, protection, spatial prioritisation and monitoring of key freshwater sources in SWSAs at the local government level. Two case study areas were selected to represent different municipal structures and levels of complexity within the local sphere. These case study municipalities are as follows:

- A large Category A metropolitan municipality (City of Cape Town), and
- A small to medium, Category B local municipality (Witzenberg Local Municipality).

Only two case studies could be conducted within the scope of the project, so the third category of municipalities in South Africa, Category C District municipalities, are not represented in the case study sample, due to time and budgetary constraints.

The framework was developed and refined with inputs from municipal officials and representatives from the two case study municipalities. Engagements consisted of an in-person workshop and online meeting with City of Cape Town in October 2023; an in-person workshop and online meeting with Witzenberg Local Municipality in November and December 2023, an engagement with senior City of Cape Town municipal officials in July 2024, and a meeting with a Witzenberg Municipality Town and Regional Planner in July 2024. For more detailed information on the framework development see Part 2.

3.1.5 What are Strategic Water Source Areas and what benefits do they provide?

South Africa, Lesotho and Eswatini together have 22 SWSAs for surface water, and South Africa has 37 SWSAs for groundwater (Le Maitre et al., 2018). SWSAs are defined as shown in Information Box 1 below and spatially defined for both groundwater and surface water in South Africa (Figure 3.1). A WRC funded project on SWSAs in 2018 refined the first set of SWSAs (Nel et al., 2013) considering national water resource planning priorities and including SWSAs for groundwater (Le Maitre et al., 2018). Since then, surface water SWSAs have been refined in various ways with increasing precision in each iteration.

Information Box 1. Definition of Strategic Water Source Areas

Strategic Water Source Areas (SWSAs) are "… areas of land that either: (a) supply a disproportionate quantity of mean annual surface water runoff in relation to their size and are considered nationally important; or (b) have high groundwater recharge and where the groundwater forms a nationally important resource; or (c) areas that meet both criteria (a) and (b). They include transboundary areas that extend into Lesotho and Swaziland" (Le Maitre et al., 2018: iv).

SWSAs supply a disproportionate amount of mean annual runoff to important areas in the country such as the major metropolitan areas and agricultural landscapes. Their degradation can have a disproportionately negative effect on the settlements and ecosystems that they support (Nel et al., 2013). From a regional perspective, surface water SWSAs represent just 10% of the land surface area of South Africa, Lesotho and Eswatini, but generate 50% of the region's surface runoff (Le Maitre et al., 2018). Groundwater SWSAs cover 9% of the land surface in South Africa and generate up to 42% of the baseflow in their areas, performing an important role in the dry season through maintaining surface water flows (Le Maitre et al., 2018, Figure 3.1).

SWSAs provide many benefits to society, including water for domestic (e.g. drinking and cleaning), industrial (e.g. cooling at power stations) and agricultural (e.g. irrigation) purposes (Le Maitre, 2018). Surface water SWSAs supply water that supports at least half of the population and economic activities that generate more than 64% of Gross Value Add (GVA); as well as providing water - directly or indirectly - for 70% of irrigated agriculture (Nel et al., 2017; Le Maitre et al., 2018; SANBI, 2019).

Le Maitre et al. (2018) emphasised that it is important to recognise that SWSAs are 'working landscapes' that encompass a variety of land uses and human activities. The governance of SWSAs therefore crosses multiple government departments, spheres of government (i.e. traditional, local, provincial and national) and stakeholders (e.g. private landowners, private sector, NGOs and CSOs. It is important to understand that SWSAs are part of an integrated social-ecological system which supports their continued function and service provision.

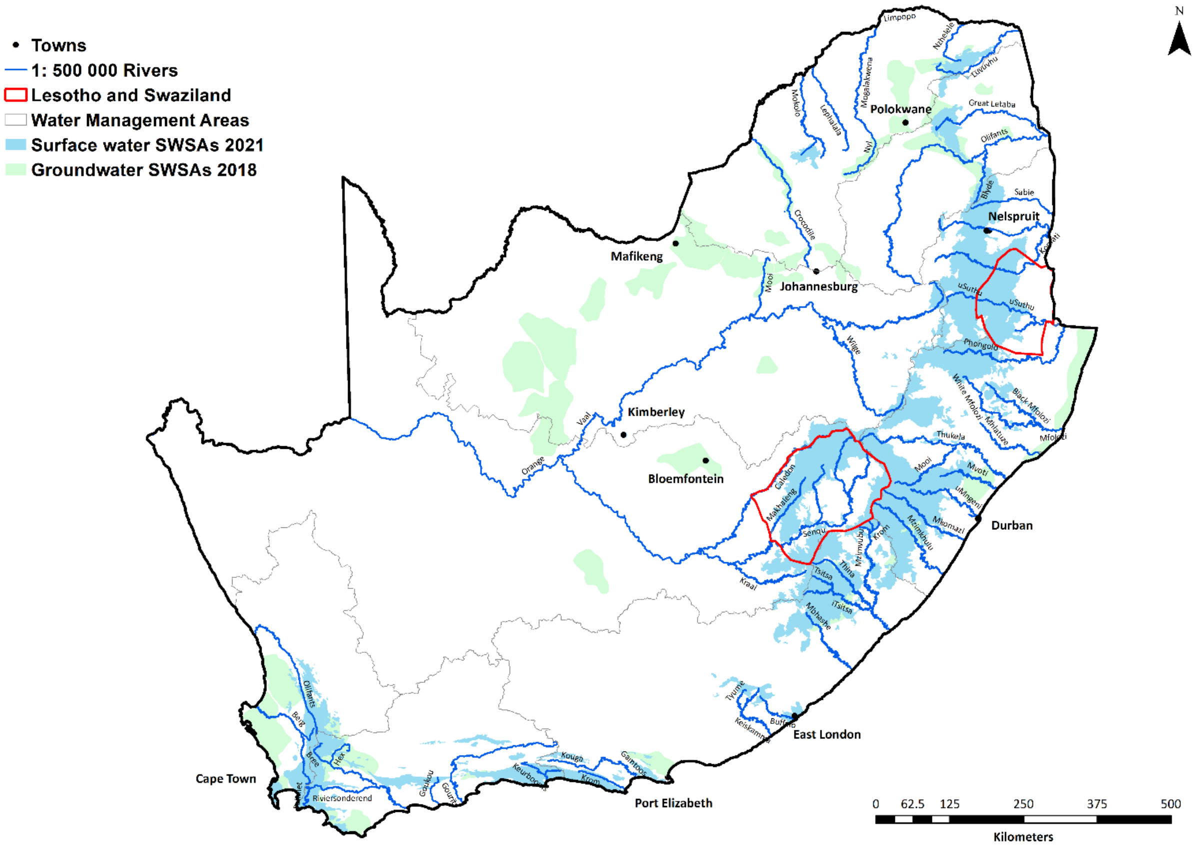

Figure 3.1: South Africa's Strategic Water Source Areas for groundwater (Le Maitre et al., 2018) and surface water (Lötter and Le Maitre, 2021)

3.2 PRESSURES ON STRATEGIC WATER SOURCE AREAS

This section summarises the pressures on water resources in the SWSAs based on land use and land cover changes that have occurred, as well as mining activities, changes to the hydrological regime, the impacts of invasive alien plants, pollution and climate change.

Table 3.1. Key pressures on water resources in the SWSAs

Drivers of SWSA degradation	Examples of pressures	References (further reading)
Loss of natural habitat and land degradation		
Habitat loss and or fragmentation and land degradation due, for example, to unsustainable land use activities, including over-grazing, uncontrolled urban expansion, unsustainable	Increase in surface runoff, reducing infiltration and groundwater recharge, reducing water availability. Removal of vegetation in riparian zones leading to soil erosion and sedimentation, which increases turbidity and decreases water quality. Increase in water pollution resulting from pesticides, fertilisers and industrial effluent, among other factors.	Beaumont, 1981; Fogg and Wells, 1998; Elliot et al., 1998; IPBES, 2018; Knox, 2001; Smakhtin, 2001 and

Drivers of SWSA degradation	Examples of pressures	References (further reading)
agricultural practices and certain extractive industries.	Destruction of species habitat and biodiversity as well as changes in the fire regime. Irrigation return flows (i.e. non-point source pollution) resulting in eutrophication and also affects baseflow related to lower groundwater levels. Changes in surface water flows due to, for example, channelisation and the construction of dams. Reduced infiltration and groundwater recharge as a result of increased impervious surfaces, which leads to a reduction in water availability. Removal of vegetation in the riparian zone resulting in flooding and channel enlargement.	Dabrowski et al., 2013.
Mining		
Coal mining (e.g. open cast and extensive shallow coal which mainly support power production) and other mining such as gold mining.	Gold and coal mining causes acid mine drainage (AMD) as water reacts with sulphides in rock, causing sulphuric acid. This acid then dissolves toxic metals, and these metals damage the health of riverine fish, livestock and people. Acidic water can also contaminate groundwater. Bad effects on both water quality in the forms of AMD, discharges, slimes dam overflows, or runoff and water quantity, mainly through water consumption in the mining processes.	Ashton and Dabrowski, 2011; CSIR, 2011; Colvin et al., 2011; Matthews, 2017 and Le Maitre et al., 2018.
Changes to the hydrological regime		
Construction of dams and weirs along rivers and resultant fragmentation; unsustainable rates of abstraction from aquifers, rivers and wetlands for example municipal water use and irrigated agriculture; channels/drains that are used to drain wetlands to reduce the soil saturation/inundation, so that the land can be used for grazing or crop production and water diversion from the local rerouting of surface water to inter-basin water transfer schemes.	Instream dams and weirs reduces the ability of rivers to deliver sediment downstream and concurrently inhibiting the migration of biota (e.g. fish) along rivers for various parts of their life cycles (e.g. fish spawning in estuaries). Direct river abstractions decrease the amount of water flowing in the channel impacting on river and wetland ecosystems. This also have a pronounced effect on streamflow during the dry seasons (i.e. causing drying-out events). A reduction in water availability because of over-abstraction may have several impacts, including changes in species composition, the deterioration and loss of habitats, bank and bed erosion in recipient catchments, loss of sensitive species, species invasion, mobilisation of trace metals and changes in the chemistry and thermal ranges of recipient rivers. Groundwater abstraction can impact rivers and wetlands to different degrees, since only some rivers and wetlands are Aquifer Dependent Ecosystems (ADEs). Return water primarily from urban and agricultural water users is of a poorer water quality than abstracted water.	Fogg and Wells, 1998; Le Maitre et al., 1999; Malai et al. 2018; Snaddon et al., 1999; Smakhtin, 2001 and van Deventer, et al., 2019.
Invasive alien plants		
Invasive alien plant species introduced intentionally (for e.g. agriculture or forestry) or unintentionally by for	Invasions in rivers and wetlands threaten ecosystem integrity and reduce their ability to deliver vital services in several ways. They reduce the country’s available water resources, the natural biodiversity, use more water than indigenous	Van Wilgen, 2009; Le Maitre et al., 2015; Dzikiti et al., 2016 and

Drivers of SWSA degradation	Examples of pressures	References (further reading)
example commodity contaminants. Rivers, riparian zones and wetlands are amongst the most heavily invaded ecosystems.	plants and degrade freshwater ecosystems (e.g. channel erosion). Invasions are a huge threat to water security particularly in water scarce areas including towns and cities because of their excessive water consumption. They alter fire regimes due to their ability to produce large volumes of highly flammable biomass.	Faulkner et al., 2017
Pollutants of water resources		
Water quality deterioration in the form off: Sedimentation (e.g. via changing land cover/use). Pollution (e.g. nutrient such as Waste Water Treatment Works (WWTW) and agricultural runoff; chemical such as mining waste; microbial such as livestock waste and thermal such as industrial effluent or stream regulation). Salinity related to return flows (surface and subsurface) and saltwater intrusion in groundwater. Industrial effluent and urban runoff. Pesticides and fertilizers, agriculture. Microplastics (e.g. industrial spillages and user discards). Pharmaceutical products from WWTW. Aquaculture (e.g. land-based farms and cage-based farms, (instream and dam-based).	Loss of habitat for aquatic biota. Nitrification with resultant loss of oxygen and eutrophication of water bodies. Acidification of surface water affecting primary and secondary producers. Increased biomass in wetland vegetation and changes in productivity and species composition Salinity results in alterations in distribution patterns of species or communities The impacts of mining on water resources are considered to be some of the biggest current environmental threats. Toxicity of high sulphate and metal concentrations leads to loss of species. Contamination has significant negative impacts on water quality, biodiversity and human health. The resulting nutrient enrichment of water courses contributes to eutrophication in rivers and several large dams across the country. Leaking, spillage or flooding of waste water can result in untreated sewage entering rivers, wetlands, dams and aquifers. Waste water contamination in SWSAs can enhance the spread of diseases such as E. Coli bacteria, diarrhoea and Hepatitis A. Organic enrichment and increase in turbidity and suspended solids. Aquaculture practices in mountain stream catchments will have a greater impact on water quality and biota than farms further downstream. Increased water temperatures result in changes to water quality, which will impact aquatic biodiversity.	Ashton 2010 and van Deventer et al., 2019.
Climate Change		
Climate change (i.e. long-term shifts in temperatures and weather patterns) due to the burning of fossil fuels like coal and gas,	South Africa is likely to experience changes in temperature and changes to the amount, intensity and season of precipitation, which will likely result in changes of the evapotranspiration and other parts of the hydrological cycle. Evidence of warming and subsequent increasing in air temperature, number of hot days and duration of warm spells	Engelbrecht, 2019 and van Deventer et al., 2019.

Drivers of SWSA degradation	Examples of pressures	References (further reading)
is being felt mainly through water impacts. It is considered a key driver of evolutionary change and will exacerbate existing pressures altering the frequency, intensity and timing of events.	is very likely to increase evapotranspiration and impact the hydrological regime of freshwater ecosystems. The arid interior (the Karoo region in particular) is expected to experience larger increases in temperature than the coastal regions. Higher temperatures will mean that plants need more water, evaporation rates increase, and algal blooms are more likely to make the water in dams unusable. Human responses to climate change are likely to further increase some pressures, for example, reduced rainfall (compounded by biological invasions) drives an increase in water abstraction which compounds the pressure on the aquatic ecosystem and species.	

3.3 FRAMEWORK FOR SWSA MANAGEMENT FOR LOCAL GOVERNMENT

3.3.1 Introduction

As mentioned above, the structure of this Guide is designed around a traditional strategy development process (DEAT, 2004). However, this is not a comprehensive guide to this process as the focus is on key, broad elements of strategy development which can be integrated into other municipal processes (e.g. the IDP process). The purpose of the Guide is to highlight the factors that should be considered when planning for the management and enhancement of SWSAs. The planning process consists of five phases (Figure 3.2), each of which is described in more detail in the sections that follow.

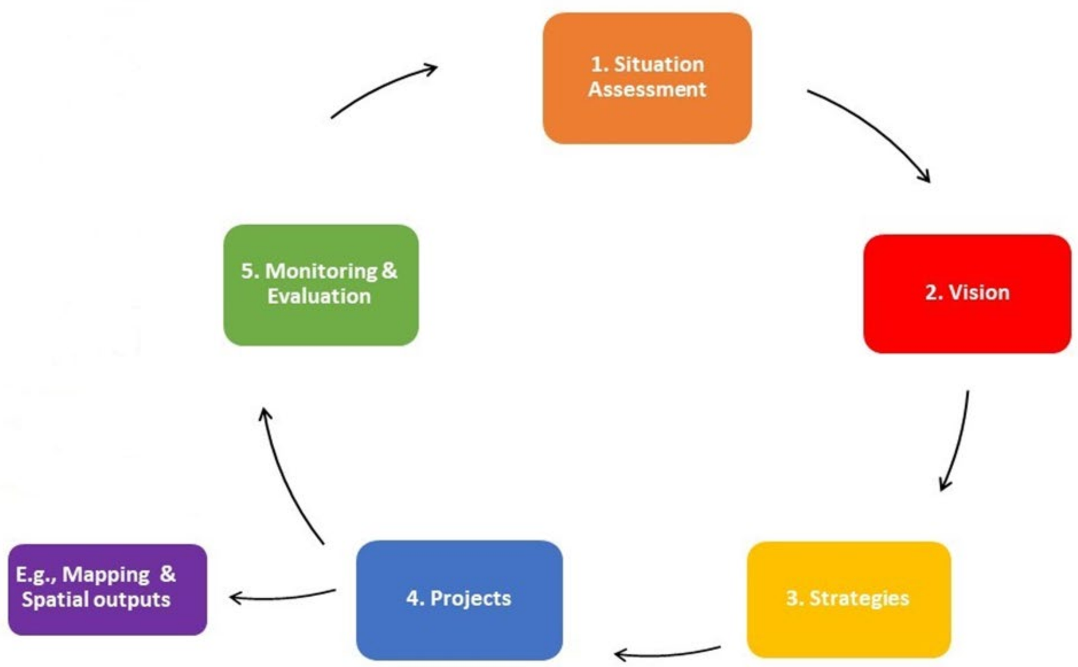

Figure 3.2: Process flow diagram illustrating the process and approach followed in the case study areas.

3.3.2 Situation assessment

Situation assessment is a method for studying complex adaptive systems (Martin, 2016). The situation assessment can assist in developing a picture of the broader context in which the project will operate. A situation assessment should include the following elements (IUCN, 1999):

- An analysis of the state of ecosystems and the socio-economic environment, including identification of trends and pressures;
- Identification of major socio-economic and ecological issues that should be addressed; and
- Identification of key stakeholders – individuals, groups of people and/or institutions with a mandate and/or interest in resources and their management in the geographic area under consideration.

A situation assessment should be carried out with the key stakeholders in the municipality; and Opportunities and Constraints should be identified based on an understanding of the current situation (as well as the vision identified in Phase 2) (DEAT, 2000).

Application to Strategic Water Source Areas

To ensure that SWSAs are properly managed and protected in a rapidly changing and complex world, managers need to be aware of and understand the context within which SWSAs occur (IUCN, 1999). This is essential in developing goals objectives, strategies, and activities that will allow managers to adapt and respond to both current and emerging issues (Montanye, 2006). A situation assessment can serve as a baseline against which to monitor and manage change. It can also advance our understanding of the broad range of people, institutions and organisations involved in the protection of SWSAs (IUCN, 1999).

Objectives of the Situation Assessment

This section will guide the reader through the steps to develop a situation assessment. After completing the steps in the situation assessment, the reader will:

- Have a good understanding of the current situation (extent and severity of socio-economic and ecological issues);
- Understand the broad context within which SWSAs exists;
- Understand the key trends, pressures and drivers; and
- Have a holistic understanding of the opportunities and constraints to enhancing and managing SWSAs (i.e. achieving the vision identified in Section 3.3.3).

Undertaking a Situation Assessment

Step 1: Define the boundaries of the area to be included in the assessment

The first step in a situation assessment is to define the boundaries of the assessment (Guijt and Moseev, 2011). Ideally this should be done using maps and descriptive statements. For municipalities, the boundary will likely be the administrative municipal boundary. Spatial layers that can be included to orientate participants include the catchment boundary, municipal boundary, SWSAs, rivers and their ecological status, wetlands, protected areas, land cover classes and towns. The maps of the area should be displayed clearly and used during the rest of the situation assessment.

Step 2: Identify the relevant information

In this step, information is collected through a review of relevant literature. The situation assessment should be based on relevant data and can include both quantitative and qualitative information on the issues affecting the ecological and socio-economic environment (Guijt and Moseev, 2011). Available data and information from credible sources such as local, regional and national datasets should be used. Other sources include national strategies and policies to address the issue, sector or thematic studies, technical reports or academic theses, bibliographies, and references of relevant research studies, published research and media reports. Municipal policy documents such as the IDP, Spatial Development Framework (SDF) and Water Master Plan should be consulted. It is important to include information on the condition of both the ecological and socio-economic environments, as they are vitally important in managing and enhancing SWSAs.

Examples of ecological characteristics to consider:

- The diversity and quality of inland water;
- The effect of land use modification, pollution, and water withdrawal on waterways;
- The diversity and quality of land ecosystems including their modification, conversion; degradation;
- Resource use in terms of water demand and supply;
- Water-related climate change predictions; and
- Protected or conserved areas.

Examples of social characteristics to consider:

- Demographic information (e.g. age, race, gender, population growth, level of education);
- Economic factors (e.g. level of unemployment, income, economic growth, inflation);
- Access to social facilities (e.g. health care);
- Access to water and sanitation;
- Knowledge and culture (knowledge/awareness of ecosystem processes related to water);
- Governance and institutional arrangements;
- Level of crime;
- Equity (e.g. distribution of benefits and burdens among males and females; and between income groups); and
- State of water infrastructure.

Step 3: Research and describe the state and condition and identify trends and pressures of the biophysical and socioeconomic environment.

Based on the information collected, the current state and condition of the biophysical and socioeconomic environment should be researched and described. This is undertaken by analysing the information to identify the trends in changes in conditions as well as the drivers of these changes. To identify trends, it is useful to consider how people and ecosystem conditions have changed in recent years. For example:

- Is there a pattern of water quality decline that can be identified?
- Has the population increased or decreased and how might this affect SWSAs?
- Which pressures are generating the trends identified?
- Is the municipality facing any problems related to invasive species management, changes associated with climate change, stream fragmentation and/or in-stream flow alterations, or changes in protection status?

Step 4: Discuss the assessment and identify the major issues requiring attention.

Discuss the situation assessment, trends and pressures identified with municipal officials, stakeholders, experts, and partners to identify gaps and reach agreement on the most important issues to be addressed for enhancing and managing SWSAs.

Step 5: Identify opportunities and constraints to enhancing and managing SWSAs.

Based on an understanding of the current situation as derived from the situation assessment and the vision identified (Section 3.3.3), the key opportunities and constraints to managing and enhancing SWSAs should be identified. An opportunity is a resource, capacity, or favourable situation the municipality can use effectively to achieve its vision. Constraints are a limitation, unfavourable situation or barrier that will keep the municipality from achieving its vision (University of Cambridge, 2016). It is important to note that the identification of opportunities and constraints and the development of the vision, is an iterative process. In the example below in the City of Cape Town case study (2), the opportunities and constraints (to the general maintenance and enhancement of SWSAs) were identified prior to formulating the vision. Ideally once the vision is completed the opportunities and constraints should be re-visited in light of that vision (i.e. is the list of opportunities and constraints completed when considered in light of achieving the vision?).

Information Box 2. Example process for identification of Opportunities and Constraints

Opportunities and Constraints: City of Cape Town
The way in which this step was implemented in the development of this Guide in the City of Cape Town case study, was that the project team drafted a preliminary list of opportunities and constraints based on information drawn from existing literature on best practice in water resource management and from relevant City of Cape Town documents. The list was presented to participants in an in- person workshop. Participants were then divided into three groups based on the departments in which they work. Below an example from the City of Cape Town workshop.

- **Group 1**: Participants working in the Bulk Water Department.
- **Group 2**: Participants from the Scientific Services Branch and Catchment, Stormwater and River Management Department.
- **Group 3**:Participants from Environmental Management Department, Spatial Planning Department and Water and Sanitation Communication and Partnership Branch.

Each group was provided with a print-out of the draft opportunities and constraints and asked to discuss, add and/or edit these as they see fit. Additional opportunities and constraints were written down on cards. Additional and edited opportunities and constraints were then grouped and summarized by the CSIR team in the workshop and presented back to the participants. Participants were asked to expand or clarify points that were not clear.

Example of an Opportunity
Opportunities currently exist for the municipality to form partnerships around SWSA education and awareness.

Example of a Constraint
Ecosystem services provided by SWSAs (e.g., water purification by wetlands) are threatened by, for example: unplanned development (including escalating illegal land invasions); development in areas of high environmental sensitivity (e.g. because of a lack of land for housing); and/or by environmental degradation (e.g., from pollution or the spread of invasive alien plants (IAPs).

Step 6: Conduct a stakeholder analysis.
A stakeholder analysis involves a process of identifying potential stakeholders in the municipality/or catchment and assessing their mandate, interest and influence regarding SWSAs and the way in which these can potentially affect, or be affected by, the project (IUCN, 1999). Given the interconnected nature of SWSAs, collaborative governance involving multiple stakeholders such as government officials, local communities, and NGOs is essential in managing and enhancing SWSAs effectively.

Based on a comprehensive stakeholder analysis, a stakeholder engagement strategy can be developed. This should describe the level of participation for each stakeholder at each phase of the project. It is important to manage stakeholder expectations throughout the project by providing regular updates, seeking feedback and addressing issues promptly (Sedmak, 2021). The stakeholder analysis should be updated regularly throughout the project to reflect stakeholder dynamics and adapt strategies and projects accordingly. For a more detailed description of this process see Guijt and Moseev (2011).

Recommendations and key actions

- The extent of the situation assessment will be influenced by resources such as time, budget and capacity. It will also be influenced by the spatial area being studied. A rapid assessment, if based primarily on existing resources, could take approximately two to three weeks. However, a more comprehensive assessment could take longer.
- Although the situation assessment begins with a literature review, stakeholders should have an opportunity to address any gaps in this literature, as well as provide their experiential knowledge and perspectives. Such engagement can be undertaken through workshops, focus groups and meetings; together with circulating the situation assessment for comment.
- SWSAs occur in working landscapes, with a mixture of land uses and land management activities that can adversely affect water flows and quality. It is important that the project team undertake a site visit to understand how water quality and quantity of rivers changes as it moves through the landscape; as well as to observe the different socio-economic dynamics around SWSAs (e.g. current land uses, the manner in which water is practically managed) that may not be addressed in the literature.
- To identify the opportunities and constraints to enhancing and managing SWSAs, a SWOT (Strengths, Weaknesses, Opportunities and Threat) analysis can also be done.
- The Situation Assessment is one of the first steps to be undertaken in developing a strategy for the management of SWSAs; but should be used and updated throughout the project.

3.3.3 Visioning

The vision is a broad, overarching statement of what the strategy aims to achieve in the medium - to long - term future (DEAT, 2000). The vision statement is typically quite ambitious and should be inspiring and aspirational. It should also, however, provide a clear focus and direction for the strategy and be meaningful, realistic, and achievable (Kaplan et al., 2008). The vision assists in aligning stakeholders around a shared view of the desired future and should therefore include all key stakeholders (Surya, 2023).

Application to Strategic Water Source Areas

Visioning is typically undertaken in a workshop/meeting context and representatives from all key stakeholders should be invited to participate. In the context of SWSAs this is important, *inter alia,* because the management of these areas requires an inter-disciplinary approach that crosses the responsibilities of multiple stakeholders and municipal departments.

The vision should build on an understanding of the current situation (socio-economic and biophysical). The visioning process should be undertaken in the context of a broad goal of maintaining and enhancing SWSAs; aligning with the principles of sustainable development contained in the National Environmental Management Act (NEMA) No 107 of 1998). The vision should also align with other municipal visions of the future articulated, for example, in the IDP. A general vision for SWSAs would typically aim for example, to enhance water quality and quantity for the benefit of future generations. There are numerous ways to develop the vision an example of the process followed in the City of Cape Town and Witzenberg Local Municipality is shown in Information Box 3 below.

Information Box 3. Example of visioning process followed in case studies

City of Cape Town and Witzenberg Local Municipality Visioning Process

In the City of Cape Town and Witzenberg Local municipalities the visioning process was conducted by presenting and discussing information on key trends, pressures and drivers from the situation assessment to workshop participants. This provided an opportunity to discuss the most significant issues to be addressed in the protection of SWSAs and improvement of the condition of ecosystems and the lives of the people. Each participant was then presented with three cards on which to write words/phrases that they think are important to include in the vision. The CSIR team then grouped these phrases (Figure 3.3) and drafted a preliminary vision statement which was then discussed with the participants and edited through until a final draft vision statement was reached. The vision was finalised in a follow-up online meeting held with City of Cape Town officials.

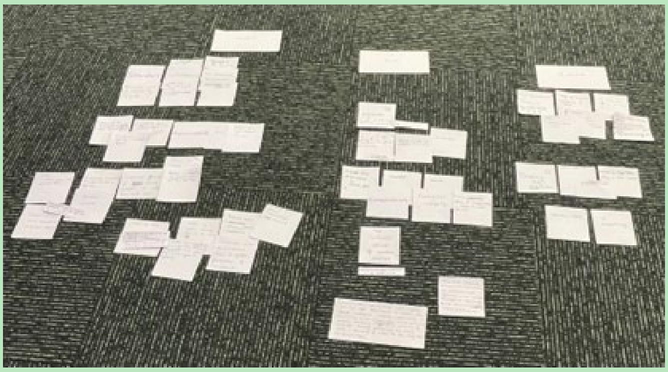


Figure 3.3: The CSIR team grouping cards for vision statements at City of Cape Town workshop on 10 October 2023.

Example Vision 1: City of Cape Town

We, the City of Cape Town, are working together with partners and communities to identify risks, monitor, protect and improve the green infrastructure of our Strategic Water Source Areas (SWSAs) biodiversity and social wellbeing-enhancing the future value of SWSA and advancing the City's vision to become a water sensitive city by 2040.

Example Vision 2: Witzenberg Local Municipality

Working with the community and forming partnerships to ensure adequate supply, protection and conservation of SWSAs for water security, while ensuring equitable access to effective and efficient services, balancing the economy and ecology.

Recommendations and key actions

- If possible, make use of an experienced facilitator to guide the visioning process.
- As mentioned above, all key stakeholders should be provided with an opportunity to be part of the visioning process. Beyond the local authority, these stakeholders should include NGOs, business, private landowners, community representatives, Community-Based Organisations (CBOs,) and universities, among others. When considering participants from the local authority, it is important to ensure the involvement of multiple departments, to facilitate the effective maintenance and enhancement of SWSAs (Table 3.2).
- It is important that senior leadership (i.e. officials and politicians) support for the SWSA strategy process (or its integration into another municipal process) is obtained.

- Sufficient time should be allocated for the visioning process and all participants should have an opportunity to provide their input. However, it is also important that a time limit is placed on this process if it is undertaken in a workshop, for example, because the vision can typically always be further refined.

Table 3.2. Examples of municipal departments to typically involve in SWSA projects (Adapted from City of Cape Town)

Municipal Department/Sub-Department	Expertise/functions related to SWSAs
Environmental Department	Conservation planning Environmental education Invasive alien species management
Technical Services	Water infrastructure maintenance
Urban Planning and Design Department	Land use management Spatial Development Frameworks- spatial planning input and proactive planning assistance Integrated Development Planning (IDP)
Disaster Risk Management Centre	Public Awareness and Preparedness Special Planning and Critical Infrastructure
Financial Services Department	Financial management Supply chain management
Social Development and Early childhood development department	Community engagement Expanded Public Works Programme Social and economic development Safe and healthy environment
Recreation and Parks Department	Greenbelts (open spaces, forest, farms, parks)
Waste Services Department	Reducing the impacts of waste on health, well-being and environment Conserving resources and the environment
Water and Sanitation	Catchment, stormwater and river management (water quality, flood risk, stormwater harvesting) Bulk water (water catchment areas, storage dams, groundwater sources, water treatment works) Reticulation Waste Water Treatment Water Demand Management and Strategy

These departments and sub-departments are listed here as an example adapted from the City of Cape Town (https://www.capetown.gov.za/Departments); however, different municipalities will have different departmental configurations.

3.3.4 Strategies

Strategies are the pathways through which (based on the current situation) the vision (Phase 2) is to be achieved. In other words, the strategy provides a link between the current situation and the envisaged desired future (Indeed Editorial Team, 2022). Strategies should be clear and concise and developed in a way that addresses the constraints and maximizes the opportunities identified in the situation assessment (Phase 1) (DEAT, 2000). The set of strategies should aim for mutually beneficial gains for achieving the vision (OECD, 2006) and ideally all key stakeholders should be involved in the process of strategy development. The effectiveness of the strategy can be determined by the extent to which it achieves the vision (DEAT, 2000).

Application to Strategic Water Source Areas

In the context of SWSAs, strategies would relate, for example, to monitoring water quality, conserving water quantity, and protecting floodplains. As mentioned above, the strategies should aim to address the constrains and enhance the opportunities identified in the situation assessment. Examples related to the municipal maintenance and enhancement of SWSAs is provided below. This is to demonstrate the relationship between the opportunities and constraints and the strategies. It should be noted that some strategies may address multiple opportunities and/or constraints; or multiple strategies could address single opportunities and/or constraints.

Information Box 4. Opportunities and constraints to achieving the vision for SWSAs in the municipal area with examples of corresponding strategies

EXAMPLES OF OPPORTUNITIES AND CONSTRAINTS	EXAMPLES OF CORRESPONDING STRATEGIES
CONSTRAINT: Increasing urbanisation results in increased water demand and reduced infiltration and groundwater re-charge.	Ensure that future urban development and design does not compromise water quantity and quality in the municipal area. Consistently monitor groundwater and surface water quantity, ensuring that existing activities that may adversely affect surface water and groundwater quantity are effectively managed (e.g. enforce conditions of water use licences) and the impacts monitored and mitigated. Minimise water losses, as far as possible, to ensure sustainable supply Ensure that future urban development and design does not compromise water quantity in SWSAs in the municipal area (e.g. considering water availability when drafting the SDF).
CONSTRAINT: Continued water losses due to increases in the spread of invasive alien plants (IAPs). In addition, IAPs in SWSAs decrease runoff and recharge and degrade the ecosystem's ability to maintain its integrity and ability to deliver ecosystem services. **OPPORTUNITY**: Initiatives exist in the municipality to remove invasive alien plants (in partnership with others) and to expand land under conservation which will assist in the management and protection of SWSAs (e.g., through reducing water losses).	Ensure the effective clearing of invasive alien plants in river systems and catchment areas - including the upper catchment as well as downstream - to protect ecosystems and enhance stream flow.
CONSTRAINT: A lack of diversification of water sources, raises the City's vulnerability to increased demand and climate change, among other factors.	Explore opportunities to diversify water sources to increase resilience within the municipal area.

EXAMPLES OF OPPORTUNITIES AND CONSTRAINTS	EXAMPLES OF CORRESPONDING STRATEGIES
CONSTRAINT: There are currently capacity shortages (e.g. skills) within the Municipality in key areas related to SWSAs. OPPORTUNITY: Opportunities currently exist for the municipality to form partnerships around SWSA education and awareness.	Promote and enable awareness and communication within the municipality - and among all stakeholders - around SWSAs, the benefits that they provide, and the need for their maintenance and enhancement.

Depending on the municipal context (its current status, challenges and opportunities) and the vision for SWSAs, the strategies developed in each municipality will differ. However, as part of the development of this Guide, a list of generic strategies for municipal maintenance and enhancement of SWSAs was developed to provide a *basis or starting point* for municipalities to use when developing their own strategies to address the opportunities and constraints to achieving their SWSA vision (as discussed in Section 3.3.2). It is proposed that these generic strategies be used to begin the discussion within local municipalities. The strategies are necessarily broad, with more specific ideas for action being provided under the section on 'projects' (Section 3.3.5). These strategies, which are listed in Table 3.3 and Table 3.4, are based on:

- A review of the literature which is listed separately in the references list at the end of this report. This review was undertaken to identify 'best practice' in management of SWSAs locally and internationally;
- Engagements with the City of Cape Town in October 2023;
- Engagements with Witzenberg Local Municipality in November and December 2023;
- Engagement with senior City of Cape Town municipal officials on the draft Framework in 2024;
- Meeting with a Witzenberg Local Municipality Town and Regional Planner in July 2024;
- Written comments and inputs received from WRC Reference Group on draft Framework and;
- Written comments and inputs received from City of Cape Town and Witzenberg Local Municipality on draft Framework.

For a detailed description of this engagement process see (Part 2). The generic SWSA strategies are divided into five themes as shown in Figure 3.4 below.

Figure 3.4: Main themes of the proposed strategies for local government protection and management of SWSAs.

Table 3.3. Generic SWSA strategies

Ecosystem Maintenance and Rehabilitation
In collaboration with relevant partners, implement effective maintenance and/or rehabilitation, based on a holistic understanding of the catchment and its priority ecosystem components.
Protect floodplains, river corridors, wetlands, and riparian zones from any development that hardens surfaces, disturbs riverbanks or wetlands, or changes streamflow characteristics.
Ensure the effective clearing of invasive alien plants in river systems and catchment areas - including the upper catchment as well as downstream - to protect ecosystems and enhance stream flow.
Collaborate with stakeholders for the effective maintenance and/or rehabilitation of SWSAs within the municipal area.
Raise awareness of the need for ecosystem protection and maintenance, both within the Municipality (i.e. officials and politicians); as well as among key stakeholders, including communities.
Water Quality
Monitor and manage the water quality in surface – and groundwater SWSAs for human health, reduced treatment costs and ecosystem protection.
Ensure that future urban development and design does not compromise water quality in the municipal area.
Ensure transparency and stakeholder awareness around water quality.
Facilitate the co-management of water quality in SWSAs with stakeholders, including forming partnerships with public and private entities and community groups.
Water Conservation and Demand Management
Consistently monitor groundwater and surface water quantity, ensuring that existing activities that may adversely affect surface water and groundwater quantity are effectively managed and the impacts monitored and mitigated.
Minimise water losses, as far as possible, to ensure sustainable supply.
Diversify water sources to increase resilience.
Ensure that future urban development and design does not compromise water quantity in SWSAs in the municipal area.
Effectively manage water demand in an equitable manner within the municipal area, such that a sustainable supply exists for all key users, as well as for ecosystem protection.
Ensure transparency and stakeholder awareness around water quantity.
Facilitate the co-management of water quantity in SWSAs with stakeholders, including forming partnerships with public and private entities and community groups.
Stakeholder Engagement
Facilitate the co-management of SWSAs with stakeholders, including forming partnerships with public and private entities and community groups.
Promote and enable awareness and communication within the Municipality - and among all stakeholders - around SWSAs, the benefits that they provide, and the need for their maintenance and enhancement.
Financial Support
Increase municipal financial resources for the maintenance and enhancement of SWSAs.
Increase access to 'external' resources for the maintenance and enhancement of SWSAs.
Understand and communicate the value, including the financial value, of SWSAs.

Recommendations and key actions

There will be many different options and perspectives for addressing the constraints and maximising the opportunities to achieve the vision. It is therefore important that not only municipal departments and technical experts are part of the process, but also stakeholders.

The strategies should be developed through various forms of engagement including, for example: stakeholder workshops; focus group meetings; the circulation of draft documents for comment; cross-departmental municipal discussions, among others.

It is useful to facilitate the identification of strategies from different angles, including for example solutions that relate to, for example (Coetzee et al., 2000):

- Institutional arrangements and partnerships (e.g. participation in Catchment Management Forums);
- Finances (e.g. identify and communicate the financial value of SWSAs to officials and politicians);
- Social development (e.g. stakeholder awareness raising around SWSAs);
- Economic development (e.g. development of small businesses from removed alien invasive plants);
- Spatial (e.g. integration of SWSAs into urban design and strategic planning) and
- Technological aspects (e.g. explore innovative mechanisms for water quality monitoring by the municipality and the community).

Some strategies may be sector-specific (e.g. related to water quality monitoring); while others will be across municipal departments (e.g. related to capability development and water demand management). It is therefore important that the opportunity is provided for cross-sectoral discussion (i.e. across sector stakeholders and municipal departments) within the process of formulating the strategies.

In developing the strategies, align with those related to SWSAs already developed through other municipal processes, such as the IDP, SDF, Environmental Management Framework (EMF) (if this is available), a Local Economic Development (LED) strategy and/or a municipal Water Conservation and Demand Management Strategy, among several others. In addition, align with those relevant strategies developed by other spheres of government (e.g. the District IDP); as well as neighbouring municipalities (particularly where SWSAs cross municipal boundaries).

A considerable amount of research has been undertaken related to the effective management of SWSAs even if this terminology is not specifically used. Draw on 'best practice' experience described in this literature in the development of the strategies.

3.3.5 Projects

Phase 4 is where implementation occurs. The projects identified in Phase 4 should enable the implementation of the strategies developed in Phase 3. Project design should be informed by stakeholders, as well as technical, financial, and other experts (Coetzee, 2000). The intended project outputs should be clearly stated.

3.3.6 Application to Strategic Water Source Areas

As defined by Coetzee (2000) and ETU (n.d.) each project proposal should include at least:

- A description of how the project will assist in achieving the vision and strategies, as well as who will directly benefit;
- Outputs of the project;
- Cost and budget estimates;
- Funding sources;

- Time schedule; and
- Responsible departments/agencies/organisations.

It is important that stakeholders and project specialists; as well as all the relevant municipal departments participate in the project development process. This process may involve a combination of workshops, focus group meetings, stakeholder review of draft reports, among other activities. Projects should be classified into those that can be done in the short, medium and long term. All legal processes required for permits and authorisations (e.g. environmental assessments and water use licenses) should be identified early in the project development stage, as these requirements will have implications for the project schedule. It is important to ensure that the SWSA projects have clear objectives and outcomes and are clearly communicated to stakeholders so that stakeholder expectations are aligned with the objectives and outcomes. Project implementation and outputs should be effectively monitored throughout, with adjustments made in light of the results of such monitoring.

Examples of project ideas are provided in Table 3.4 below. These are simply to stimulate discussion and to guide municipalities when developing their own specific detailed projects.

Similar to the strategies, the project/activities ideas are based on:

- A review of the literature which is listed separately in the references list at the end of this report (Section 3.6.2). This review was undertaken to identify 'best practice' related to the management of SWSAs locally and internationally;
- Discussions in a workshop and online meeting with the City of Cape Town in 2023; and
- Discussions in a workshop and online meeting with the Witzenberg Local Municipality in 2023.
- Inputs and comments received in a hybrid meeting with City of Cape Town senior management in 2024

The last column in Table 3.4 links the projects/activities to mechanisms for SWSA identified by the Department of Forestry, Fisheries and the Environment (DFFE). The DFFE (2024) has developed a guiding Framework to provide a better understanding of surface SWSAs, as well as to present a toolbox of mechanisms that can be used to secure surface SWSAs in South Africa. The DFFE Framework (2024) is intended for use by different spheres of government departments, civil society organisations and communities at the local level, among others. The mechanisms presented are divided into three categories as shown in Box 5 below.

Information Box 5. Mechanisms to Secure Strategic Water Source Areas (DFFE, 2024)

Enabling mechanisms:

These are foundational mechanisms that make the implementation – and adaptative - mechanisms possible. Examples include policy and legislation, funding mechanisms, building human resources and partnerships

Implementation mechanisms

Operational in nature, these mechanisms result in direct positive and quantitative effects on the ground. Examples include the protection of land and water, avoiding the loss of biodiversity resources (and therefore water) and restoration.

Adaptive mechanisms

These mechanisms enable reflection by all stakeholders on the measures that have been implemented to secure surface SWSAs, thereby facilitating adaptative management. Examples include data collection, research, evaluation and learning and communication.

The DFFE (2024) notes that a parallel initiative has been started by the DWS to ensure the protection and sustainable use of groundwater SWSAs; and that it is foreseen that future revisions of the DFFE Framework will specifically include mechanisms to secure SWSAs-gw. In Table 3.4 below, the correlation between the proposed strategies and projects/actions and the DFFE mechanisms have been applied to both surface- and groundwater SWSAs.

Table 3.4. Draft framework for local government protection and management of SWSAs.

Note: Links have been made to the DFFE mechanism framework as per Information Box 5 (DFFE, 2024)

THEME 1: ECOSYSTEM MAINTENANCE AND REHABILITATION		
STRATEGIES	EXAMPLES OF PROJECTS AND/OR ACTIVITIES	DFFE FRAMEWORK
In collaboration with relevant partners, implement effective maintenance and rehabilitation, based on a holistic understanding of the catchment and its priority ecosystem components.	Develop, in a participatory way, an Integrated Environmental Management (IEM) Policy relating to water, land and air, which aims to protect and maintain all prioritized ecosystems. Ensure that the policy recognizes the role of both internal municipal actions, as well as external stakeholder involvement in ecosystem management.	Enabling Mechanism
	Undertake a holistic assessment of the catchment, taking into account existing Catchment Management Plans, to determine which priority ecosystem components should be maintained, rehabilitated and/or restored (e.g. floodplains, rivers, wetlands, river corridors and riparian areas) for the protection of SWSAs. This assessment should consider, not only relevant ecosystem components that are vulnerable to the impacts of climate change and/or urban expansion, but which also those that provide direct benefits to the community, among other factors.	Enabling Mechanism
	Based on the above assessment, identify and implement maintenance and rehabilitation and/or restoration measures (e.g. alien clearing, vegetation re-establishment, erosion control) to ensure SWSAs continue to deliver ecosystem services such as purifying water, storing carbon, cycling nutrients, and maintaining habitats.	Implementation Mechanism
	Participate in and/or engage with relevant collaborative institutions such as Catchment Management Forums and sub-forums, as well as Water Users Associations, ensuring that SWSAs are integrated into Catchment Management Plans and other initiatives.	Enabling Mechanism
Protect floodplains, river corridors, wetlands, and riparian zones and estuaries from any development that hardens surfaces, disturbs riverbanks or wetlands, or changes streamflow characteristics.	Develop and implement groundwater and surface water protection zones (and associated management measures) within SWSAs. Formulate guidelines on the type of development that is appropriate to each zone and the typical mitigation measures which can be implemented to protect water quality and quantity in SWSAs. For example, identify buffer zones along rivers and drainage line corridors to ensure that floodplains, wetlands, river corridors, riparian zones and estuaries (which are vulnerable to the impacts of climate or land use change) are protected from activities that disturb riverbanks, reduce streamflow (e.g. forestry) or increase water abstraction (e.g. irrigated agriculture) and/or reduce infiltration (e.g. creation of hard surfaces).	Implementation Mechanism Enabling Mechanism
	Integrate the SWSA protection zones (and associated management measures) defined above (including Critical Biodiversity Areas and Ecologically Sensitive Areas) into: The Metropolitan Spatial Development Framework (MSDF),	Enabling Mechanism

	Relevant policies and strategies (e.g. bulk water management strategy, water strategy, housing strategy, and the environmental/ biodiversity strategy), Decisions on rezoning and land use planning applications Relevant by-laws being developed such as the stormwater by-law and wastewater by-law; and Comments provided on environmental authorisations	
	Develop and implement River Management and Maintenance Plans as required in terms of legislation (e.g. the National Environmental Management Act: EIA Regulations (2014) and the Biodiversity Act of 2004).	Implementation Mechanism Enabling Mechanism
	Expand the protection of SWSAs through formal protected area expansion strategies and other effective area-based conservation measures (OECM).	Implementation Mechanism Enabling Mechanism
	Ensure that the urban edge is well-defined and effectively implemented to prevent urban sprawl and implement restrictions on development beyond this limit to protect sensitive peri-urban areas.	Enabling Mechanism
Ensure the effective clearing of invasive alien plants in river systems and catchment areas - including the upper catchment as well as downstream - to protect and rehabilitate ecosystems and enhance stream flow.	Undertake mapping of invasive alien plants in a consistent way, at regular intervals, across the municipal area.	Enabling Mechanism
	Develop and implement a plan for priority invasive alien plant clearing and maintenance of cleared areas.	Implementation Mechanism Enabling Mechanism
Collaborate with stakeholders for the effective maintenance and rehabilitation of SWSAs within the municipal area.	Participate in and/or engage with relevant collaborative institutions such as Catchment Management Forums and sub-forums, as well as Water Users Associations, ensuring that SWSAs are integrated into Catchment Management Plans and other initiatives.	Enabling Mechanism
	Form partnerships with organisations and initiatives (e.g. Working for Water) currently involved in invasive alien plant clearing.	Enabling Mechanism
	Support and promote Water and Land Stewardship Programmes for the maintenance and restoration of SWSAs and the ecosystem services that they provide; as well as raising awareness around sustainable and equitable water use.	Implementation Mechanism Adaptive Mechanism Enabling Mechanism
		Adaptive Mechanism

	Incorporate a spatial representation of SWSAs (and the protection zones described above) into online municipal map viewers) and/or data portals, to ensure that they are accessible to all stakeholders.	Enabling Mechanism
Raise awareness of the need for ecosystem protection rehabilitation and maintenance, both within the Municipality (i.e. officials and politicians); as well as among key stakeholders, including communities and businesses.	Facilitate capability development and awareness-raising within the Municipality to: Promote the protection and management of SWSAs across all municipal departments responsible for land use - and environmental - management, in a coordinated manner. Ensure commitment to the management of SWSAs at the highest level within the municipality (i.e. leadership and political buy-in).	Adaptive Mechanism
	Facilitate capability development and awareness-raising sessions among key stakeholders, including communities, business, civil society and others. For example, awareness around waste recycling to decrease the amount of waste being disposed in waterways. A possible initiative is the development of a 'buy-back' recycling centre where individuals can trade waste that they have collected for certain goods or commodities (e.g. airtime).	Adaptive Mechanism
	Where possible link to existing initiatives for capability development on ecosystem services being undertaken by NGOs and others.	Enabling Mechanism Adaptive Mechanism

THEME 2: WATER QUALITY		
STRATEGIES	EXAMPLES OF PROJECTS AND/OR ACTIVITIES	DFFE FRAMEWORK
Monitor and manage the water quality in surface – and groundwater SWSAs for human health, reduced treatment costs and ecosystem protection.	Aim for continuously increasing the City's Blue Drop and Green Drop status.	Adaptive Mechanism Enabling Mechanism Implementation Mechanism
	Consistently monitor both surface water and groundwater quality, ensuring chemical, physical, and biological parameters are included, as well as impacts on fauna and flora.	Adaptive Mechanism
	As far as possible, expand the water quality monitoring network to enable a holistic view (i.e. source to mouth) rather than only targeting a specific problem area.	Adaptive Mechanism
	Ensure that, for each catchment, Water Safety Plans, which include the identification of risks and measures to mitigate these, are regularly updated and effectively implemented.	Implementation Mechanism Enabling Mechanism
		Adaptive Mechanism

	Ensure that existing activities that may adversely affect surface water and groundwater quality are effectively managed and the impacts monitored and mitigated. Enhance enforcement capacity to ensure the polluter pays for violations of laws and licences.	Enabling Mechanism
	Ensure efficient and reliable water treatment by maintaining water treatment infrastructure and system.	Implementation Mechanism
	Support water treatment facilities with alternative energy sources and energy storage to prevent pump failure during loadshedding.	Implementation Mechanism
	Re-direct poor quality water into sewers for treatment.	Implementation Mechanism
Ensure that future urban development and design does not compromise water quality in the municipal area.	Establish a cross-departmental Task Team for evaluating and commenting on development proposals, their potential impact on water quality in SWSAs and proposed mitigation measures.	Enabling Mechanism
	Coordinate water and sewage infrastructure with current and future urban expansion through cross-departmental engagement; both in strategic planning and in evaluating development proposals.	Enabling Mechanism
	Explore opportunities in strategic planning (e.g. SDF) - and in the evaluation of development proposals - to promote innovative urban design mechanisms to reduce pollution of city waterways and increase water quality (i.e. Water Sensitive Urban Design, Armitage et al., 2014).	Enabling Mechanism
Ensure transparency and stakeholder awareness around water quality.	Develop effective systems (e.g. mobile phone application) for pollution incidence reporting; and undertake awareness-raising and capability development among all residents related to these systems.	Adaptive Mechanism
	Undertake regular awareness raising sessions: Among Councillors and City officials to ensure continued high-level commitment within the Municipality to the maintenance and enhancement of water quality in SWSAs, and Among all key stakeholders to raise awareness and appreciation of the City's SWSAs, their benefits and the need for their protection.	Adaptive Mechanism
	Discourage inappropriate wastewater disposal through signage and a public education campaign.	Adaptive Mechanism
	Ensure transparency and stakeholder awareness around water quality ensuring, for example, that monitoring information is accessible.	Adaptive Mechanism
Facilitate the co-management of water quality in SWSAs with stakeholders, including forming partnerships with	Develop an effective institutional mechanism for the coordinated management of SWSAs, which is recognized by the Municipality (e.g. official forum) and can therefore participate in internal budget discussions (e.g. IDP budget).	Enabling Mechanism
	Form partnerships with neighbouring municipalities to, for example, expand the City's water quality monitoring network across administrative boundaries.	Adaptive Mechanism

public and private entities and community groups;		Enabling Mechanism
	Participate in and/or engage with relevant collaborative institutions such as Catchment Management Forums and sub-forums, as well as Water Users Associations, ensuring that SWSAs are integrated into Catchment Management Plans and other initiatives.	Enabling Mechanism
	Support and promote the implementation of Water Stewardship Programmes for improving water quality and raising awareness around pollution prevention.	Implementation Mechanism Enabling Mechanism Adaptive Mechanism

THEME 3: WATER CONSERVATION AND DEMAND MANAGEMENT		
STRATEGIES	EXAMPLES OF PROJECTS AND/OR ACTIVITIES	DFFE FRAMEWORK
Consistently monitor groundwater and surface water quantity, ensuring that existing activities that may adversely affect surface water and groundwater quantity are effectively managed and the impacts monitored and mitigated.	Consistently monitor both surface water and groundwater quantity, as well as impacts on fauna and flora and the potential for seawater intrusion in the case of groundwater over abstraction. Develop enforcement capacity to implement the polluter pays principle.	Adaptive Mechanism
	Manage and monitor surface water and groundwater abstraction throughout the catchment.	Implementation Mechanism Adaptive Mechanism
	Develop and implement an effective groundwater management plan for the municipal area.	Implementation Mechanism Enabling Mechanism
Minimise water losses, as far as possible, to ensure sustainable supply	Ensure proper maintenance and protection of the water reticulation system (e.g. distribution infrastructure) to reduce water losses. This includes updating and implementing an effective Water and Sanitation Infrastructure Operations and Maintenance (O&M) Plan.	Implementation Mechanism Enabling Mechanism
	Install sufficient working water meters and ensure that the water balance is accurately determined and informs the allocation of water from SWSAs in all municipal decision-making and strategic planning.	Implementation Mechanism Enabling Mechanism
	Aim for continuously increasing the Municipality's No Drop status.	Adaptive Mechanism Implementation Mechanism

		Enabling Mechanism
	Undertake mapping of invasive alien plants in a consistent way, at regular intervals, across the municipal area; and develop and implement a plan for priority invasive alien plant clearing and maintenance of cleared areas.	Implementation Mechanism Enabling Mechanism
Diversify water sources to increase resilience	Explore opportunities and implement measures for diversifying water sources, such as the sustainable use of groundwater and/or water re-use (e.g. greywater recycling) and/or desalination.	Implementation Mechanism Enabling Mechanism
	Support and promote existing community initiatives for water reuse in a manner that promotes job opportunities.	Adaptive Mechanism Enabling Mechanism
Ensure that future urban development and design does not compromise water quantity in SWSAs in the municipal area	Establish a cross-departmental Task Team for evaluating and commenting on development proposals, their potential impact on surface – and groundwater quantity in SWSAs and proposed mitigation measures.	Enabling Mechanism
	Coordinate water and sewage infrastructure with current and future urban expansion through cross-departmental engagement; both in strategic planning and in evaluating development proposals.	Enabling Mechanism
	Explore opportunities in strategic planning (e.g. SDF), urban development- and in the evaluation of land use proposals - to promote innovative urban design mechanisms to maintain water quantity. Examples include the use of vegetated areas for rainwater absorption, stormwater retention measures and/or infiltration systems and increasing opportunities for water reuse (i.e. Water Sensitive Urban Design).	Implementation Mechanism Enabling Mechanism
	Consider water availability when undertaking strategic development planning and determining appropriate land uses for the area, taking climate change predictions and anticipated growth pressure into account.	Enabling Mechanism
Effectively manage water demand in an equitable manner within the municipal area, such that a sustainable supply exists for all key users, as well as for ecosystem protection	In cases where a Municipality is a Water Service Provider: develop, implement and update an effective Water Services Development Plan (as required by the Water Services Act (No. 108 of 1997) that ensures equitable water supply and basic sanitation is provided.	Implementation Mechanism Enabling Mechanism
	Ensure that an effective Water Conservation and Demand Management (WCDM) Strategy is developed, implemented and updated.	Implementation Mechanism Enabling Mechanism
	Develop climate change scenarios that provide an indication of future water availability and integrate these into development planning, land use planning decision-making and demand management strategies.	Enabling Mechanism
	Monitor bulk users of potable water both in terms of their quantity of water used, ensuring that any negative impacts are mitigated and legislation is enforced.	Adaptive Mechanism

	Facilitate an increase in the use of water conservation measures and water-smart practices (including managed aquifer recharge with high-quality treated wastewater) among all stakeholders.	Implementation Mechanism
	Implement water-use efficiency measures within the Municipality itself (e.g. low-flow taps and showers and low-flush toilets)	Implementation Mechanism
	Consider the implementation of pressure management, particularly to reduce leakage during off-peak periods, as well as to provide water savings.	Implementation Mechanism
Ensure transparency and stakeholder awareness around water quantity	Facilitate transparency and effective communication regarding water quantity among all key stakeholders; ensuring, for example, that monitoring information is accessible.	Adaptive Mechanism
	Undertake regular awareness raising sessions: Among Councillors and City officials to ensure continued high-level commitment within the Municipality to the maintenance and enhancement of water quantity in SWSAs, and Among all key stakeholders to raise awareness and appreciation of the City's SWSAs, their benefits and the need for their protection.	Adaptive Mechanism
	Undertake awareness raising that encourages the sustainable use of water (e.g. low-flush toilets) among all major water users and residents.	Adaptive Mechanism
Facilitate the co-management of water quantity in SWSAs with stakeholders, including forming partnerships with public and private entities and community groups	Participate in and/or engage with relevant collaborative institutions such as Catchment Management Forums and sub-forums, as well as Water Users Associations, ensuring that SWSAs are integrated into Catchment Management Plans and other initiatives.	Adaptive Mechanism
	Support and promote the implementation of Water Stewardship Programmes for improving water quantity and raising awareness around sustainable and equitable water use.	Implementation Mechanism Enabling Mechanism Adaptive Mechanism
	In collaboration with partners, undertake technical studies and stakeholder engagement around the possible use of alternative water source options within the municipality (e.g. from aquifers and water reuse).	Enabling Mechanism Adaptive Mechanism
	Identify potential private and/or public partners in maximizing opportunities for increasing water conservation measures and water-smart practices and undertake awareness raising around the use of use of these measures.	Enabling Mechanism Adaptive Mechanism

THEME 4: STAKEHOLDER ENGAGEMENT, PARTNERSHIPS AND COMMUNICATION IN THE MANAGEMENT OF SWSAs

STRATEGIES	EXAMPLES OF PROJECTS AND/OR ACTIVITIES	DFFE FRAMEWORK
Facilitate the co-management of SWSAs with stakeholders, including forming partnerships with public and private entities and community groups.	Develop an effective institutional mechanism for the coordinated management of SWSAs, which is recognized by the Municipality (e.g. official forum) and can therefore participate in internal budget discussions (e.g. IDP budget).	Enabling Mechanism
	Undertake stakeholder engagement with other government organizations, NGOs, CBOs and business entities, as well as key water users, around their roles and activities related to the protection and management of SWSAs.	Adaptive Mechanism
	Identify opportunities for new partnerships and strengthen existing partnerships with the private and public sector that advance the maintenance and enhancement of SWSAs (e.g. partner with NGOs to support the cleaning of rivers or conduct SWSA awareness raising programmes).	Enabling Mechanism
	Support and promote Water and Land Stewardship Programmes for the maintenance and restoration of SWSAs and the ecosystem services that they provide; as well as raising awareness around sustainable and equitable water use.	Implementation Mechanism
		Adaptive Mechanism
		Enabling Mechanism
Promote and enable awareness and communication within the Municipality - and among all stakeholders - around SWSAs, the benefits that they provide, and the need for their maintenance and enhancement.	Identify and develop innovative tools to communicate the importance of SWSAs and their protection to all residents and key water users in the Municipality (e.g. the use of entertaining and informative murals, wall art and/or signage to communicate messages related to water, its quality and quantity). Ensure that communication tools are adapted to the needs of the various stakeholders.	Adaptive Mechanism
	Facilitate capability development initiatives around the protection and management of SWSAs with both municipal officials and politicians.	Adaptive Mechanism
	Facilitate cross-departmental awareness of SWSAs and their benefits; as well as the role that each municipal department can play in their maintenance and enhancement.	Adaptive Mechanism
	Increase staff awareness of relevant by-laws and capability to enforce these (e.g. by- laws related to water revenue).	Adaptive Mechanism
	Monitor the effectiveness of capability development initiatives and awareness campaigns.	Adaptive mechanism

THEME 5: ADEQUATE FINANCIAL SUPPORT FOR THE MANAGEMENT OF SWSAs		
STRATEGIES	EXAMPLES OF PROJECTS AND/OR ACTIVITIES	DFFE FRAMEWORK
Increase municipal financial resources for the	Identify and assess possible, innovative internal municipal financial mechanisms that can be used to support SWSA management, complying with all relevant legislation (e.g. MFMA). Possible examples that can be explored:	Enabling Mechanism

maintenance and enhancement of SWSAs	Ring fencing funding from the industrial levy for upgrades in water infrastructure; and Integrating infrastructure requirements into conditions of approval for development.	
	Include projects relevant to the maintenance and enhancement of SWSAs into the municipal Integrated Development Plan (IDP) and budget accordingly.	Enabling Mechanism
	Improve supply chain management (SCM) to enable the more efficient procurement of necessary equipment and materials for the management, enforcement of laws and licences and monitoring of SWSAs.	Enabling Mechanism
	Ensure effective cross-departmental collaboration in the development of relevant transversal calls for tenders (e.g., for alien clearing).	Enabling Mechanism
	Ensure proactive and effective maintenance to reduce non-revenue water from water losses, due to broken infrastructure and/or illegal connections. Ensure that working meters are installed and the capacity for accurate and regular meter reading is available.	Implementation Mechanism
Increase access to 'external' resources for the maintenance and enhancement of SWSAs	Explore opportunities to form partnerships with other entities (e.g. business organisations, community organisations) undertaking projects related to SWSAs to increase efficiency and overcome budget limitations.	Enabling Mechanism
	Apply, together with partners, to external local and international funding organisations for resources (e.g. human capacity, financial support and/or materials needed) to support projects related to the maintenance and enhancement of SWSAs.	Enabling Mechanism
	Participate in existing programmes led by other spheres of government (e.g. Department of Public Works) for job creation, capability development and project implementation (e.g. invasive alien clearing).	Adaptive Mechanism Implementation Mechanism Enabling Mechanism
	Explore training opportunities available to municipal officials which are hosted by external capability development organisations (e.g. NGOs) and/or other spheres of government.	Adaptive Mechanism Enabling Mechanism
	Identify and use existing online data platforms and/or portals that are available to municipalities and which can inform SWSA management and capability development (e.g. the Biodiversity GIS (BGIS) (http://bgis.sanbi.org/) and the Green Book (https://greenbook.co.za/).	Adaptive Mechanism Enabling Mechanism
Understand and communicate the value, including the financial value, of SWSAs.	Estimate, as far as possible, the financial value of SWSAs to the biodiversity economy, as well as in mitigating the effects of climate change in the municipal area. Communicate this value to key stakeholders such as local political representatives, business and communities, to make the 'business case' for their support for the protection of these areas.	Adaptive Mechanism Enabling Mechanism

Recommendations and key actions

The active participation of communities in project development and implementation (e.g. community monitoring; river clean-up activities) assists with effective implementation and community buy-in.

Awareness raising and education programmes among all stakeholders around the SWSA projects being implemented is important. This should focus on aspects such as the concept of SWSAs, the links between water supply and use, among many other factors.
When introducing alternative forms of service delivery (e.g. water re-use), awareness raising and capability development is critical.

Ensure that project development is informed by accurate spatial data related to the SWSAs (e.g. the location of surface and groundwater SWSAs, protected areas, river status, critical biodiversity areas and land uses) within the Municipality; which can enable the identification of an appropriate location for the project under consideration, potential partners required for effective implementation (e.g. neighbouring municipalities); and important trends and patterns to consider.

As far as possible, integrate SWSAs projects into the IDP, so that they become part of the municipal budgetary process.

In addition to developing new projects, explore opportunities to integrate SWSA priorities (e.g. maintenance of water quality) into existing municipal projects or programmes already identified.

In order to maximise the use of resources (e.g. skills and finances); explore opportunities to form partnerships with other organisations undertaking projects related to the maintenance and enhancement of SWSAs (e.g. Expanded Public Works Programme (EPWP) and NGOs undertaking monitoring, awareness raising and other projects).

3.3.7 Monitoring

Generic description of this phase

In this last phase, a monitoring programme - including indicators - should be developed to assess the extent to which the vision (Phase 2) and strategies (Phase 3) are being achieved through project implementation (Phase 4). Indicators should enable reporting on inputs, activities, outputs, and outcomes, among other factors (The Presidency: South Africa, 2007). Monitoring results should provide a basis for the revision and/or amendment of the strategy or projects and/or their implementation.

It should include both qualitative and quantitative indicators (Falkenberg, 2021). Qualitative indicators should be SMART i.e. specific, measurable, achievable, relevant and time bound (Catholic Relief Services, 2022). In the context of SWSAs an example of such an indicator could be a 10% reduction in water salinity in a specific river within 2 years. Whereas qualitative indicators, which lead to a narrative evaluation rather than a numerical one, can be summarised as SPICED i.e. subjective, participatory, interpreted, cross-checked, empowering and diverse (Catholic Relief Services, 2022). An example within the context of SWSAs could be the perception among different stakeholders of water availability.

Application to Strategic Water Source Areas

In the section below generic examples of indicators are provided for each of the strategies listed in Section 3.3.4, taking account of the projects/activities listed in Section 3.3.5. It is important to note that these are *examples* only and would need to be adapted to the municipal context under consideration. References for the indicators listed are provided separately in Section 3.6.3.

Table 3.5. Indicators for Theme 1: Ecosystem Maintenance & Rehabilitation

STRATEGIES	EXAMPLES OF MONITORING INDICATORS
In collaboration with relevant partners, implement effective ecosystem maintenance and/or rehabilitation, based on a holistic understanding of the catchment and its priority ecosystem components	An Integrated Environmental Management (IEM) Policy has been developed that aims to protect and maintain all prioritised ecosystems.
	Number of ecosystem rehabilitation projects implemented.
	Number of monitoring points identified and installed in key wetlands, rivers, riparian strips and estuaries to monitor waterway health, macrophyte habitats and biota.
	Number of environmental water sampling done (e.g. for Escherichia coli) in waterbodies used for recreational purposes (e.g. vleis or dams) based on requirements and seasonal changes.
	Percentage of water bodies or ecosystems with a PES rating of A (natural condition) or B (near natural/good).
	Percentage of water bodies and ecosystems assessed to determine the rate of morphological change.
	Number of ecosystem services and economic/social benefits provided by the ecosystem (e.g. flood regulation, water purification, recreation, biodiversity support).
	Number of wetlands, river reaches and estuaries under active restoration.
	Percentage change in plastic pollution levels in estuaries and river reaches over specified time (e.g. annually).
	Number of monitoring sites within estuaries and river reaches where plastic pollution assessments are routinely conducted.
	Percentage of rivers and streams meeting established environmental flow requirements.
Protect floodplains, river corridors, wetlands, and riparian zones and estuaries from any development that hardens surfaces, disturbs riverbanks, estuaries or wetlands, or changes streamflow characteristics	Frequency of water monitoring to establish estuarine mouth conditions, water levels, salinity, sedimentation, and coverage by alien species.
	An effective Stormwater Management Plan and stormwater infrastructure is in place for the municipality
	Percentage of waterways designed, upgraded, or maintained to contain at least a 1:100 year or 1:50-year flood.
	Number of flood risk assessments conducted.
	Total area of floodplain or waterway modified or maintained to increase capacity to hold floodwaters effectively.

STRATEGIES	EXAMPLES OF MONITORING INDICATORS
	Percentage of waterway area with 80-100% permeability or connectivity both longitudinally and vertically to the floodplain.
	Number of flood risk assessments conducted.
	Total area of floodplain or waterway modified or maintained to increase capacity to hold floodwaters effectively.
	Percentage of SWSA within municipality that is formally protected through National Parks, Nature Reserves, Other Effective Conservation Measures and stewardship agreements.
	Developments occurring outside the urban edge show a decreasing (negative) trend.
	Water-Sensitive Urban Design principles are included in architectural guidelines where applicable, e.g. thresholds for hardening of surfaces and their influence on runoff patterns and velocities, urban heat island effect and air circulation are understood and included into spatial planning.
	Groundwater protection zones are defined and enforced (as buffer zones) with appropriate planning and management guidelines for each zone.
	Riparian, estuarine and wetland buffer zones are defined and enforced with appropriate planning and management guidelines for each zone.
	Priority within the municipal boundaries are defined and enforced (as buffer zones) with appropriate development planning and management guidelines for each zone in the Spatial Development Framework (SDF) and included in land-use planning instruments such as the zoning scheme.
Ensure the effective clearing of invasive alien plants in river systems and catchment areas - including the upper catchment as well as downstream - to protect ecosystems and enhance stream flow	Number of invasive alien plant clearing projects in catchment.
	An up-to-date implementation plan exists and is used for planning invasive alien plant clearing projects and the maintenance of cleared areas (follow-ups).
	Annual identification of priority areas for clearing and follow-up (annual plan of clearing operations).
	Area cleared within municipal boundary per annum.
	Number of follow-ups completed per project.
Collaborate with stakeholders for the effective maintenance and/or rehabilitation of SWSAs within the municipal area	Number of meetings attended and active participation by municipal officials in Catchment Management Forums and Water Users Associations.
	SWSA management priorities are integrated into Catchment Management Plans and other water management initiatives.

STRATEGIES	EXAMPLES OF MONITORING INDICATORS
	Municipal officials participate in joint programmes/forums with SANParks, provincial conservation agencies and consultants who assist with stewardship agreements, land contractual agreements and management effectiveness tools/assessments in order to improve SWSA protection status through formal Protected Areas or Other Effective Area-based Conservation Measures.
Raise awareness of the need for ecosystem protection and maintenance, both within the Municipality (ie officials and politicians); as well as among key stakeholders, including communities	Number of capacity development initiatives around ecosystem protection and maintenance relating to SWSA management for officials within the municipality.
	Level of participation in capacity development initiatives around ecosystem protection and maintenance relating to SWSA management for officials within the municipality
	Number of capacity development initiatives around ecosystem protection and maintenance relating to SWSA management for politicians within the municipality.
	Level of participation in capacity development initiatives around ecosystem protection and maintenance relating to SWSA management for politicians within the municipality.

Table 3.6. Indicators for Theme 2: Water Quality

STRATEGIES	EXAMPLES OF MONITORING INDICATORS
Monitor and manage water quality in surface and groundwater SWSAs for human health, reduced treatment costs and ecosystem protection	Percentage increase in municipality's Blue Drop status annually.
	Percentage increase in the Blue Drop and Green Drop status
	Percentage of SWSAs under water quality monitoring (geographic coverage of water quality monitoring across surface and groundwater SWSAs)
	Percentage decrease in specific contaminants (e.g., nitrates, phosphates, heavy metals, pesticides) in surface and groundwater sources compared to baseline levels.
	Process audits are done annually for wastewater and water treatment plants to assess water quality risks, ensure optimization and enhancement, and to determine capacity needs vs budget.
	The capacity of water treatment plants is monitored and managed.
	Number of alternative energy sources and energy storage solutions implemented and optimised to prevent contamination and ensure continuous operation of water treatment facilities during power outages.
	Reduction in downtime due to alternative energy sources and storage solutions implemented in water treatment facilities.
	Number of incentives provided to water users, industries, and businesses to reduce water pollution.

STRATEGIES	EXAMPLES OF MONITORING INDICATORS
	Percentage reduction in pollution incidents.
Ensure that future urban development and design does not compromise water quality in the municipal area	Number of development applications reviewed for water quality impacts and impacts on water-related ecosystems (e.g. wetlands).
	Percentage of developments incorporating water-sensitive urban design principles (e.g. vegetated swales, buffer strips, bio-retention systems) aimed at minimizing pollution and managing stormwater.
	Number of water quality management plans integrated into urban planning processes to minimise impacts of urban development on water quality.
Ensure transparency and stakeholder awareness around water quality	Number of water quality reports and catchment management reports published and distributed (e.g. quarterly, annually).
	Number and type of water quality information platforms (e.g. website, mobile app, or community information boards) that provide up to date water quality information.
	Number and type of reporting systems (e.g., a mobile application linked to photo locations, online website, and hot line) developed and operational.
	Percentage of residents aware of and using the reporting systems (assessed through e.g. surveys)
	Number of pollution incidents reported, and percentage successfully resolved within a specified time.
	Number of stakeholder engagement sessions conducted to present water quality data and engage stakeholders on water quality management.
Facilitate the co-management of water quality in SWSAs with stakeholders, including forming partnerships with public and private entities and community groups	Number of formal agreements or partnerships developed with stakeholders to co-manage water quality in SWSAs.
	Number of stakeholder meetings (meetings, workshops or forums) held to engage stakeholders.
	Number of joint water quality monitoring programs implemented to collect and share data on water quality in SWSAs.
	Number of training sessions or capacity-building programs to build stakeholder capacity in water quality management practices.

Table 3.7. Indicators for Theme 3: Water Conservation and Demand Management

STRATEGIES	EXAMPLES OF MONITORING INDICATORS
Consistently monitor groundwater and surface water	Existence of a water quality monitoring plan with clear objectives and outcomes that is regularly updated.

STRATEGIES	EXAMPLES OF MONITORING INDICATORS
quantity, ensuring that existing activities that may adversely affect surface water and groundwater quantity are effectively managed and the impacts monitored and mitigated	Number of monitoring stations installed and operational for both groundwater and surface water monitoring, i.e. piezometers and gauging stations.
	Trends in water quantity and sustainable yield levels.
	Number of incidents of over-extraction after the monitoring program is implemented.
	Number of identified and reported incidents at monitoring stations where activities adversely affecting water quantity (such as excessive water extraction) are detected.
	Financial savings achieved by identifying and mitigating issues early (e.g., avoiding costs from droughts or water scarcity crises).
	Increase in public and key stakeholder understanding of the issues of water security and their role in protecting water resources (e.g., through surveys or feedback mechanisms).
Minimise water losses, as far as possible, to ensure sustainable supply	Number of water-saving devices (e.g., pressure management valves, leak detection sensors, or smart meters) installed and operational in key areas of the water network.
	Percentage of total length of the reticulation network that is actively monitored for water losses.
	Type and number of leaks identified and repaired.
	Number of proactive leak inspections and repairs carried out in the water distribution system.
	Number of public outreach or educational programs designed to raise awareness of water conservation and reducing water wastage.
	Number of monthly water balance reports compiled.
	Percentage reduction in water that is produced but not billed to customers due to leaks, theft, broken meters or inefficiencies.
	Percentage decrease in relation to baseline water losses.
	Percentage cost savings achieved from reduced water treatment and distribution due to minimized losses, including savings on energy for pumping and reduced chemical use.
	Percentage increase in the No Drop status annually.
	Percentage increase in flow rates in rivers, streams or groundwater sources after invasive plants are cleared from nearby areas, compared to flow rates before clearing.
	Percentage of meters that consistently provide accurate readings.

STRATEGIES	EXAMPLES OF MONITORING INDICATORS
	Submission of annual municipal water report (including the water losses)
	Number of training sessions provided to municipal staff on water loss prevention, leak detection, and repair techniques.
Diversify water sources to increase resilience	Number of new water sources established, such as desalination plants, recycled water systems, or rainwater harvesting facilities.
	Proportion of total water demand that is supplied by diversified water sources (e.g., rainwater harvesting, greywater recycling, etc.).
	Number of outreach campaigns or educational programs (e.g. quarterly, annually) to encourage the use of alternative water sources, such as greywater for irrigation or rainwater for non-potable purposes.
	Percentage improvements in the reliability of the water supply, especially during droughts, extreme weather events, or infrastructure failures, by assessing whether diverse sources help avoid service interruptions.
	Improvement in public satisfaction related to water availability and service continuity, particularly during droughts or emergencies, because of diversified water sourcing strategies (assessed through e.g. surveys, public polls).
Ensure that future urban development and design does not compromise water quantity in SWSAs in the municipal area	Minutes of quarterly Cross-Departmental Task Team (CDT) meetings.
	Percentage of urban development projects that incorporate water-sensitive urban design (WSUD) features (e.g., permeable pavements, rainwater harvesting systems, green roofs).
	Number of urban developments that comply with zoning or land-use regulations specifically designed to protect SWSAs.
	Number of urban development proposals evaluated for water resource impacts by cross-departmental task team before approval.
	Number of public or stakeholder engagement sessions conducted to raise awareness about the potential impact of urban development on water resources and to incorporate community input.
Effectively manage water demand in an equitable manner within the municipal area, such that a sustainable supply exists for all key users, as well as for ecosystem protection	The existence of a completed Water Services Development Plan that has been submitted in line with statutory deadlines requirements.
	Number of new or upgraded water services infrastructure projects (e.g., pipelines, water treatment plants, sanitation facilities) launched because of the Water Service Development Plan.

STRATEGIES	EXAMPLES OF MONITORING INDICATORS
	Number of water-saving or demand management projects implemented as part of the WCDM strategy (e.g., leak detection programs, water reuse systems, public awareness campaigns).
	Number of development planning, land use planning decision-making and demand management strategies that include climate change scenarios.
	Trends in potable water used by bulk water users.
	Number of initiatives or programs launched to promote water conservation, such as rebates for water-efficient appliances, educational campaigns, or community workshops.
	Number of campaigns or outreach programs aimed at educating the public on equitable water use and sustainable water demand practices.
	Percentage of stakeholders adopting water conservation measures.
Ensure transparency and stakeholder awareness around water quantity	Number of capacity development initiatives around water quantity management in SWSA for officials within the municipality.
	Number of capacity development initiatives around water quantity management in SWSA for politicians within the municipality.
	Number of public meetings, workshops, or stakeholder consultations conducted to discuss water quantity, current challenges, and management strategies.
	Number of updates on water quantity (e.g., reservoir levels, groundwater table, springs, rainfall) made publicly available through various platforms (e.g., websites, newsletters).
Facilitate the co-management of water quantity in SWSAs with stakeholders, including forming partnerships with public and private entities and community groups	Number of municipality-led forums or working groups where stakeholders can discuss water quantity and participate in water management discussions.
	Number of formal agreements or partnerships (e.g. stewardship programme) between the municipality, landowners and large water users, for co-managing water quantity in SWSAs.
	Number of consultations, workshops, or meetings held to engage stakeholders in the co-management process and gather their input on water management in SWSAs.
	Number of training sessions, capacity-building workshops, or educational programs offered to stakeholders to equip them with skills and knowledge for co-managing water resources.
	Number of community-led water conservation projects or local monitoring programs (e.g. mini-SASS, water sampling, river clean-ups etc.) initiated.

Table 3.8. Indicators for Theme 4: Stakeholder Engagement, Partnerships and Communication in the Management of SWSAs

STRATEGIES	EXAMPLES OF MONITORING INDICATORS
Facilitate the co-management of SWSAs with stakeholders, including forming partnerships with public and private entities and community groups	Existence of a multi-stakeholder forum with a steering committee and external auditor that enables the coordinated management of SWSA's which is recognized by the municipality
	Number of meetings attended by the municipality and active participation in - this SWSA multi-stakeholder forum.
	Number of formal partnerships developed (e.g. with municipal service partnership agreement in place) which contribute to the co-management of SWSA's (e.g. with business, civil society and research organisations).
	Number of inter-directorate and cross departmental partnerships within the municipality (e.g. solid waste management and water and sanitation).
	Number of informal partnerships and/or collaborations developed contributing to the co-management of SWSA's (e.g. with business, civil society and research organisations)
	Number of stewardship agreements which the municipality has signed as a landowner.
	Number of – and participation in – stakeholder engagement processes (led by other government agencies) relating to the management of SWSA's.
Promote and enable awareness and communication within the Municipality - and among all stakeholders - around SWSAs, the benefits that they provide, and the need for their maintenance and enhancement	Number of – and level of participation in - communication and/or awareness raising initiatives undertaken among key water users in the Municipality (e.g. residents and business).
	Effectiveness of initiatives undertaken to raise awareness around SWSA's (determined through survey's, interviews, social media analytics etc).
	Range of communication tools/media, adapted to the audience, developed to raise awareness around the importance of SWSA's and the need for their protection and rehabilitation.
	Effectiveness of communication tools developed to raise awareness around SWSA's (determined through survey's, interviews, social media analytics etc).
	Number of – and level of participation in – capacity development initiatives around SWSA's (e.g. their importance, the need for rehabilitation, relevant by-laws) for officials within the municipality
	Number of – and level of participation in – capacity development initiatives around SWSA's for politicians within the municipality

Table 3.9. Indicators for Theme 5: Adequate financial support for the management of SWSAs

STRATEGIES	EXAMPLES OF MONITORING INDICATORS
Increase municipal financial resources for the maintenance and enhancement of SWSAs	Number of projects in IDP (in progress or completed) per budget cycle emanating from funding ringfenced to benefit SWSAs.
	Total budget amount allocated for SWSAs maintenance and enhancement per budget cycle.
	Number of projects related to SWSAs completed successfully per budget cycle.
	Number of multi-year capital planning projects that aim to reduce water losses or non-revenue water per budget cycle.
Increase access to 'external' (financial and institutional) resources for the maintenance and enhancement of SWSAs	Number of cross-departmental SWSA projects initiated.
	Number of SWSA-related government grant applications submitted per year.
	Number of partnerships with other entities (e.g. private sector, NGO's, research institutions to undertake SWSA projects.
	Number of existing programmes led by other spheres of government for SWSA management to which the municipality is a party.
	Number of research projects undertaken by municipality in collaboration with partners that determine the financial value of SWSAs to the economy.
	Number of outreach programmes implemented, and customised for different audiences (e.g. public, businesses) which show the value of SWSAs.
	Number of training courses/workshops attended, led by other external development organisations around SWSA management.
Understand and communicate the value, including the financial value, of SWSAs	Number of research projects undertaken by municipality in collaboration with partners that determine the financial value of SWSAs to the economy.
	Number of outreach programmes implemented, and customised for different audiences (e.g. public, businesses) which show the value of SWSAs.
	Number of training courses/workshops attended, led by other external development organisations around SWSA management.

Recommendations and key actions

Ensure that all indicators developed are directly linked to the municipality's vision and strategies to maintain relevance and drive focused project implementation.

Municipalities should establish baseline data as a reference point for evaluating progress over time, as this will aid in assessing the impact of SWSA interventions effectively.

Indicators should be reviewed and updated periodically to adapt to new challenges, priorities and data insights.

Municipalities should provide training to municipal staff on data collection, analysis and interpretation to enhance their capacity for monitoring and evaluation.

Municipalities can partner with universities and research institutions to build capacity and to gain access to specialised expertise and resources.

Budget and resources should be allocated specifically for the development, monitoring and ongoing review of indicators.

3.4 USEFUL RESOURCES

3.4.1 Examples of useful reports

Municipal Integrated Development Plans (IDPs)

Municipal Spatial Development Frameworks (SDFs)

Environmental Management Frameworks (EMFs)

State of Rivers reports (DWS) (www.dwa.gov.za/iwqs/rhp/state_of_rivers.aspx)

Reports on water quality indicators e.g. Water quality of rivers and open waterbodies in the City of Cape Town: Status and Historical trends with a focus on period April 2015 to March 2020

State of the Environment Reports (SoER)

Riemann, K., 2021, World Water Quality Alliance African Use Case Study Cape Town Aquifers: Deliverable 5: Summary Report, UN Environment Programme.

Department of Forestry, Fisheries and the Environment, 2023, Environmental Programmes Rehabilitation in the SWSAs.

Climate change strategy reports

Climate Change Action Plans

Climate Change Adaptation Plans

Reports on Water Quality Indicators e.g. City of Cape Town Metropolitan Municipality, 2020, Water Quality of Rivers & Open Waterbodies in the City of Cape Town: Status and Historical Trends, with a Focus On The Period April To March 2020: Technical Report.

Municipal Water Strategy Reports

State of the Environment Reports

Water Outlook Reports

City of Cape Town Metropolitan Municipality, 2023, The Western Cape Environmental Education Friends Handbook: March 2023.

3.5 GENERAL ONLINE RESOURCES, PLATFORMS AND DATABASES

1 Stats SA (Statistics South Africa). The National Census. https://census.statssa.gov.za/#/.

2 The GreenBook supports government in South Africa with adapting settlements to the impacts of climate change by providing an online repository of downscaled, baseline and future, municipal climate risk data and insights as well as adaptation information to be integrated into broader settlement planning. https://greenbook.co.za/

3 The main SANBI resource for GIS with interactive mapping, biodiversity data, training and legislation. http://bgis.sanbi.org.

4 The Journey of Water campaign, launched by WWF with support from Sanlam, aims to connect urban water users to their water sources. www.journeyofwater.co.za.

5 The Freshwater Biodiversity Information System (FBIS). FBIS is an open-access, online platform for serving, hosting, analyzing, visualising and sharing freshwater biodiversity data in South Africa. https://freshwaterbiodiversity.org/; https://www.frcsa.org.za/our-work/freshwater-biodiversity-information-system-fbis-2/.

6 The advanced fire information system (AFIS) is a satellite-based fire information tool that provides near real time fire information to users across the globe. https://www.afis.co.za/

7 The South African Environmental Observation Network (SAEON) Open Data Platform (ODP) is a metadata repository that facilitates the publication, discovery, dissemination, and preservation of earth observation and environmental data in South Africa. SAEON is a long-term environmental observation and research facility of the National Research Foundation (NRF). https://catalogue.saeon.ac.za/

8 South African National Ecosystem Classification System (SA-NECS). http://bgis.sanbi.org/Projects/Detail/1237 and 2018 National Biodiversity Assessment (NBA) http://bgis.sanbi.org/Projects/Detail/223.

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PART 4: STRATEGIC WATER SOURCE AREA SPATIAL MAPPING AND MANAGEMENT GUIDANCE

4.1 INTRODUCTION

Local government play a vital role in the protection of surface water, groundwater, drinking water and wetlands, often filling in the gaps in provincial and national government regulations (Koma, 2010; Middleton, 2011). South African municipalities often face competing demands, limited resources, and localized pressures such as urban expansion, invasive species, and agricultural runoff (Irlish et al. 2017; Kgomo, 2019). Capacity and capacity building to support source water protection at the local municipal level has been emphasised in several studies (e.g. Le Maitre, et al., 2018). In the absence of local capacity to develop and implement SWSA management plans, municipalities may fall behind in their ability to be proactive in planning to protect their drinking water sources and instead pursue reactive measures such as investment in expensive water treatment technologies (Haigh et al. 2008; Rawlyk and Patrick, 2013).

Place-based recommendations can provide context-specific guidance that aligns with local priorities while addressing these challenges holistically. They focus on integrating SWSA protection into municipal planning, fostering collaboration across departments, and engaging local communities and stakeholders. By offering practical, locally relevant solutions, these recommendations enable municipalities to safeguard critical water resources while supporting sustainable development and resilience to climate change. Given the country's diverse landscapes and varying challenges, these recommendations are crucial for effectively managing and protecting Strategic Water Source Areas (SWSAs), which are vital for ensuring water security.

The City of Cape Town Metropolitan Municipality was selected as a case study due to the unique advantages that metropolitan municipalities (Category A) offer for advanced mapping and management guidance. These municipalities typically have access to higher-resolution spatial data, GIS capabilities, and long-term environmental monitoring datasets. They also benefit from dedicated GIS specialists, hydrologists, and environmental planners, which can facilitate the integration of advanced mapping techniques. Metropolitan municipalities also include a mix of urban, peri-urban and natural areas, offering insights into multi-scale management challenges. With larger budgets and greater access to external funding, they are often better positioned to implement and sustain environmental projects (BER, 2021). Additionally, they often have well-established policies and regulatory frameworks for environmental and water resource management (City of Cape Town, 2017;2022b). The lessons from a metropolitan case study can be adapted to local municipalities, whereas the reverse is often more challenging due to resource and capacity limitations.

4.1.1 Structure of this Part

This Spatial Mapping and Guidance document is structured as follows:

- Section 4.2 and Section 4.3 introduces the case study municipality and explains the approach used in data collection, spatial mapping and the development of place-based recommendations.
- Section 4.4 to Section 4.7 looks at each of the City of Cape Town SWSAs in detail, providing descriptions and key statistics for the SWSAs, its main impacts along with placed based recommendations for the water bodies, wetlands, rivers, and aquifers within the SWSA.
- Section 4.8 deals with transboundary SWSA management and
- Section 4.9 introduces the data repository and its intended use for municipalities.

4.1.2 Aims and outcomes

The report uses the City of Cape Town Metropolitan Municipality as a case study to illustrates how spatial data, and mapping can be used to guide municipal planning and decision-making are presented for the case study area and recommendations for land use practices are provided. The report should help the user to:

1. Improve the management and protection of SWSAs within the municipal area.
2. Identify the threats to rivers, waterbodies, wetlands and aquifers in SWSAs.

3. Understand the links between threats, management recommendations and the identified strategies and projects for SWSAs within local government.
4. Identify key national spatial datasets for SWSA management.

4.1.3 Intended users

This Spatial Mapping and Management Guidance document is intended for use by wide range of stakeholders involved in municipal planning, environmental management and service delivery within a municipal context. These users typically include:

- Urban and Regional Planners responsible for integrating SWSA considerations into Spatial Development Frameworks (SDFs) and land-use planning to ensure sustainable urban growth and appropriate zoning.
- Environmental Management Practitioners focused on implementing conservation strategies, monitoring biodiversity and ecosystem health, and enforcing environmental regulations related to SWSAs.
- Technical Services department (water and infrastructure) can use the document to plan and manage water supply systems, address infrastructure impacts on SWSAs, and mitigate risks like leaks or over-extraction.
- Finance and budgeting departments can reference the document to prioritise and allocate funding for SWSA-related projects and ensure compliance with funding conditions linked to environmental conservation.
- Senior managers and municipal directors can use the guidance to inform high-level decision-making, align departmental activities with strategic objectives, and fulfil governance mandates related to water security and environmental sustainability.
- External stakeholders and partners including NGOs private sector entities and community groups who collaborate with municipalities on conservation projects can use the document to align their efforts with municipal objectives.

4.2 STUDY AREA DESCRIPTION

The City of Cape Town Metropolitan Municipality is situated in the southern peninsula of the Western Cape Province (Figure 4.1). the City spans the Berg-Olifants Water Management Area which extends north to include both the Berg and the Olifants river catchments, as well as the smaller natural catchments within the City's boundaries. The City has a coastline of 294 km and stretches from Gordon's Bay to Atlantis and includes the suburbs of Khayelitsha and Mitchells Plain.

The CCT is a large urban area with a high population density, an intense movement of people, goods and services, extensive development and multiple business districts and industrial areas. It is one of four coastal metropolitan municipalities in South Africa together with eThekwini, Nelson Mandela and Buffalo City, and the only Category A Metropolitan Municipality in the Western Cape province. The City of Cape Town is South Africa's second largest economic centre and second most populous city after Johannesburg.

The City of Cape Town has one surface SWSA completely contained within its boundaries, namely the Table Mountain SWSA, and two groundwater SWSAs namely the Cape Peninsula and Cape Flats SWSA and the West Coast aquifer. Partially contained within its municipal boundaries are the surface water SWSA of the Boland Mountains and the Southwestern Cape Ranges groundwater SWSA (Figure 4.1). The Southwestern Cape Ranges groundwater SWSA was omitted from this assessment as only a small portion of its land area falls within the City of Cape Town boundary. Historically, the water sources within the City of Cape Town Municipal boundaries provided the first sources of water for a growing City of Cape Town (CCT) and were incorporated directly into the urban and industrial landscape. Today, they provide just under 2% of the city's bulk water supply, as most water is obtained from surface water sources supplied outside the city through the Western Cape Water Supply System (CCT, 2019a; 2023).

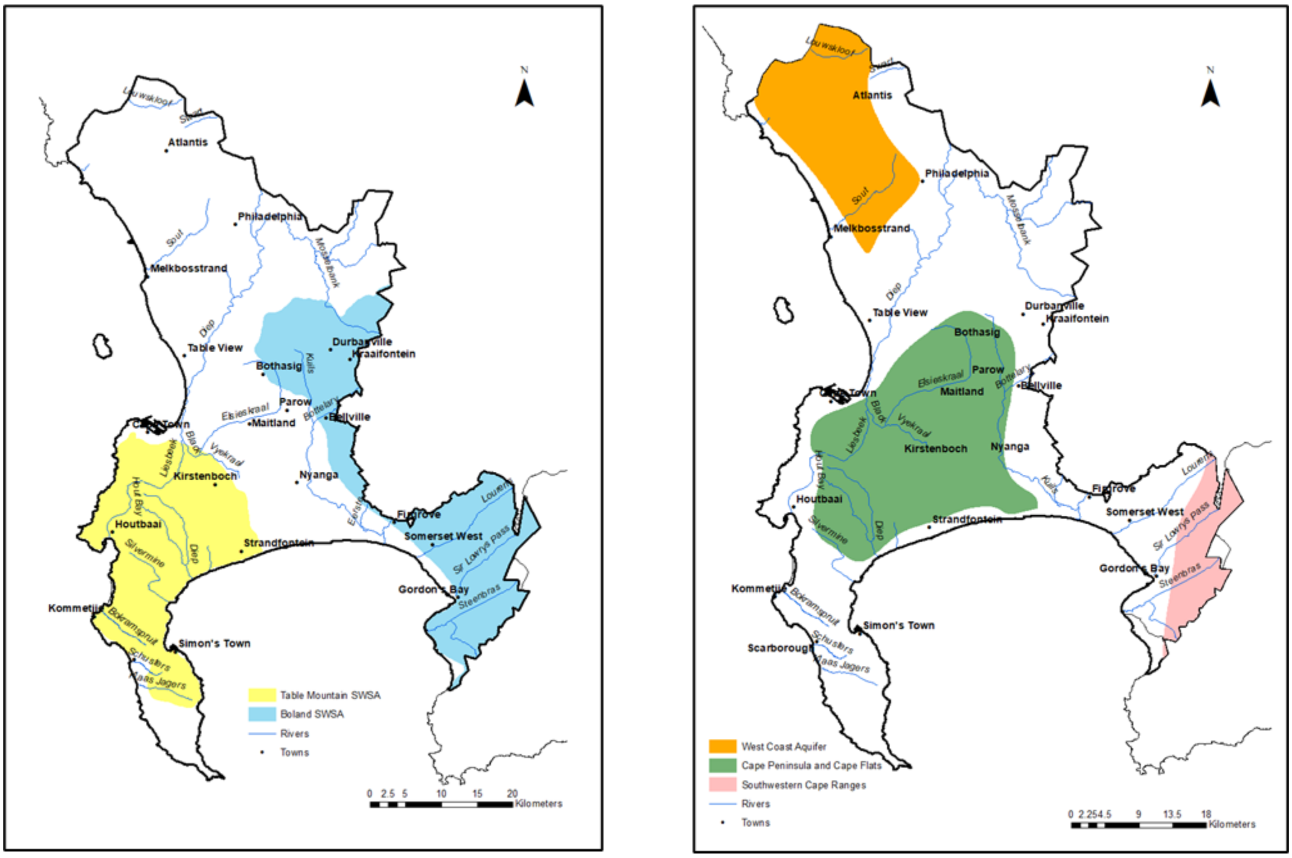

Figure 4.1. City of Cape Town surface water SWSAs (left, Lötter and Le Maitre, 2021) and groundwater SWSAs (right, Le Maire et al., 2018). The location of the study area within the southern peninsula of the Western Cape Province is also indicated

4.3 APPROACH

Place-based recommendations were developed for the SWSAs of the City of Cape Town Metropolitan Municipality following three main steps which include a situation assessment, spatial mapping to assist identification of key issues and impacts and the development of place-based recommendations.

4.3.1 Situation assessment

A situation assessment was undertaken to assess the current state and condition of the freshwater ecosystems within the two surface SWSAs and two groundwater SWSAs of the City of Cape Town (Figure 4.2).

To further inform the situation assessment site visits were undertaken in April 2023 in areas of the Sand River catchment which flows through the Table Mountain SWSA-sw and overlaps with the Cape Peninsula Cape Flats SWSA-gw (Figure 4.2). As well as the Kuils-Eerste River catchment which transverses the Cape Peninsula Cape Flats Aquifer. The site visits allowed the project team to observe the present state of the two river systems as they transverse the highly urbanised catchments of the City of Cape Town from source to sea. It also provided an opportunity to view sites along the river reaches where the City has rehabilitation and monitoring programs. The sites visited are shown in more detail in

Figure 4.3 below. For more detail on the site visits see Section 2.3.3.

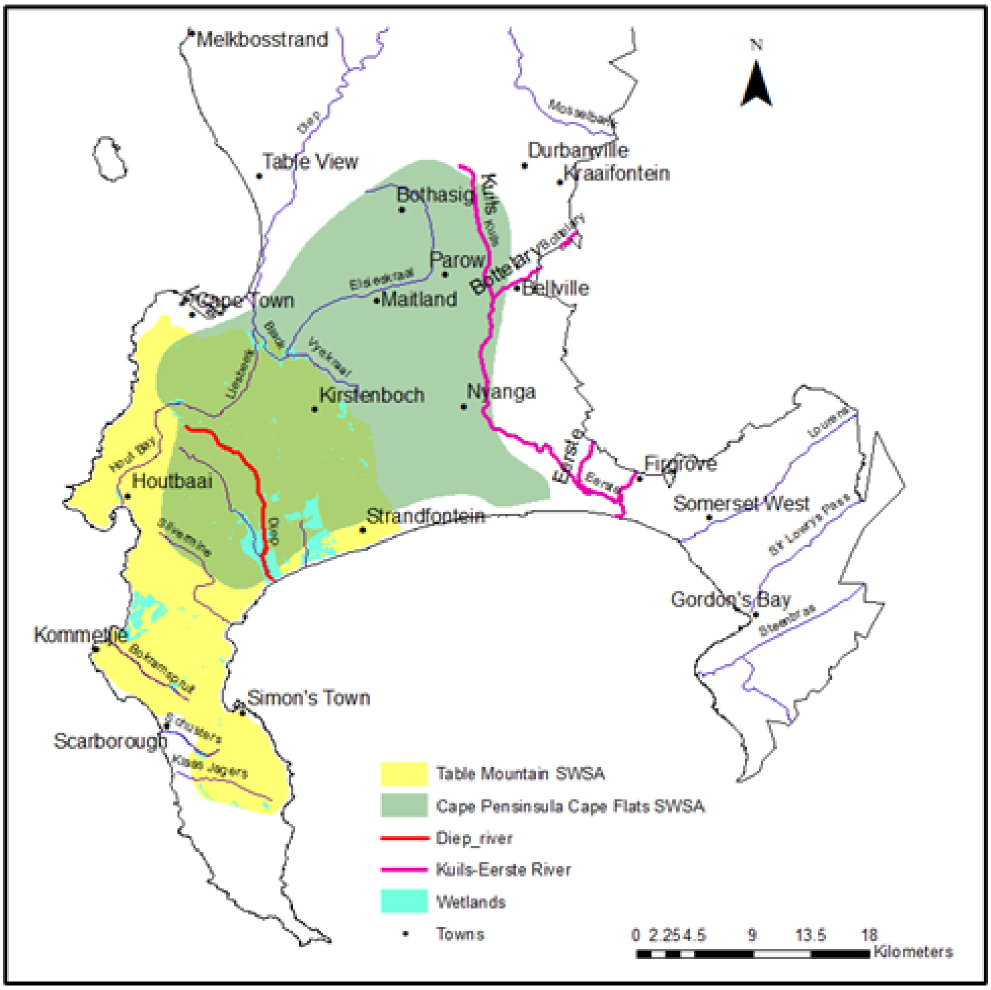

Figure 4.2. Location map showing the rivers where site visits were undertaken in the Diep River and Kuils-Eerste River, City of Cape Town

4.3.2 Spatial mapping for SWSA management

The spatial mapping procedure included collecting, analysing, and visualising spatial data to inform decision-making and ensure that recommendations are relevant to the specific characteristics of the study area. Spatial data was collected from City of Cape Town municipal GIS database and national datasets (e.g. DWS, SANBI, CSIR). Key data layers include:

- SWSA boundaries and locations
- Land cover
- Hydrology (e.g. rivers, aquifers)
- Biodiversity (e.g. protected areas, critical ecosystems)
- Infrastructure (e.g. roads, dams)
- Socioeconomic factors (e.g. population density, settlements)

Data validation and preprocessing was undertaken to ensure datasets are accurate, up to date, and free of errors. All datasets were converted to compatible formats, coordinate systems and resolutions for analysis and placed in a geodatabase. ArcGIS 10.7 (ESRI, 2012) and ArcGIS Pro Maps were used to create maps and visualise findings using bar graphs and pie charts.

Figure 4.3. Sand River Catchment: (a) Spaanschemat river, (b) Westlake River and (c) Zandvlei Estuary; Kuils-Eerste River Catchment: (d) Kuils River source in Durbanville, (d) canalised reach in Kuilsriver and (f) river reach in Driftsands Nature Reserve after passing through the Khayelitsha wetlands

The assessment focused on water quality and quantity, ecosystem health, human activities and land use as listed below.

- The ecological status of rivers in each SWSA was identified based on the classification set out in the South African National Biodiversity Assessment (Van Deventer, 2019).
- Sources of pollution and their impacts on water quality were reviewed and assessed through a review of relevant literature.
- The health of riparian and aquatic ecosystems was assessed through a review of existing studies and reports.
- The presence of invasive species and their impact on local biodiversity was researched and assessed.
- Habitat condition for indigenous species were evaluated.
- Land use was mapped for landcover classes using the National Landcover Map of South Africa, 2022.
- Percentage of area covered for main land use classes of agricultural, industrial and urban areas were calculated
- The impact of human activities on water sources were identified through a review of relevant studies and reports.

A detailed list of data sources can be found in Reference list (Section 4.10.2).

4.3.3 Broad-scale management zones: Essential Life Support Action Areas

One of the main spatial data source layers used in the analysis for the City of Cape Town was the spatial layer obtained from the Essential Life Support Action Areas (ELSAA) project (further reading at https://unbiodiversitylab.org/en/maps-of-hope/) which incorporated 44 input data layers to produce several project outputs, including the broad-scale spatial management zones (i.e. land surface zoning) used in this project. These underlaying data layers included protected areas (e.g. formal protected areas and private nature reserves); areas designated by the 2017 Western Cape Biodiversity Spatial Plan (Pool-Stanvliet et al., 2017) as Critical Biodiversity Areas (CBAs) and Ecological Support Areas (ESAs); other natural areas in proximity to or adjacent to core areas, and the National Land Cover data. Critical Biodiversity Areas 1 (CBA1) are areas in a natural condition that are required to meet biodiversity targets for species, ecosystems or ecological processes and infrastructure. In contrast, Ecological Support Areas 2 (EBS2) are areas that are not essential for meeting biodiversity targets but play an important role in supporting the functioning of protected areas or CBAs and are often vital for delivering ecosystem services (Pool-Stanvliet et al., 2017).

The ELSAA actions, defined as areas where nature positive and nature-based actions can safeguard key biodiversity and ecosystem services, employ five actions (UNDP, 2021).
These action categories include:

- **Protect**: Conserve and maintain ecosystems
- **Reduce pressures**: Avoid loss and reduce pressures on ecosystems
- **Restore**: Restore degraded ecological infrastructure
- **Urban adapt**: Use ecosystem-based approaches to urban development
- **Avoid loss**: Prevent the loss of biodiversity and ecosystem services

4.3.4 Development of place-based recommendations

To develop the place-based recommendations critical impacts were identified based on the situational analysis, with a focus on the most pressing threats and opportunities highlighted in the spatial analysis. Where possible recommendations were tailored to the specific characteristics of the municipality's SWSAs and aligned with local socio-economic and environmental conditions. Many SWSA issues, such as water quality management or habitat restoration require collaboration across multiple departments (e.g., Environmental Management, Public Works and Water Services). A column has therefore been included in the management recommendation table stating which department is responsible for executing the management action. Each recommendation is given a priority of high, medium or low and is explained in detail in Table 4.1.

Table 4.1. Priority Key Explanation

Priority Level	Explanation	Criteria for Assignment
High Priority	Urgent issues that require immediate action to prevent further degradation or address critical risks.	Directly impacts essential ecosystem services (e.g., water supply, biodiversity). Clear and cost-effective solutions available Addresses root causes of widespread problems (e.g., pollution, invasive species).
Medium Priority	Important issues that significantly affect ecosystem health and functionality but are less time sensitive.	Impacts are moderate and can be managed over time without immediate risks. Requires additional planning, resources, or collaboration before implementation
Low Priority	Long-term or lower-impact issues that do not pose an immediate threat but still require attention.	Indirect or localised impacts that accumulate over time. Complex solutions requiring significant resources or extensive stakeholder coordination.

The SWSAs located within the boundary of the CCT are situated within highly urbanised landscapes in the Western Cape. These SWSAs provide essential ecosystem services, including water supply, flood regulation and biodiversity support to surrounding urban and peri-urban areas. However, their proximity to dense human settlements and extensive agricultural activities exposes them to a range of shared challenges. Common issues in such landscapes include invasive alien vegetation, pollution from stormwater and agricultural runoff, high nutrient levels leading to eutrophication, erosion, sedimentation and the disruption of natural river flows due to infrastructure and urban expansion (Toroitich, 2008; Chamier et al., 2012; Kumari and Paul, 2022). Instead of listing these issues for each SWSA they have been listed in Table 4.2 below and are common throughout all the SWSAs in the City of Cape Town.

Table 4.2. Common issues experienced within the SWSAs of the City of Cape Town Municipality

Common Issue	Description	Impact	Recommendation	Priority
Invasive Alien Vegetation	Dominance of species like Port Jackson, Rooikrans, Black Wattle and River Gum along riverbanks.	Reduces water availability, biodiversity, and soil stability.	Conduct phased clearing, replant with indigenous vegetation, and repurpose biomass for cost recovery.	High
Poor Water Quality from Stormwater Runoff	Pollution from urban areas, agriculture, and industrial activities.	Degrades ecosystems, leads to eutrophication, and impacts aquatic species.	Establish constructed wetlands and buffer zones to filter runoff; promote sustainable land-use practices.	High
High Nutrient Levels and Eutrophication	Nutrient enrichment from fertilizers, wastewater, and agricultural runoff.	Leads to algal blooms, oxygen depletion, and loss of aquatic biodiversity.	Introduce nutrient management practices and natural filtration systems (e.g., reed beds).	High
Decreased Aquatic Biodiversity	Reduction in sensitive species like invertebrates and fish due to pollution and habitat loss.	Disrupts ecosystem balance and river health.	Restore riparian zones, reduce pollution sources, and create refuges for sensitive species.	Medium
Erosion and Sedimentation	Increased sedimentation from urban development, deforestation, and poor land management.	Destabilizes riverbanks, clogs waterways, and reduces water quality.	Stabilize riverbanks with bioengineering techniques; implement contour farming and reforestation.	High
Reduced River Flow and Altered Flow Regimes	Caused by dams, water abstraction, and urbanization.	Reduces water availability for ecosystems and increases downstream flooding.	Advocate for regulated water releases; promote water-efficient irrigation and rainwater harvesting.	Medium
Canalization and Infrastructure Impact	Modification of natural river channels by roads, bridges, and urban expansion.	Disrupts natural flow, reduces habitat, and increases flood risk.	Identify areas for partial restoration of natural channels; enforce environmental impact assessments.	Medium
Loss of Riparian Vegetation	Degradation or removal of riparian vegetation for development or agriculture.	Reduces ecosystem services like erosion control and water filtration.	Replant riparian zones with native vegetation to stabilize soils and improve water quality.	Medium
Increased Flooding and Water Logging	Caused by urban sprawl, loss of wetlands, and altered flow dynamics.	Increases flood risk, damages infrastructure, and affects communities.	Reconnect floodplains and wetlands to enhance natural flood control.	Low

4.4 STRATEGIC WATER SOURCE AREAS IN FOCUS

4.4.1 Table Mountain SWSA-sW

The Table Mountain SWSA-sw has an extent of 465 km^2 and falls completely within the boundaries of the City of Cape Town Municipal area. The Diep, Silvermine and Hout Bay Rivers are the main rivers which flow from Table Mountain water source area (Figure 4.4). The ecological status of the Diep River is EF (seriously to critically modified) as it flows largely through an urbanised area where wastewater from urban areas and agricultural runoff (e.g. dairy industry) cause nutrient enrichment and reduce its water quality. Silvermine River has an ecological status of AB (natural/near natural) and flows through the Silvermine Reserve which forms part of the Table Mountain National Park. Silvermine River is the only river in the Cape Peninsula which runs its whole course without going through a developed area (Figure 4.4). Hout Bay River has an ecological status of C (moderately modified, Van Deventer et al., 2019). The upper reaches of the Hout Bay River lie within the Cape Peninsula National Park. Downstream water quality has been impacted by peri-urban and urban development (storm water discharges, abstraction, invasive alien vegetation, sedimentation and flood banks (River Health, 2005).

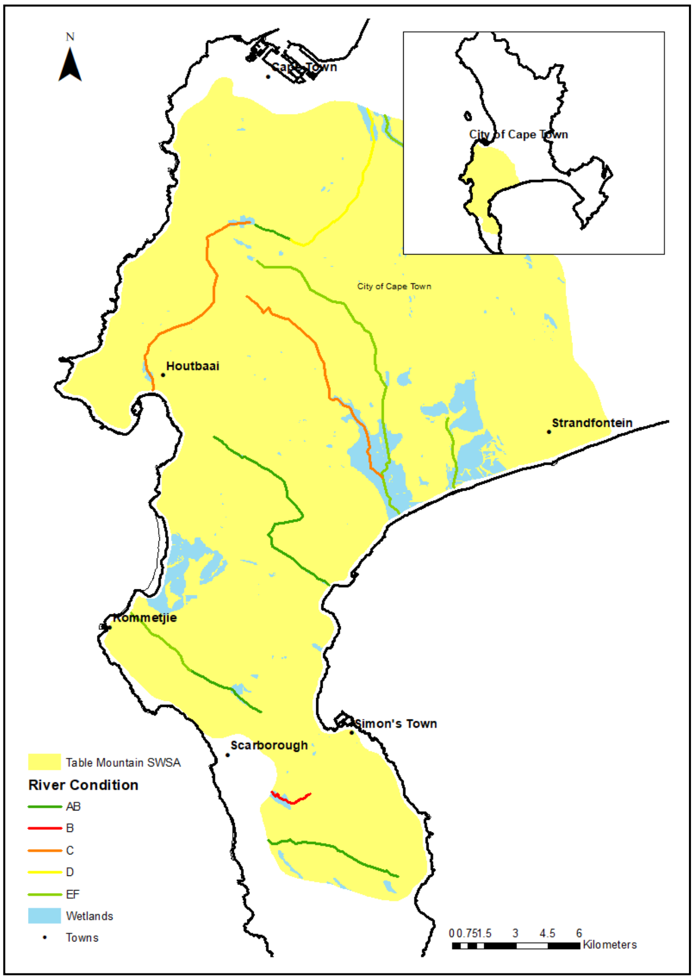

Figure 4.4. Map showing the Table Mountain SWSA-sw. Key for River Condition. AB- Intact able to contribute to river ecosystem biodiversity targets, A – unmodified, B – largely natural with few modifications, C– moderately modified, D – largely modified, E – seriously modified, F - critically modified (Van Deventer et al., 2019)

Klaas Jagers River is a free-flowing river in the Table Mountain National Park and has an ecological status of AB (natural/near natural). Schusters river which also runs through the national park has an ecological status of B (near natural). Bokramspruit has an ecological status of AB (natural/near natural) for the parts of the river which runs through Table Mountain National Park, whereas the sections running through urban areas have an ecological score of EF (seriously to critically modified, Van Deventer et al., 2019). Liesbeek River has an ecological status of AB (natural/near natural) in its upper reaches, but changes to a D (severely modified) as it flows through urban areas. Black and Vyekraal Rivers have an ecological status of EF (seriously to critically modified). The Salt/Black River Catchment of which the Liesbeek, Black and Vyekraal rivers form part are the most urbanised of all the catchments in the City of Cape Town (Aziz, 2020).

4.4.2 Essential Life Support Action Areas

The ELSAA dataset shows that the Table Mountain surface water SWSA supports a diverse plant life with 36% of its surface area classified as Protected whilst the areas assigned to the Urban Adapt action area occupy 27% (Figure 4.5). Figure 4.6 shows the settlement areas in the City of Cape Town in finer detail. Poorly planned urban development can magnify the risk of environmental hazards such as flash flooding as infiltration is reduced by the presence of hard surfaces in this area. Larger settlements generate more sewage, solid waste, and industrial effluents, which can contaminate surface and groundwater in SWSAs. Balancing the needs of growing settlements with the conservation goals of SWSAs requires careful urban planning. The settlements layer can be used to identify where settlements overlap with or are encroaching wetlands or buffer zones, or where urban expansion can pose risk to groundwater recharge, water quality or natural habitats. The area classified with the Restore action area makes up (16%) of the SWSA and includes natural areas and bare ground which can be restored to the degree to which they deliver sufficient ecosystem services.

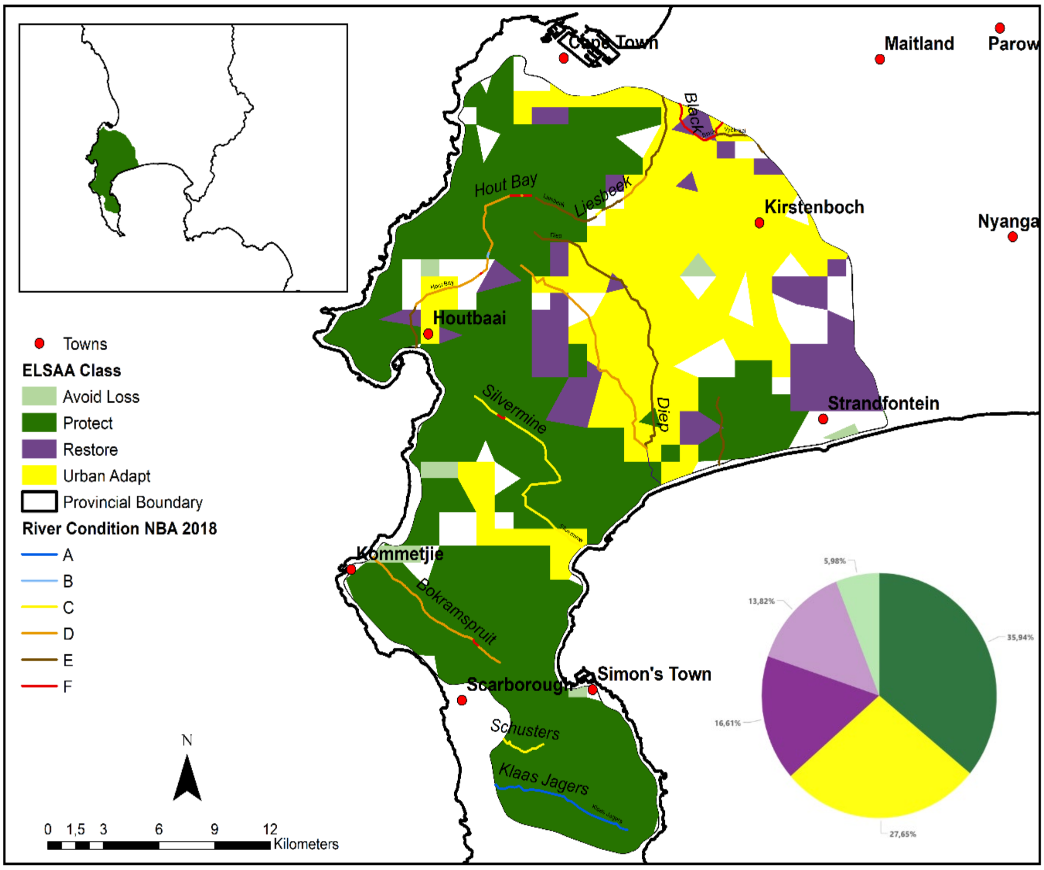

Figure 4.5. Table Mountain SWSA-sw and ELSAAs.

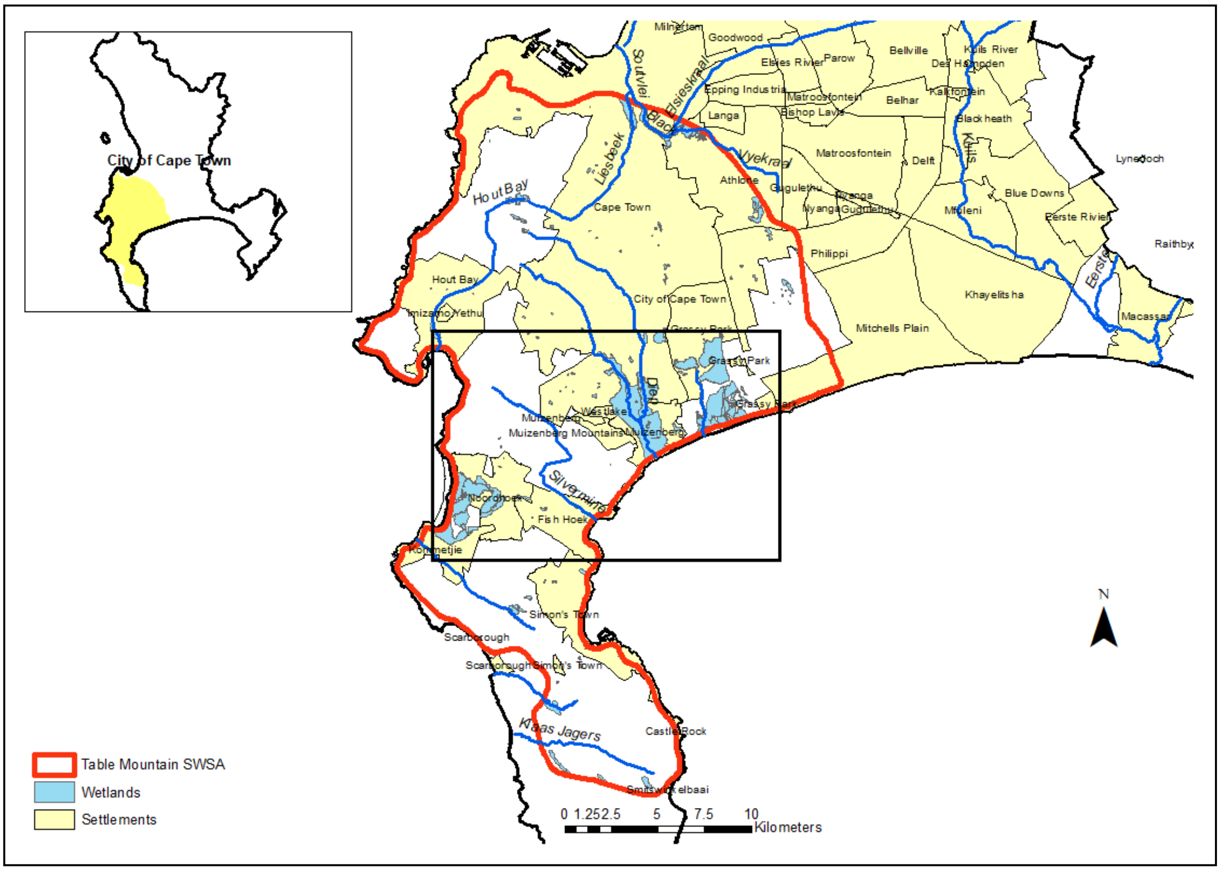

Figure 4.6. The Settlements that occur within the Table Mountain SWSA-sw

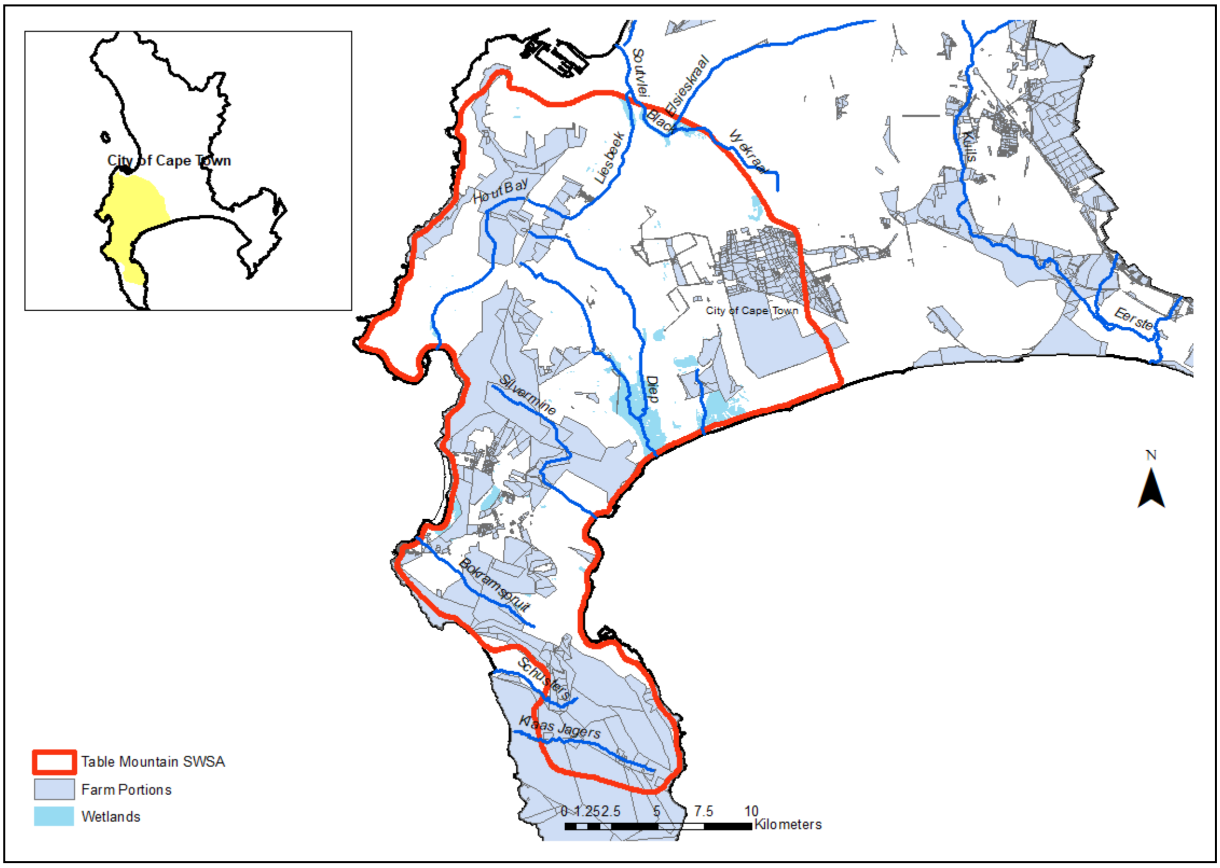

Figure 4.7. Showing the farm portions that fall within the Table Mountain SWSA-sw

A farm portion is a subdivided area of land that is part of a parent farm (Figure 4.7). Farm portions may be divided among various right holders, which can increase the likelihood of cumulative environmental impacts that degrade SWSA functionality. Municipalities can use farm portions (e.g. agriculture, forestry, grazing, mining) to identify activities that may negatively affect SWSAs. The spatial layer can also be used to engage with private farm owns and cooperatives in conservation initiatives to identify areas where municipal and private resources can be combined to address common challenges, such as invasive species or erosion control.

Figure 4.8. Table Mountain Strategic Water Source Area: (a) Silvermine wetlands providing ecosystem service of water quality improvement, flood alleviation, recreation and climate control. (b) Siltation in the river reach of the Diep River, (c) Gabion baskets in Hout Bay River to prevent slope from sliding or eroding, and (d) workers cleaning up reeds clogging riverbeds in local river. Source: City of Cape Town

4.4.3 Key threats and challenges to Table Mountain SWSA

The key issues and challenges in the Table Mountain SWSA are those typical of an urban catchment river system, where the natural vegetation cover in the wider catchment area has been transformed and consists largely of hardened or paved surfaces and grassed areas (Figure 4.8) and include:

- Urban and peri-urban development, including informal settlements, contribute to runoff and pollution.
- Farming along riverbanks disturbs natural vegetation and contributes to nutrient runoff and erosion.
- Levees and canalization prevent natural floodplain absorption, leading to intensified flood flows and increased siltation.
- Increased erosion from cultivation and vegetation removal results in sediment accumulation in river channels and estuaries.
- Water storage, abstraction, and diversion structures significantly reduce natural river flows, especially in the dry season.

- Cultivation practices and flood management structures increase erosion, leading to higher sediment loads.
- Nutrient enrichment from agricultural runoff, treated wastewater, and stormwater discharge degrade water quality.
- Poor water quality and habitat degradation result in the loss of pollution-sensitive invertebrates and fish species like the endemic Cape galaxias (*Galaxias zebratus*).
- The proliferation of invasive alien vegetation outcompetes indigenous species and destabilizes riverbanks.

4.4.4 Management recommendations for Table Mountain SWSA

Table 4.3. Table Mountain SWSA-sw place-based recommendations

Issue	Recommendation	Under Resourced Municipalities	Responsible Department	Priority
Severe siltation in the Diep River	Install low-cost sediment traps using natural materials (e.g., rocks, vegetation).	Engage local communities in periodic sediment removal through public work programs	Environmental Management, Public Works	High
	Conduct public awareness campaigns about activities contributing to sedimentation, such as poor land management upstream.	Partner with local schools or NGOs to create monitoring programs and manage buffers as community projects.	Community Engagement, Agriculture	Medium
Reduced flow due to water abstraction	Implement seasonal water abstraction limits and engage water users in setting withdrawal schedules	Focus on education campaigns.	Technical Services, Community Engagement	High
Poor water quality and ecosystem decline	Establish vegetative buffers along zones along riverbanks to filter runoff and improve water quality	Partner with local schools or NGOs to create monitoring programs and manage buffers as community projects.	Environmental Management, Agriculture	Medium
	Educate local communities and businesses on proper waste management and its impact on river ecosystems.		Community Engagement	Medium
Invasive alien vegetation destabilizing riverbanks	Prioritise removal of invasive species in critical areas affecting water flow, starting with small-scale projects		Environmental Management, Public Works	High
	Replant cleared areas with indigenous vegetation to prevent		Environmental Management	High

Issue	Recommendation	Under Resourced Municipalities	Responsible Department	Priority
	erosion and maintain ecosystem stability.			
	Explore biomass reuse (e.g. for biochar of mulch) to offset costs and provide economic benefits.		Public Works, Private Sector Partnerships.	Medium
Nutrient enrichment from wastewater and runoff.	Construct basic wetland filters or reed beds near discharge points to reduce nutrient loads.		Wastewater Management	High
	Work with local farmers to implement simple runoff control methods, such as grassed waterways and contour farming.		Agriculture Department	Medium
	Pilot treated wastewater reuse programs for irrigation in collaboration with agricultural stakeholders.		Technical Services, Agriculture	High
Dams and water abstraction reducing river flows	Promote upstream rainwater harvesting to minimise the need for river water abstraction.		Technical Services, Public Works	Medium
Pollution from stormwater and septic seepage (Hout Bay River).	Install sediment traps and bioswales in critical stormwater runoff areas.	Provide low-cost or subsidised septic tank inspections and upgrades for affected households.	Public Works, Health and Sanitation	Medium
	Educate communities about proper septic tank maintenance and its environmental benefits.		Community Engagement	Medium
Overgrowth of reeds clogging channels (Hout Bay River)	Combine clearing with upstream flow regulation to prevent regrowth in critical zones.	Use local labour for clearing and re-evaluate annually; avoid over-clearing to protect biodiversity.	Technical Services	Medium
Erosion due to palmiet removal and cultivation (Hout Bay River)	Reintroduce palmiet shrubs in eroded areas to stabilise soils and reduce sedimentation	Work with local farmers to restore eroded areas and train them on cost-effective soil stabilization methods.	Environmental Management	Medium
	Promote contour farming techniques to		Agriculture Department	Medium

Issue	Recommendation	Under Resourced Municipalities	Responsible Department	Priority
	reduce erosion in agricultural areas.			
E. coli contamination from septic systems (Silvermine River)	Subsidize septic tank maintenance for households near the river.	Work with local health agencies to offer low-cost solutions like community septic maintenance programs.	Health and Sanitation	High
	Conduct awareness campaigns on the risks of improper waste disposal and encourage community monitoring programs.		Community Engagement	Medium
Increasing orthophosphate levels (Silvermine River)	Install natural reed bed filters and promote low-phosphate fertilizers			Medium
	Educate farmers on low-phosphate alternatives and create small-scale demonstration filtration systems.		Environmental Management, Agriculture	Medium
Pollution from spills and overflows	Create a community-based reporting system (e.g. hotlines or apps) for spills and overflows.		Community Engagement, Public Works	Medim
	Establish volunteer rapid response teams for minor pollution clean-ups.		Environmental Management, Community Groups	Medium

4.5 BOLAND SWSA-SW

The proportion of the Boland SWSA that falls within the City of Cape Town Municipal boundaries covers 512 km^2 and makes up 8.4% of the total Boland SWSA (Figure 4.9). The rest of the Boland SWSA spans three district municipalities namely: Cape Winelands (53,8%), Overberg (36,6%) and West Coast (1,1%). The main rivers that transverse the CCT Boland SWSA are the Upper Kuils, Lourens, Steenbras and Sir Lowry's Pass Rivers. The upper reaches of Kuils River have a current ecological state of D (severely modified) which can be attributed to human settlements and industrial activities. The very upper reaches of the Lourens have an ecological status of AB (natural/near natural) as it flows through the protected Hottentots Holland Nature Reserve with some impacts from commercial plantations, it however changes to C (moderately modified) and to D (severely modified) as it travels through the surrounding farmlands, residential, commercial and light industrial areas which has replaced the natural coastal renosterveld vegetation in the lower reaches of the river (City of Cape Town, 2010; Van Deventer et al., 2019,).

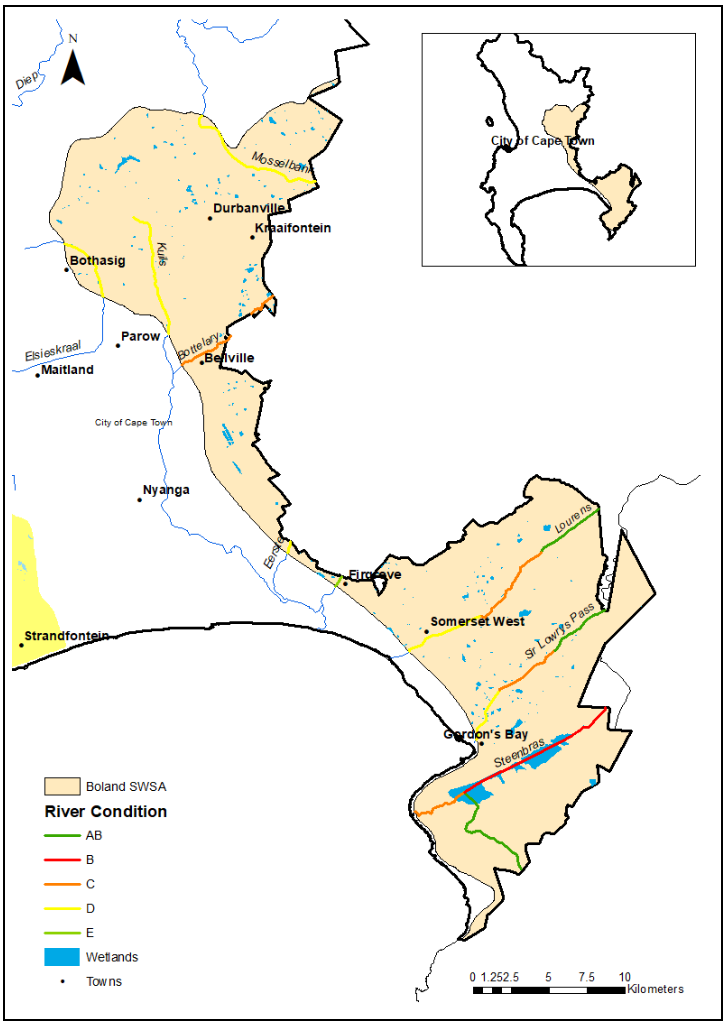

Figure 4.9. Map showing the Boland SWSA-sw, CCT case study. Key for River Condition. AB- Intact able to contribute to river ecosystem biodiversity targets, A – unmodified, B – largely natural with few modifications, C– moderately modified, D – largely modified, E – seriously modified, F - critically modified (Van Deventer et al., 2019).

The Steenbras River has an ecological status of B (near natural) in the upper reaches of the river which flow through the Steenbras Nature Reserve, while lower reaches of the river have an ecological status of C (moderately modified) (Van Deventer et al., 2019). The majority of the water in the Steenbras River is collected into the Steenbras upper and lower dams, which supplies water for domestic use for the City of Cape Town (Wittridge, 2011). The Steenbras River has an ecological status of B (near natural) in its upper reaches located on the southern slopes of the Hottentots Holland Mountains, the condition of the river degrades into ecological status C (moderately modified) as it passes through disturbed smallholdings and areas that are heavily infested with invasive alien plants in former farmlands (Day, 2020) (Figure 4.10). The river is characterised by high levels of accumulation of litter and sediment in the channels, bank and bed erosion; and periodic inflows of sewage from blocked sewers (Day et al., 2016). The riverbanks have a high prevalence of invasive alien vegetation, and the riparian corridor has little remaining indigenous vegetation.

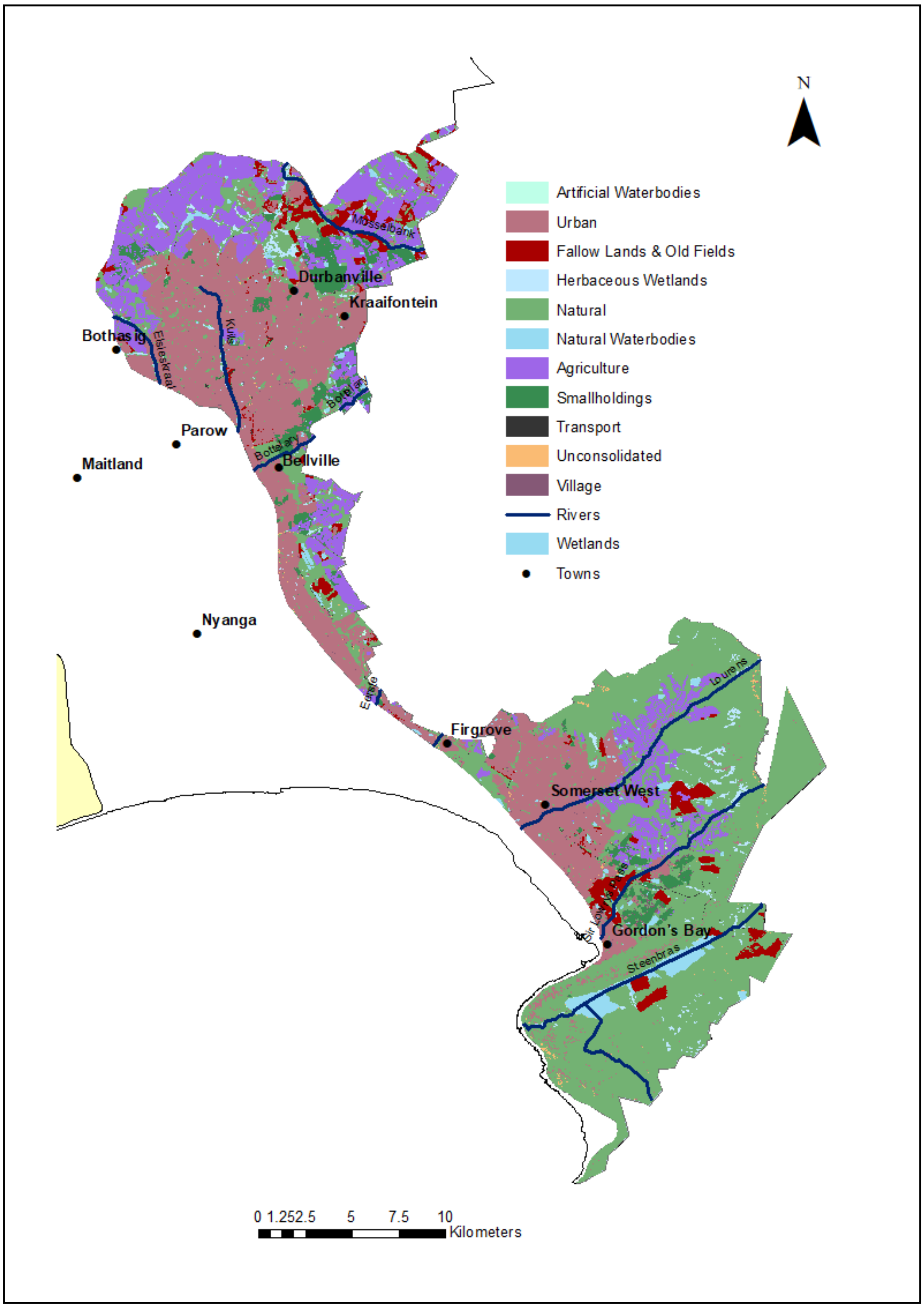

Figure 4.10. Land cover map of the Boland SWSA

4.5.1 Essential Life Support Action Areas

Currently 42% of the CCT Boland SWSA-sw is formally protected and managed for biodiversity conservation, whilst 32% of the SWSA is urbanized and categorised under the Urban Adapt action area (Figure 4.11). The surface water sources in this area have been impacted by habitat degradation and fragmentation linked to poor agricultural land use practices According to the land cover map more than 20% of the CCT Boland SWSA is made up of agricultural land (Figure 4.10). Intensive crop planting or livestock farming associated with overgrazing can be expected to accelerate runoff and soil erosion while also causing river channel and flow regime changes (Wohl, 2000; Knox, 2001; Zuazo and Pleguezuelo, 2009). At the same time, species diversity of plants, animals, and microbes occurring in these water sources is significantly reduced. The remaining natural areas with established plant cover and biodiversity will also need to be maintained as these areas play an important role in supporting the functioning of protected areas or CBAs (Skowno et al., 2019).

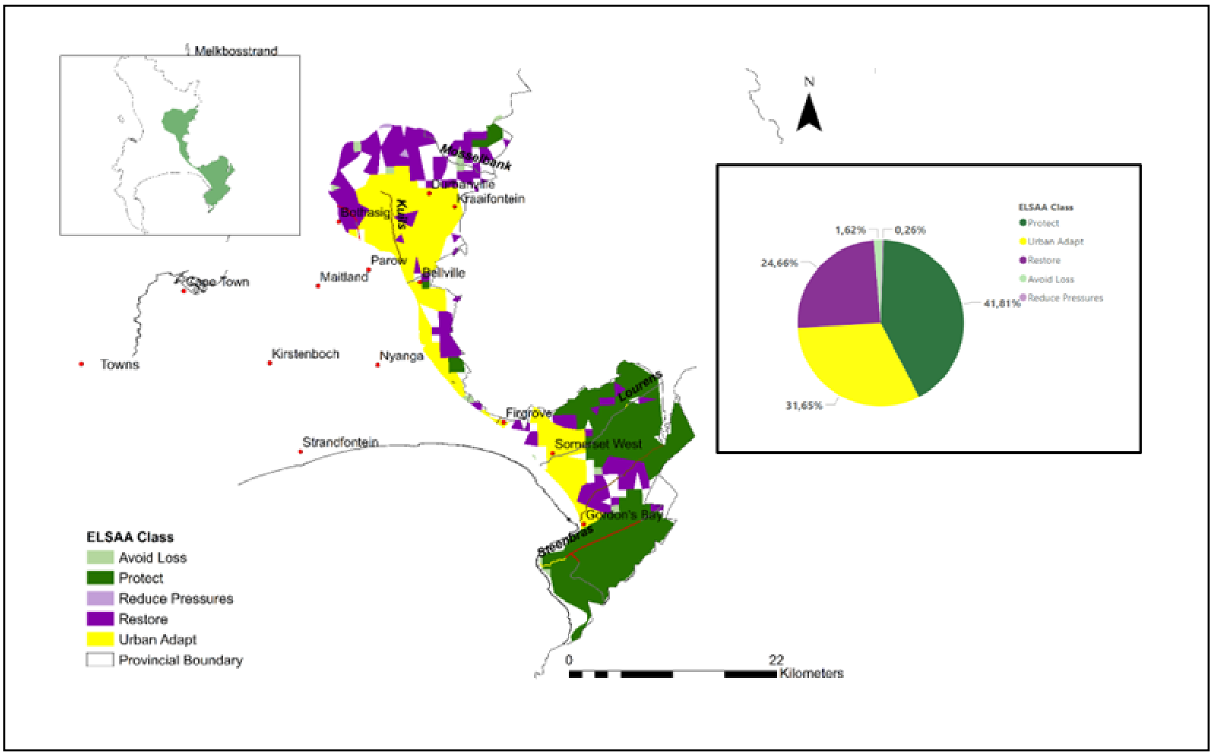

Figure 4.11. Boland SWSA-sw and ELSAAs

Figure 4.12. Main Rivers of Boland Strategic Water Source Area: (a) Upper catchment area of Steenbras River with limited human interference (b) Middle reach of the Lourens River showing disturbed natural vegetation in riparian zone (c) Lower reach of the Lourens river after transversing surrounding farmlands, residential, commercial and light industrial areas which has replaced the natural coastal renosterveld vegetation. (d) middle reaches of Sir Lowry's Pass River where accumulation of litter and organic debris in river channels, lead to poor water quality.

4.5.2 Key threats and challenges to Boland SWSA

- Pollution from various land uses significantly impacts water quality and aquatic life of the rivers in the Boland SWSA
- The spread of invasive alien plants and fish has disrupted indigenous ecosystems and reduced biodiversity.
- Excessive water withdrawal for agriculture and urban use has lowered river flow, affected aquatic habitats and reduced water availability of the downstream reaches of the rivers in the Boland SWSA.
- Development activities, both urban and agricultural, have led to significant habitat loss and fragmentation, further stressing the rivers' ecological health.
- Physical disturbances from land use activities resulted in increased erosion and sediment loads, degrading water quality and aquatic habitats.

4.5.3 Management recommendations for Boland SWSA

Table 4.4. Boland SWSA-sw place-based recommendations

Issue	Recommendation	Under Resourced Municipalities	Responsible Department	Priority
Impact of road-bridge construction and industrial activities	Enforce environmental compliance and use bioengineering for restoring affected sections	Use natural materials for bank stabilization and low-cost restoration methods.	Public Works, Environmental Management	Medium
Encroachment of urban areas into natural river zones	Implement zoning restrictions and establish riparian buffer zones	Use GIS tools to identify encroachments; enforce compliance with zoning laws.	Urban Planning, Environmental Management	High
Impact of dams (Steenbras Upper and Lower) on natural river flow (Lourens River)	Advocate for ecological flow releases to mimic natural river conditions	Partner with dam operators to schedule periodic water releases during dry seasons.	Technical Services	Medium
Loss of Cape galaxias (Galaxias zebratus) and other pollution-sensitive species (Lourens River)	Reduce pollutants and restore critical habitats for biodiversity conservation.	Focus on replanting riparian vegetation and reducing nutrient inflow upstream.	Environmental Management	Medium
	Focus on replanting riparian vegetation and reducing nutrient inflow upstream.	Focus on small-scale modifications in sections where canalization has severe impacts.	Environmental Management	Medium
Construction of weirs and canalization in certain river sections (Lourens River)	Identify priority areas to modify or remove weirs and restore natural flow regimes	Focus on small-scale modifications in sections where canalization has severe impacts.	Public Works, Environmental Management	Low

Issue	Recommendation	Under Resourced Municipalities	Responsible Department	Priority
Disconnection of river from floodplain wetlands (Lourens River)	Reconnect floodplain wetlands in key zones to restore ecological functions.	Use phased interventions, starting with areas of minimal structural barriers.	Environmental Management	Medium
Litter and organic debris accumulation in river channels (Lourens River)	Conduct regular community-driven cleanups to remove debris and improve water quality.	Partner with local schools, NGOs, and businesses for cleanup drives.	Community Engagement, Public Works	Medium
Poorly serviced residential areas contributing to pollution (Lourens River)	Provide affordable septic system upgrades and community training on proper waste disposal	Offer subsidies for septic upgrades and conduct awareness campaigns	Health and Sanitation, Community Groups	High

4.6 CAPE PENINSULA CAPE FLATS SWSA-GW

The Cape Peninsula Cape Flats Strategic Water Source has an extent of 599 km^2. The groundwater SWSA overlaps with the Table Mountain SWSA and wetlands, aquifers and rivers of these two SWSAs interact closely (Figure 4.2). Due to the interconnected nature of these water resources its management requires an integrated, coordinated and holistic approach.

The major source of water to the aquifer is vertical recharge from rainfall onto the Cape Flats. However, during winter months, the aquifer is recharged from the rivers that transverse its surface. The main rivers that transverse the SWSA are the Kuils, Diep, Liesbeek and Elsieskraal rivers. The Liesbeek and Silvermine rivers currently have an ecological status of AB (good ecological condition), whilst the Bottelary, Hout Bay rivers have a status of C (moderately modified), Esieskraal and Kuils and Liesbeek Rivers have a status of D (severely modified) and Black, Diep, Soutvlei, Vyekraal have an ecological status of EF (seriously to critically modified) (Figure 4.15, Van Deventer et al., 2019). Surface water-groundwater interaction is controlled by topography, geology, landform conditions and human activities (Cai et al. 2020). The highest potential for aquifer recharge occurs in areas that have the highest topographic elevation, such as in the eastern part of the Table Mountain region adjacent to the Liesbeek catchment (CCT, 2022). According to Riemann, (2021) the relatively clean and high-quality water from the Liesbeek River could be used to raise the groundwater level through infiltration via floodplains and ultimately recharge parts of the Cape Flats Aquifer.

The Kuils River remains mostly natural except for a 2.5 km section in the north, whereas the Elsieskraal River is almost entirely canalised and concrete lined (Figure 4.13; DWA, 2014). The central sections of the Vyekraal and Swart rivers are natural around their confluence, while the rest flow through culverts or canals. The upper reaches of the Lotus (Big and Little) and Diep Rivers are canalised or in culverts, with only the lower reaches remaining natural. Canalisation inhibits groundwater-surface water interaction, increases water flow velocity, reduces plant and animal life essential for river health, degrades water quality, and heightens downstream flooding risks (Hay and Seyler, 2008). Zeekoevlei is the largest of the Cape Flats vleis, with a surface area of about 2.56 km^2. Zeekoevlei is however not a major source of recharge water for the Cape Flats Aquifer and is only partly maintained by groundwater (Riemann, 2021).

Figure 4.13. Canalised River reach of Elsies Kraal River which flows through the Cape Peninsula Cape Flats Aquifer. Source: City of Cape Town

Figure 4.14 shows the relative ease with which the Cape Peninsula and Cape Flats SWSA can be contaminated by anthropogenic activities and takes into consideration both aquifer vulnerability and the relative importance of the aquifer. According to the map the SWSA has a medium to high risk of contamination by anthropogenic activities. This is due to a relatively high groundwater table at 1-3 meters and the overlying urban environment (Adelana and Xu, 2010).

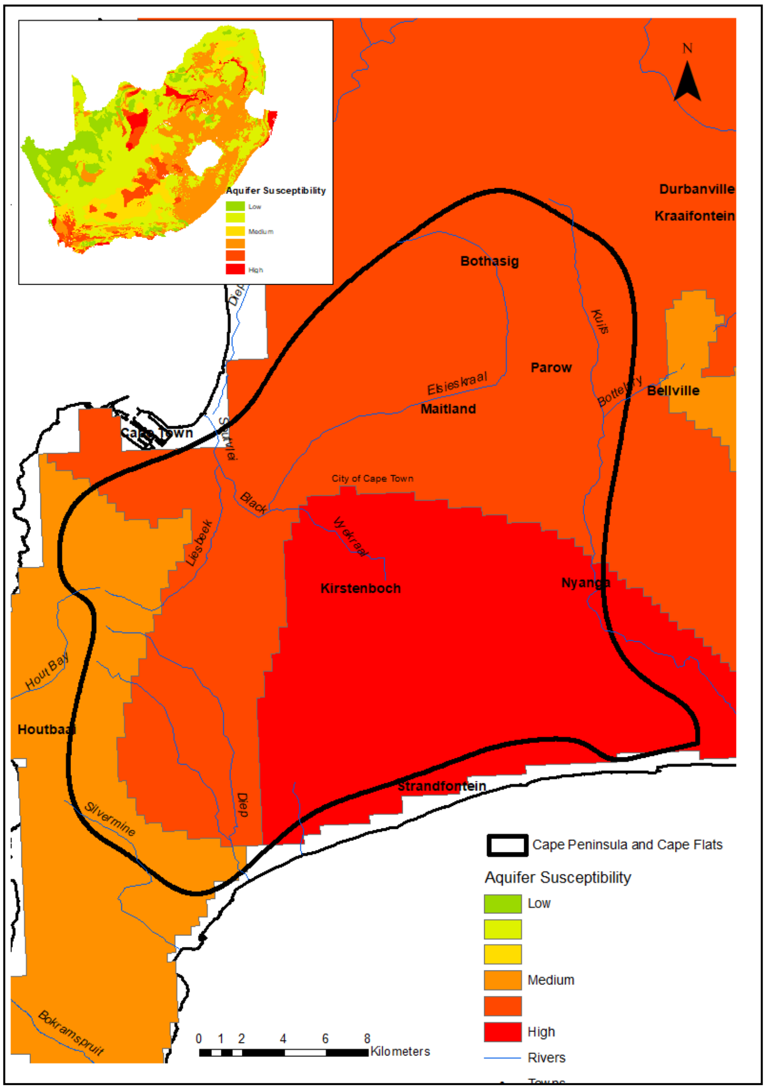

Figure 4.14. Map showing the Cape Peninsula and Cape Flats SWSA-gw aquifer susceptibility.

4.6.1 Essential Life Support Action Areas

Most of the Cape Peninsula and Cape Flats groundwater SWSA is urbanized with (61%) of its area placed in the Urban Adapt class, with only 21% of its surface area Protected (Figure 4.15). Contaminant sources related to human activities are cemeteries, storm water and wastewater systems, leakage of underground petrol and diesel storage tanks, nutrients and pathogens in human wastes, cyanide and trichloroethylene (TCE) from metal plates, chemicals used for cleaning and fertilisers and pesticides (Adelana and Xu, 2006).

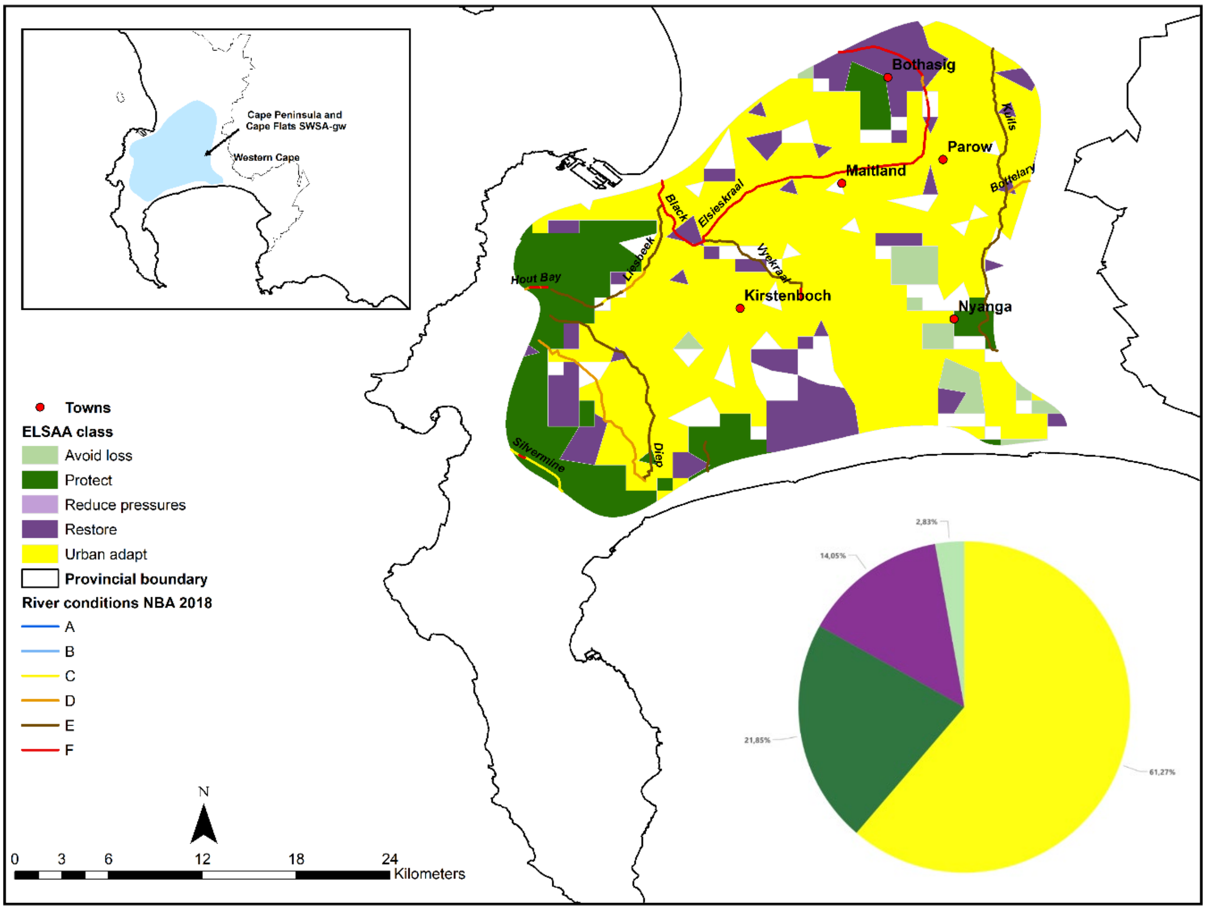

Figure 4.15. Cape Peninsula and Cape Flats SWSA-gw and ELSAAs.

4.6.2 Key threats and challenges to Cape Peninsula Cape Flats SWSA

- Extensive urban development has led to increased impervious surfaces (e.g., roads, buildings), reducing groundwater recharge and increasing surface runoff.
- Changes in natural drainage patterns due to urbanization has altered the natural flow of water, impacting recharge rates and water quality of the Cape Peninsula and Cape Flats SWSA.
- Inadequate waste management has led to illegal dumping in open spaces, wetlands, and water bodies, introducing contaminants into the groundwater. Chemicals from industrial processes and agricultural activities (e.g., pesticides, fertilizers) can infiltrate the aquifer, posing risks to water quality.
- Invasive alien species (e.g., *Acacia longifolia*, *Eichhornia crassipes*) alter soil composition and water uptake, potentially affecting groundwater recharge and quality.
- Intensive groundwater abstraction for domestic, agricultural, and industrial uses can lead to reduced water levels, affecting the sustainability of the aquifer.

- Wetlands that once existed along the rivers of the SWSA have largely disappeared due to urban development and pollution.
- Extensive canalisation in the upper sections of the Kuils River has increased water flow velocity downstream, reducing biodiversity, and worsening downstream flooding.

4.6.3 Management recommendations for Cape Peninsula and Cape Flats SWSA

Cape Peninsula and Cape Flats Aquifer

Table 4.5. Cape Peninsula and Cape Flats SWSA-gw place-based recommendations.

Key Impact	Recommendation	Under Resourced Municipalities	Responsible Department	Priority
Increased impervious surfaces	Implement green infrastructure (e.g., permeable pavements, green roofs, rain gardens).	Use low-cost solutions like gravel pathways, small rain gardens, and community tree-planting initiatives to increase infiltration.	Urban Planning, Public Works	High
	Establish buffer zones with vegetation in urban areas to reduce runoff and enhance infiltration.	Engage local communities to plant and maintain vegetation in high-runoff areas.		
Altered drainage patterns	Conduct drainage assessments and redesign natural flow pathways where possible.	Use participatory mapping with local communities to identify critical drainage issues and prioritize affordable interventions.	Technical Services, Environmental Management	Medium
	Install retention basins and infiltration trenches to slow and filter stormwater.	Focus on small-scale retention basins or trenches in critical recharge zones.	Technical Services, Environmental Management	Medium
Illegal dumping	Develop community-led waste management programs and increase surveillance in open spaces and wetlands.	Partner with local NGOs to provide low-cost waste bins and organize community clean-up campaigns.	Solid Waste Management, Community Engagement	High
	Provide accessible waste disposal facilities and launch public awareness campaigns about dumping impacts.	Use schools and community centres as hubs for educational programs.	Solid Waste Management, Community Engagement	High
Chemical contamination from	Monitor aquifer pollution levels regularly and enforce	Partner with universities for affordable monitoring	Environmental Management, Agriculture	High

Key Impact	Recommendation	Under Resourced Municipalities	Responsible Department	Priority
industrial and agricultural activities	regulations on industrial discharge and pesticide use.	programs and train local farmers on organic alternatives.		
	Promote organic farming practices and incentivize industries to adopt cleaner technologies.	Collaborate with local businesses for co-funding cleaner technologies.	Environmental Management, Agriculture	High
Invasive alien species altering soil composition and water uptake	Conduct phased removal of invasive species and replant with indigenous vegetation in recharge areas.	Focus initial clearing efforts on accessible and high-impact areas, using community labour programs for maintenance.	Environmental management, Public Works	High
	Use community-based programs to maintain cleared areas and prevent reinfestation.	Partner with national initiatives like Working for Water for funding and labour.		High
Intensive groundwater abstraction leading to reduced water levels	Implement water-use quotas and tiered pricing to limit excessive abstraction.	Provide educational workshops on water-saving techniques for farmers and industries to reduce dependence on aquifers.	Technical Services	High
	Promote alternative water sources, such as rainwater harvesting and treated wastewater reuse.	Distribute low-cost rainwater tanks to communities and small businesses.	Technical Services	High
Disappearance of wetlands due to urban development and pollution	Restore degraded wetlands in high-priority areas to enhance filtration and recharge.	Use local labour for wetland restoration projects and repurpose cleared vegetation as compost or mulch.	Environmental Management, Urban Planning	Medium
	Establish wetland protection zones and prevent further encroachment through zoning regulations.	Engage communities in participatory zoning to ensure buy-in and compliance.	Environmental Management, Urban Planning	Medium
Canalisation increasing downstream flooding and reducing biodiversity	Modify canalized sections of rivers to reintroduce natural flow dynamics where feasible.	Focus on small, cost-effective modifications in high-impact areas to restore biodiversity and reduce flooding.	Public Works, Environmental Management	Low
	Construct vegetated floodplains or off-channel retention	Use native plants for floodplain restoration, involving	Public Works, Environmental Management	Low

Key Impact	Recommendation	Under Resourced Municipalities	Responsible Department	Priority
	areas to manage high flow velocities.	local communities in planting.		

Khayelitsha Wetland

The Khayelitsha Wetland is a crucial ecological and hydrological asset that provides numerous benefits, including flood control, water purification, and habitat for diverse flora and fauna and is listed as a critical biodiversity area (African Centre for a Green Economy, 2018; Mathenjwa et al. 2022). However, it faces significant challenges due to urban development, pollution, and invasive alien species (Mathenjwa et al. 2022) (Figure 4.16). The Khayelitsha wetland system forms part of the Kuils River Catchment with the main rivers the Kuils and Eerste River (Figure 4.2). The wetland system which occupies an area of 4.45 km^2 occurs within an urban setting and is surrounded by roads, low-cost housing and informal settlements (African Centre for Green Economy, 2018).

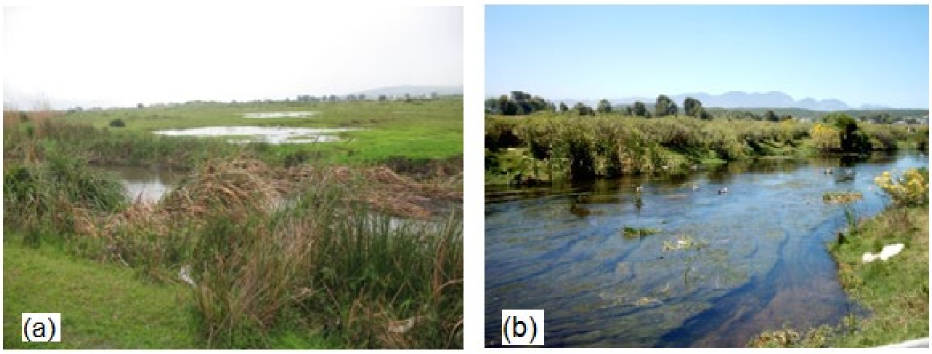

Figure 4.16. Cape Peninsula Cape Flats SWSA-gw: Khayelitsha Wetlands system which is listed as a critical biodiversity area (CBA).

Table 4.6. Khayelitsha Wetland

Key Impact	Recommendation	Under- Resourced Municipalities	Responsible Departments	Priority
High levels of waste and sewage disposal into wetland	Improve waste management by providing accessible disposal facilities and regular clean-ups.	Partner with community groups for clean-up drives and waste management education.	Solid Waste Management, Community Engagement	High
	Upgrade sewage infrastructure to prevent leakage into wetland areas.	Focus on repairing existing sewer lines in critical areas with low-cost solutions.	Sanitation and Public Works	High
Expansion of informal settlements into wetland regions	Establish clear zoning regulations to protect wetland boundaries from further encroachment.	Use participatory mapping to engage communities in delineating protected areas.	Urban Planning, Environmental Management	High
	Provide alternative housing options to	Work with provincial housing programs to	Human Settlements, Urban Planning	Medium

Key Impact	Recommendation	Under- Resourced Municipalities	Responsible Departments	Priority
	reduce pressure on wetland areas.	allocate land for informal settlements.		
Increased soil erosion due to loss of natural vegetation	Stabilize eroded areas with indigenous vegetation and bioengineering techniques.	Use community nurseries to supply plants for riparian restoration projects.	Environmental Management, Public Works	High
	Implement small-scale erosion control structures (e.g., gabions or brush packs).	Focus on critical erosion hotspots to maximize impact with limited resources.	Public Works	Medium
Proliferation of invasive plant species	Conduct phased removal of invasive species with community labour and replant native species.	Partner with national programs like Working for Wetlands for funding and labour.	Environmental Management, Public Works	High
Poor water quality from pollutants and waste	Install natural filtration systems (e.g., reed beds or constructed wetlands) at key inflow points.	Prioritise simple, low-maintenance systems near pollutant hotspots.	Environmental Health, Wastewater Management	Medium
	Promote public awareness campaigns on pollution prevention.	Focus on schools and local groups to disseminate information.	Community Engagement	Medium
Significant reduction in native vegetation and habitat	Restore native wetland vegetation to improve habitat and water absorption.	Work with local environmental groups to identify high-priority areas for replanting.	Environmental Management	High
Increased risk of flooding due to reduced water absorption	Rehabilitate degraded areas with permeable vegetation cover to enhance water retention.	Use low-cost planting strategies in flood-prone zones.	Public Works, Environmental Management	Medium
	Build small retention basins to control stormwater runoff during heavy rains.	Leverage community labour and local materials for construction.	Public Works	Medium
Loss of native species and reduced ecological function	Establish conservation zones to protect key habitats and biodiversity.	Enforce regulations and work with NGOs to fund conservation initiatives.	Environmental Management, Urban Planning	High

4.7 WEST COAST AQUIFER SWSA-GW

The West Coast aquifer SWSA covers an area of about 320 km^2, with the majority of the SWSA made up of the Atlantis aquifer which stretches inland from the Atlantic Ocean to the town of Atlantis in the east.
The area contains very few drainage features. The Donkergat and Sout Rivers to the south of the Atlantis area flow in winter, while surface drainage to the north and east of Atlantis contributes to the catchment areas of the Modder and Diep Rivers respectively (Figure 4.17). All the rivers are seasonal, drying up in summer (Tredoux et al., 2009). Due to the sandy surface over most of the area, natural groundwater recharge percentages in the order of 15 to 30% of the annual rainfall are generally experienced, with the higher recharge occurring in the unvegetated sand dune area (Van der Merwe, 1983, CCT, 2022). The Atlantis Water Resource Management Scheme (AWRMS) successfully recharges 30% of the Atlantis groundwater supply (DWA, 2010, Bugan et al. 2016). Various combinations of urban stormwater and treated wastewater from the town are infiltrated into the aquifer to maximise the available groundwater.

The Atlantis aquifer is unconfined with its water table close to the surface and covered by sandy soils making it very vulnerable to pollution (DWA, 2010). Figure 4.17 shows the relative ease with which the West Coast Aquifer SWSA can be potentially contaminated by anthropogenic activities and takes into consideration both aquifer vulnerability and the relative importance of the aquifer. According to the map the SWSA has a medium to high risk of contamination by anthropogenic activities.

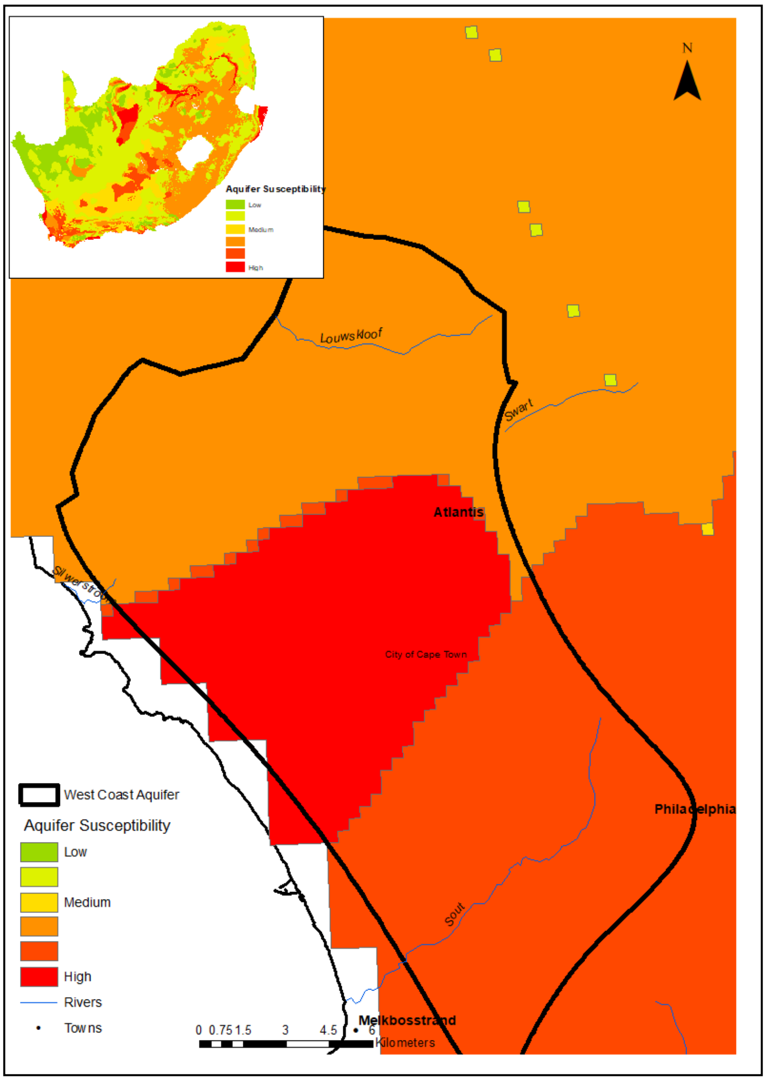

Figure 4.17. Map showing the West Coast Aquifer SWSA-gw aquifer susceptibility.

4.7.1 Essential Life Support Action Areas

The majority of the landcover of the West Coast SWSA consist of natural vegetation and have been assigned to the Protect Action Area (54%) (Figure 4.18). Approximately one thousand hectares of vacant land within the Atlantis Urban Edge, including undeveloped erven within the industrial area, contains either Critically Endangered Atlantis Sand Fynbos or Endangered Cape Flats Dune Strandveld vegetation (DFFE Government Gazette, No. 46208, 7 April 2022). Areas which have been assigned to the Restore Action Area make up (41%) of the SWSA and consist mainly of agricultural land.

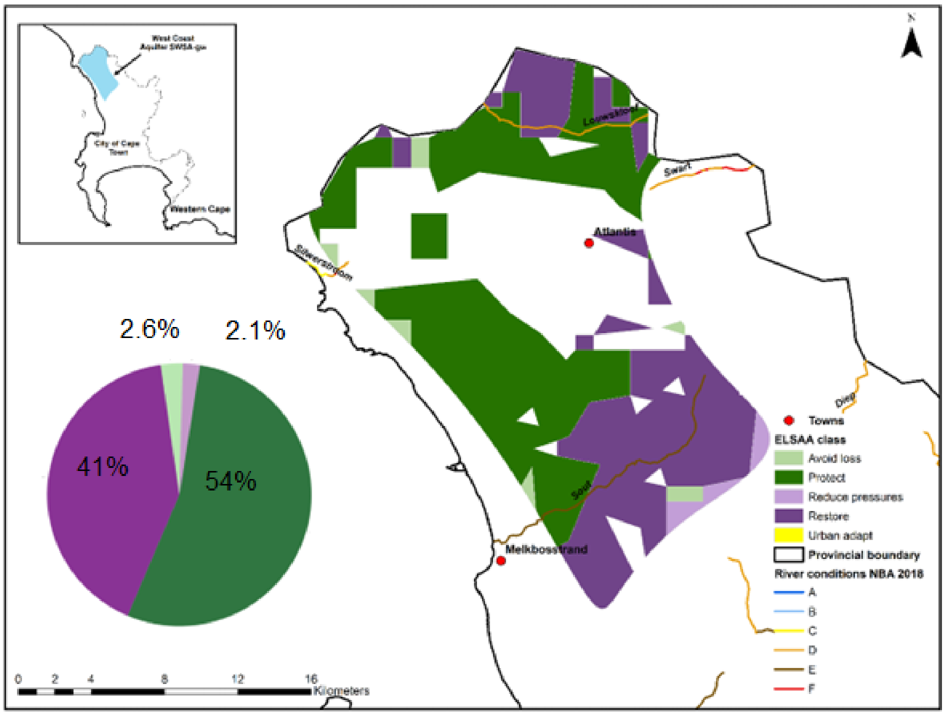

Figure 4.18. West Coast Aquifer SWSA-gw and ELSAAs.

4.7.2 Key threats and challenges to the West Coast Aquifer SWSA

- Urbanization has led to increased impermeable surfaces, generating large volumes of stormwater runoff that could otherwise recharge the aquifer.
- Accumulation of fine sediments and organic material in recharge basins reduces infiltration rates, limiting groundwater recharge.
- Small and medium-scale users with private boreholes for irrigation deplete groundwater resources.
- Species such as *Acacia cyclops* and *Acacia saligna* reduce groundwater recharge due to their high-water consumption.
- Industrial activities, hazardous chemical spills, and potential leaks from a bulk oil pipeline pose direct threats to the aquifer.
- Agricultural runoff and unmanaged waste from informal settlements contribute to groundwater contamination.
- Old, unlined municipal waste disposal sites and cemeteries pose significant risks to groundwater quality.
- Over-extraction can lead to saline water intrusion, especially in areas where the aquifer thins out against bedrock.
- Rapid urban expansion increases demand for water and creates additional stress on groundwater resources.

- Limited community involvement and awareness regarding groundwater protection and sustainable use.

4.7.3 Management recommendations for West Coast Aquifer SWSA

Table 4.7. West Coast Aquifer SWSA-gw place-based recommendations.

Key Impact	Recommendation	Under Resourced Municipalities	Responsible Departments	Priority
Urbanization increasing impermeable surfaces	Promote green infrastructure (e.g., permeable pavements, rain gardens, green roofs) to enhance recharge.	Focus on cost-effective solutions like permeable pathways and small rain gardens in public spaces.	Urban Planning, Public Works	High
	Establish retention basins and infiltration zones in urban areas.	Use community-driven projects for maintenance and monitoring.		
Sediment accumulation in recharge basins reducing infiltration rates	Regularly clean recharge basins and remove accumulated sediments and organic material.	Use local labour for maintenance and implement low-cost sediment traps upstream of basins.	Technical Services, Public Works	High
Private boreholes depleting groundwater resources	Implement groundwater-use permits and monitoring systems for private boreholes.	Encourage voluntary registration and provide education on sustainable abstraction practices.	Technical Services	Medium
	Promote alternatives like rainwater harvesting for irrigation.	Distribute affordable rainwater tanks to small-scale users.	Technical Services	Medium
Invasive species consuming water	Remove invasive species in recharge zones and replant with native vegetation.	Partner with community groups and national programs (Working for Water) to fund and implement clearing.	Environmental Management, Public Works	High
Limited community involvement and awareness	Conduct awareness campaigns on groundwater protection and sustainable use.	Use schools, community centres, and local leaders to disseminate information and organize workshops.	Community Engagement, Environmental Management	High
	Establish “Adopt an Aquifer” programs to involve communities in monitoring and protection.	Provide basic training and low-cost monitoring tools for local volunteers.	Community Engagement, Environmental Management	High

Key Impact	Recommendation	Under Resourced Municipalities	Responsible Departments	Priority
Industrial activities and chemical spills threatening the aquifer	Enforce strict regulations on hazardous material handling and storage near aquifer recharge areas.	Collaborate with industries to implement spill prevention and response protocols.	Environmental Health, Industry Regulation	High
	Install containment barriers around high-risk industrial sites.	Focus on low-cost barriers like clay-lined containment areas.	Environmental Health, Industry Regulation	High
Agricultural runoff and unmanaged waste contaminating groundwater	Promote sustainable agricultural practices, such as reduced pesticide and fertilizer use.	Provide farmers with training on organic alternatives and low-cost erosion control methods.	Agriculture, Environmental Management	High
	Improve waste collection services in informal settlements.	Partner with NGOs to provide bins and organize community waste removal initiatives.	Solid Waste Management	Medium
Old municipal waste sites and cemeteries posing risks to groundwater	Monitor groundwater near old waste sites and cemeteries for contaminants.	Partner with universities for affordable monitoring programs and analysis.	Environmental Health, Technical Services	Medium
	Cap old waste sites with impermeable layers to reduce leachate.	Focus on high-risk sites for low-cost remediation techniques.		
Over-extraction leading to saline intrusion	Monitor aquifer levels and implement abstraction limits in areas at risk.	Use simple community-based water-level monitoring methods to inform limits.	Technical Services	High
Rapid urban expansion increasing water demand	Integrate groundwater protection into urban planning policies.	Use zoning regulations to limit high water-demand developments near recharge zones.	Urban Planning, Technical Services/Scientific Services	High
	Develop long-term water demand management strategies to reduce pressure on the aquifer.	Educate residents on water-saving techniques and enforce usage limits.	Urban Planning, Technical Services/Scientific Services	High

4.8 MANAGING TRANSBOUNDARY SWSAS

Strategic Water Source Areas (surface and groundwater) often span multiple municipalities, which means no single authority has full control over the SWSA. A case in point is the Boland SWSA, which spans the City of Cape Town Metropolitan Municipality as well as three district municipalities namely: Cape Winelands, Overberg and West Coast. This fragmentation can lead to uncoordinated policies, inconsistent management practices and gaps in enforcement. Smaller or under-resourced municipalities may also lack the capacity to implement conservation measures, even if they control critical parts of the SWSA. The Governance of transboundary groundwater SWSA presents a further challenge as the resource quality and quantity is less visible than for a surface water SWSA. Joint management of these areas is essential, and in the case of groundwater, the approach needs to include management of the aquifer, the risk to water services, and operational management (Altchenko and Villholth 2013). Separating the management aspects of an aquifer scheme will result in unsustainable utilisation, depletion and/or pollution (Darnault, 2008). Shared SWSAs can act as a unifying focus for collaborative governance, fostering partnership between metropolitan, district and local municipalities. Partnerships between the different stakeholders in SWSAs at varying levels can enable the identification of win-win solutions rather than trade-offs between natural ecosystem management and socio-economic growth and development (DFFE, 2024).

4.8.1 Collaborative governance structures

Catchment Management Agencies should be strengthened as platforms for coordinating municipal actions within shared SWSAs. Inter-municipal forums or committees should be established to facilitate communication, joint decision-making, and resource sharing among municipalities. Strategic Water Sources Areas also overlap with areas delineated for various conservation initiatives and can benefit from formal protection as well as Other Effective Conservation Measures (OECMs). In the City of Cape Town, for example, the SWSAs overlap with the Berg River Improvement Plan and the Cape Winelands Biosphere Reserve (Western Cape Government, 2012; Klawer et al,2024). Such initiatives have identified and outlined aspects of water stewardship programmes that support water quality improvement for river catchments, ensuring economic sustainability and well-being of people living in the catchment. The management objectives of SWSAs are often aligned with these initiatives thereby providing opportunities for collaboration.

Some examples of partnerships currently in existence is the Umzimvubu Catchment Partnership Programme and the Boland - Groot Winterhoek Strategic Water Source Areas Collective (DFFE, 2024). A further example of collaboration between various conservation agencies, municipalities, the private sector and international funding is the Table Mountain Water Source Partnership groundwater project, monitoring the Table Mountain SWSA (WWF, 2022).

4.8.2 Data requirements and sharing

A range of data is needed to understand the SWSAs, undertake planning for future actions in the SWSAs and to report on progress in the SWSAs. Much of this can achieved by working through existing platforms. A lot of data is currently available to be used in the protection and management of SWSAs, view data repository in Appendix 1 for examples.

4.9 INTEGRATING SWSAS INTO MUNICIPAL PLANNING

To assist municipalities working to protect SWSAs a repository of relevant spatial data on biodiversity, ecosystem services and sustainable development was created. Key data layers essential for SWSA protection were identified and include amongst others:

- SWSA boundaries
- Land cover
- Hydrology (rivers, aquifers, wetlands)
- Infrastructure (dams, pipelines, urban areas)
- Ecological condition of water resources
- Biodiversity and ecological zones
- Protection level and biodiversity importance

The repository is designed to be a practical, user-friendly tool that municipalities can leverage to protect SWSAs while meeting their planning, governance and service delivery mandates (Supplementary Material).

It is intended that municipalities use it in the following ways:

- Municipalities can use the repository to incorporate SWSA protection into key plans such as Integrated Development Plans (IDPs), Spatial Development Frameworks (SDFs) and Environmental Management Plans.
- The repository provides access to reliable, up-to-date data for assessing environmental impacts, identifying high-risk areas and prioritising interventions like invasive species removal or wetland restoration.
- Departments such as Technical Services, Strategic Planning and Environmental Management can use the repository as a shared resource, fostering alignment on SWSA-related projects and policies.
- Municipalities can use the spatial datasets to create maps and visual data to educate communities, businesses, and stakeholders about the importance of SWSAs
- Spatial data can be used to justify funding proposals and build partnerships with NGOs, private sector entities, and government agencies for SWSA protection projects

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PART 5: CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

The SWSA Framework has been designed to be generic and applicable to municipalities throughout South Africa. Therefore, it is recommended that the SWSA Framework produced by this WRC project (as described in the Introductory Guide (Part 2) is refined through its application in different contexts (e.g. other municipalities within other Provinces). Examples of key lessons learnt are briefly outlined below, based on the team's experience undertaking the case studies described in this report.

5.2 LESSONS LEARNT

5.2.1 Establish formal agreements to streamline collaboration

A formal agreement, such as a Memorandum of understanding (MOU), Letter of Collaboration, or Memorandum of Agreement (MOA), provides a framework for joint research and collaboration as it establishes clear roles and responsibilities for both parties. Creating a mutual commitment to the project will help sustain engagement even amid shifting priorities or staff turnover. A formal agreement also provides legal and institutional recognition of the partnership, which facilitates resource allocation and accountability. An added value to such agreements is that they can serve as precedents for future collaborations, streamlining similar initiatives.

5.2.2 Identify specific representatives in the municipality

Establishing clear points of contact within municipalities is critical to ensure consistent communication and accountability throughout the project. Municipal representatives act as liaisons, facilitating discussions and ensuring that the research aligns with the municipality's operational and strategic priorities. When identifying representatives, it is good to begin with senior-level officials (e.g. environmental managers, or water resources managers) who typically have a broad overview of the internal structures and strategic processes.

5.2.3 Include external stakeholders in the process

While the current project faced time and budgetary limitations, municipal processes for SWSA strategy development should prioritise involving external stakeholders such as:

- Water User Associations (WUAs): As seen in the Witzenberg case study, these entities provide valuable insights into local water use patterns and challenges.
- Local Communities and Landowners: Engagement ensures that the Framework is locally relevant and socially inclusive.
- NGOs and Conservation Organisations: These groups can offer expertise and resources around environmental monitoring and public awareness campaigns.
- Private Sector Actors: Industries reliant on water resources have a vested interest in SWSA protection and may provide financial or technical support.

5.2.4 Adapt to municipal officials' time constraints

Municipal officials often face competing demands on their time due to operational responsibilities, crisis management, and strategic planning. This limited availability can hinder engagement, making efficient use of time crucial. Meetings should be structured with clear, actionable agendas to ensure productive discussions. The use of virtual meetings when in-person sessions are logistically challenging should be considered. Plan for short, targeted follow-up meetings to maintain momentum without overburdening officials. Preparation becomes important, for instance the pre-identification of potential opportunities and constraints in Phase 2 of the Framework, to minimise time spent on exploratory discussions. Incorporating project engagements into existing municipal meetings, especially those attended by directors and senior managers, will help reduce scheduling conflicts by capitalizing on pre-scheduled gatherings. It can also help to align discussions with ongoing municipal planning and decision-making processes; as well as increase buy-in and visibility by presenting the project to a broader audience.

5.2.5 Ensure cross-departmental participation

Cross-departmental participation is essential in discussions around SWSAs as the management of these areas requires technical (e.g., addressing water leaks), strategic planning (e.g., integrating SWSAs into IDPs), environmental (monitoring water quality), corporate (e.g., finance) and communications (e.g., dissemination of information around SWSAs) departments, among others. When facilitating workshops to gather input from different departments it is important to underscore their different roles in SWSA management. The interconnected aspects of water security across municipal functions should be highlighted to foster shared accountability. A challenge to anticipate is that departments may have limited experience working collaboratively on cross-cutting issues.

5.2.6 The visioning process as a focal point

A visioning process establishes a clear purpose for discussions, helping participants concentrate on shared objectives rather than isolated departmental interests. It frames the conversation around long-term goals (e.g. water security, sustainable development) and clarifies how SWSAs contribute to achieving them. Visioning serves as a common starting point where stakeholders, regardless of their technical expertise or departmental focus, can contribute meaningfully. By emphasising shared values and goals, the process builds a sense of ownership and commitment across all participants.

5.2.7 Establish a shared understanding of SWSAs and their characteristics

The term “Strategic Water Source Area” may not be uniformly understood across municipal departments or stakeholders. Misalignment in definitions or priorities can lead to inconsistent strategies and missed opportunities. A shared understanding from the outset ensures that all stakeholders recognise the ecological and economic importance of SWSAs and the implications of their management (or mismanagement) on water security and sustainability. It is also important that stakeholders understand the locational context of SWSAs as they are often integrated into broader “working landscapes”, which may include agricultural, conservation and urban areas. Displaying a map of SWSAs and their location within municipal boundaries allows stakeholders to visualise and contextualise SWSA which can help in bridging the gap between abstract concepts and tangible on-the-ground realities. It can also highlight the overlap of SWSAs with urban boundaries, protected areas and vulnerable ecosystems.

5.3 RECOMMENDATIONS FOR FUTURE RESEARCH

5.3.1 Refine and expand the SWSA Framework

a. Apply the SWSA Framework presented in the Introductory Guide in different municipal contexts (e.g., rural, coastal); and engage with a range of stakeholders to refine the Guide.
b. Adapt the SWSA Framework for use by District Municipalities (Category C); particularly those that are water services authorities.
c. Test and refine the framework in other provinces to account for diverse contexts.
d. Expand the guide to include prioritization for implementation across municipalities with different resource capacities.

5.3.2 Build Capacity and Awareness among municipal officials

a. Provide ongoing training and capacity-building programs for municipal officials using SWSA Framework in planning and decision-making.
b. Develop targeted educational materials to enhance officials’ and politicians’ understanding of the spatial characteristics and ecological importance of SWSA.

c. Create peer-learning networks where municipalities share case studies and best practices, such as processes for cross-departmental review of development proposals affecting SWSAs; and institutional mechanisms for sustained stakeholder engagement around SWSAs (particularly where SWSAs are shared between municipalities).

5.3.3 Integrate SWSA maintenance and enhancement into Strategic development planning

a. Identify effective strategies for the integration of SWSA maintenance and enhancement into strategic development planning (e.g. Spatial Development Frameworks and Environmental Management Frameworks) and town planning instruments (e.g. zoning schemes).

5.3.4 Secure sustainable funding and resource allocation

a. Conduct research to produce the evidence required for municipalities to motivate for increased budget allocations towards SWSA protection and management, within the range of competing priorities that municipalities face.
b. Undertake projects that quantify the value of SWSA to society, demonstrating the social-ecological business case for protecting surface water and groundwater SWSAs.

5.3.5 Integrate Green infrastructure and Nature-based Solutions

a. Design and implement future-focused solutions that include green infrastructure and Nature-based Solutions for SWSA restoration and protection in the municipal context. Such solutions include wetland restoration, establishment of riparian buffer zones, community-based initiatives for invasive alien plant removal or promoting sustainable agriculture within the municipality.

5.3.6 Strengthen monitoring and evaluation

a. Develop a standardized monitoring and evaluation framework for municipalities to track the effectiveness of their SWSA strategies; and make recommendations for the role that stakeholders (e.g. community-based monitoring programs, citizen science) can perform in monitoring.

5.3.7 Improve stakeholder engagement

a. Demonstrate the efficacy of a diverse range of tools for communicating the value of SWSAs to multiple stakeholders.

b. Investigate the most appropriate institutional mechanisms for cross-sectoral engagement (e.g. NGOs, government, private sector and academia); and well as cross-departmental collaboration within the municipality for improved protection of SWSAs.

c. Investigate the roles of national, provincial and other local bodies (e.g. Water Users Association, SALGA, COGTA) in supporting municipalities in the protection of SWSAs and make recommendations for increased co-ordination and collaboration.

APPENDICES

These appendices include:

Appendix 1: *Supporting Information for Part 4: SWSA repository of relevant spatial data on biodiversity, ecosystem services and sustainable development.*

Appendix 2: *Human Capacity Development*

PhD student
Research Intern

Appendix 3: *Research Dissemination*

APPENDIX 1: SWSA REPOSITORY OF RELEVANT SPATIAL DATA ON BIODIVERSITY, ECOSYSTEM SERVICES AND SUSTAINABLE DEVELOPMENT

Layer Name	Description	Source	URL/web link
ELSAA	Essential Life Support Action Areas (ELSAA) project dataset: The ELSAA actions, defined as areas where nature positive and nature-based actions can safeguard key biodiversity and ecosystem services, employ five actions. These include avoid loss, protect, reduce pressures, restore and urban adapt (UNDP, 2021).	UN Biodiversity Lab	https://unbiodiversitylab.org/en/maps-of-hope/)
FEPAs_2011	Freshwater Ecosystem Priority Areas (hereafter referred to as 'FEPAs') 2011	SANBI	https://bgis.sanbi.org/Search?searchterm=FEPAs
SANLC_2022	Raster layer showing national land cover of South Africa	DFFE	https://egis.environment.gov.za/sa_national_land_cover_datasets
SWSA_SW	Vector layer showing the surface water Strategic Water Source Area for the Witzenberg Municipality and City of Cape Town.	SANBI	https://bgis.sanbi.org/Search?searchterm=SWSA
SWSA_ GW	Vector layer showing the groundwater Strategic Water Source Area for the Witzenberg Municipality and City of Cape Town.	SANBI	https://bgis.sanbi.org/Search?searchterm=SWSA
Biodiversity network	Vector layer showing the natural vegetation cover in the City of Cape Town	City of Cape Town	https://bgis.sanbi.org/SpatialDataset
GW protection zones	Groundwater Protection Zones are areas demarcated in order to protect groundwater resources important for current or potential future for municipal bulk water abstraction.	City of Cape Town	City of Cape Town: Research Office Contactable person: Meagan Donnelly Meagan.Donnelly@capetown.gov.za
Groundwater data, various	National Groundwater Archive (NGA). The purpose of this site is to allow you to access groundwater related data for South Africa.	DWS	https://www.dws.gov.za/NGANet/Security/WebLoginForm.aspx; https://www.dws.gov.za/Groundwater/NGIS.aspx
Hydrogeological map series	Several map series are produced by the Department of which the Groundwater Level Maps are available online, e.g. 1 : 500 000 scale hydrogeological map series	DWS	https://www.dws.gov.za/Groundwater/maps.aspx
Aquifer_classification	Aquifer Classification Map sets of South Africa	DWS	DWS: Groundwater - Aquifer Classification of South Africa

Layer Name	Description	Source	URL/web link
NBA2018_Rivers	This GIS layer summarizes the river ecosystem types, river condition, Ecosystem Threat Status (ETS) and Ecosystem Protection Level (EPL) as well as the free-flowing (62 identified by the NFEPA project) and flagship river information.	SANBI	https://bgis.sanbi.org/SpatialDataset
National IAP_2023	National IAP Survey (2023): Extent of 14 most widespread & abundant, terrestrial invasive alien plant taxa (approx. 40 species) in South Africa. Excludes invasions in transformed (i.e. cultivated, built-up & planted forest) landcover	DFFE	https://dffeportal.environment.gov.za/portal/home/item.html?id=17de13c509ef4d3caf279d84e77312c3
NPAES_2017_Protected areas	This layer was intended for the identification of Protected Areas and their current protection levels of habitat biodiversity are, which helps identify where future conservation efforts should be focused.	SANBI	https://bgis.sanbi.org/SpatialDataset
RSA_Geology	1: 000 000 Geological Map	Council of Geoscience	https://www.geoscience.org.za/media/news/the-cgs-launches-the-1-000-000-geological-map/
Riv_500_dws	South Africa 1:500 000 Rivers. The Resource Quality Information Services river coverage is a South African surface drainage network for GIS, originally based on a 1994 1:500 000 rivers coverage from the Chief Directorate of National Geo-spatial Information	DWS	https://www.dws.gov.za/iwqs/gis_data/river/rivs500k.aspx
SAPAD	SA Protected Areas Data (SAPAD, Protected and Conservation Areas Database	DFFE	https://egis.environment.gov.za/protected_and_conservation_areas_database
SA_Key Biodiversity Areas	A new set of Key Biodiversity Areas for South Africa was identified through the application of the Global Standard for the Identification of Key Biodiversity Areas version 1.2 (IUCN 2016) to South African species and ecosystems	SANBI	https://bgis.sanbi.org/SpatialDataset
SANBI National Vegetation Map_ Version 5	To provide the potential and historical extent of ecologically based vegetation units of South Africa (Including Prince Edward and Marion Islands), Lesotho and Swaziland at a landscape scale.	SANBI	https://bgis.sanbi.org/SpatialDataset
SANBI_National_Wetland Map_Beta_ Version 6	The National Wetland Map shows the distribution of inland wetland ecosystem types across South Africa and includes estuaries and the extent of some rivers.	SANBI	https://bgis.sanbi.org/SpatialDataset
T2023 NBAL's	Invasive alien vegetation data	DFFE	
Wetland_clusters	NFEPA wetland clusters 2011. This GIS layer codes for Wetland cluster Freshwater Ecosystem Priority Areas (FEPAs). Wetland	SANBI	https://bgis.sanbi.org/SpatialDataset/Detail/396

Layer Name	Description	Source	URL/web link
	clusters are groups of wetlands within 1 km of each other and embedded in a relatively natural landscape.		
DWS_Dams	1:500 000 scale dataset of the major dams in South Africa	DWS	https://gia.dws.gov.za/portal/home/item.html?id=487d74ecf16a434c9ec7867297ee4666
Informal Settlements	Vector layer showing the location of informal settlements in the City of Cape Town.	City of Cape Town	City of Cape Town: Research Office Contactable person: Meagan Donnelly Meagan.Donnelly@capetown.gov.za
New development areas	New Development Areas: 20230126 (Council-approved Jan 2023) An area earmarked for future development. Undeveloped and partially developed land parcels that are suited for future residential or non-residential urban development, which were identified through a technical investigative process for the City's 2040 Land Use Model in order to determine the required supply and quantum of residential and non-residential development to accommodate the projected future growth of population in Cape Town.	City of Cape Town	City of Cape Town: Research Office Contactable person: Meagan Donnelly Meagan.Donnelly@capetown.gov.za
Mixed Use Intensification Areas	Mixed use intensification areas: 20230126 (Council-approved Jan 2023) These are developed or partially developed areas where further intensification and diversification of existing land uses is supported or where appropriate redevelopment to a mix of land uses is actively encouraged.	City of Cape Town	City of Cape Town: Research Office Contactable person: Meagan Donnelly Meagan.Donnelly@capetown.gov.za
Areas of Agricultural Significance	Agricultural areas of significance in the City of Cape Town: 20230126 (Council-approved Municipal Spatial Development Framework (MSDF) Jan 2023).	City of Cape Town	City of Cape Town: Research Office Contactable person: Meagan Donnelly Meagan.Donnelly@capetown.gov.za
Spatial Transformation Areas	Spatial Transformation Areas: 20230126 (Council-approved Municipal Spatial Development Framework (MSDF) Jan 2023)	City of Cape Town	City of Cape Town: Research Office Contactable person: Meagan Donnelly Meagan.Donnelly@capetown.gov.za
Stormwater Floodplains Areas	Vector data layer indicating areas demarcated as stormwater floodplains.	City of Cape Town	City of Cape Town: Research Office Contactable person: Meagan Donnelly Meagan.Donnelly@capetown.gov.za
Tourism Development Area	Vector data layer indicating areas demarcated for future touristic development.	City of Cape Town	City of Cape Town: Research Office Contactable person: Meagan Donnelly Meagan.Donnelly@capetown.gov.za

Layer Name	Description	Source	URL/web link
Urban Development Edge	Urban Development Edge: 20230126 (Council-approved Municipal Spatial Development Framework (MSDF) Jan 2023)	City of Cape Town	City of Cape Town: Research Office Contactable person: Meagan Donnelly Meagan.Donnelly@capetown.gov.za
Environmental Focus Areas	Environmental Focus Areas: 20230126 (Council-approved Jan 2023) Spatially targeted areas with critical environmental significance (in terms of national conservation targets) outside of formally protected areas which have been identified as priority areas for investment and/or protection in the short to medium term. See Priority Local Facilitation Areas (PLFA).	City of Cape Town	City of Cape Town: Research Office Contactable person: Meagan Donnelly Meagan.Donnelly@capetown.gov.za
Stormwater Waterbodies	Storm water Waterbodies attenuate ground-surface water in natural and artificial wetlands and waterbodies.	City of Cape Town	City of Cape Town: Research Office Contactable person: Meagan Donnelly Meagan.Donnelly@capetown.gov.za

APPENDIX 2: HUMAN CAPITAL DEVELOPMENT

Student: Earl Graham PhD Student, University of the Western Cape

This WRC project has funded Earl's PhD studies at the University of the Western Cape from 2023-2025. The focus of his thesis and major findings to date are documented.

Thesis title: Evaluating source-flux-dispersal pathways of sediment and adsorbed chemical species at catchment scale to inform catchment ecosystem management planning.

Background

Catchment-scale sediment connectivity (and dis-connectivity) is a fundamental control on nutrient-fluxes (Johnston, 1991), concentrations of organic and inorganic pollutants (Pescimoro et al., 2019), and general fluxes of materials from source to sink (Correll, Jordan & Weller, 1992; Boulton et al., 1998). The dynamics of sediment connectivity in a catchment has important implications for catchment geomorphology (Coulthard & Van De Wiel, 2016), hydrology (Pringle, 2001; Pringle, 2003) and ecology (Merriam, 1984; Ward, 1989; Ward, 1997).

Whilst not directly a function of sediment connectivity, land cover/ land use changes control the geomorphology and sediment dynamics at a catchment scale. A study by Coulthard and Van De Wiel, 2016 indicated that land cover and land use change downstream of the River Swale in Northern England changed the erosion and depositional processes in upstream headwaters due to changes in the valley floor base level resulting from incision and alluviation. These land cover changes (attributed to deforestation and reforestation) invariably changed sediment yield dynamics which in turn changed the river geomorphology. This provides an example of the impact of sediment connectivity on the geomorphology of a catchment. Sediment connectivity, particularly in an urban-agricultural catchments, is rarely stagnant but rather a dynamic process that changes over various spatial and temporal scales (Mati et al., 2008).

The mechanisms that control sediment connectivity such as sediment detachment and sediment transport is not always a function of hydrology and thus sediment connectivity can influence the hydrology of a system. A review by Bracken et al., 2015 describes this disconnect in four main scenarios, 1) Where sediment transport and sediment detachment is hydrologically controlled,2) where sediment transport is not hydrologically controlled, 3) where sediment detachment is not hydrologically controlled and 4) where neither sediment transport nor sediment detachment is hydrologically controlled. This review in particular highlighted the large inconsistencies in the dissemination of sediment pathways, where hydrological connectivity is exclusively applied without the consideration of sediment connectivity, particularly in areas of low precipitation or areas where sediment is produced from anthropic sources. Furthermore, sediment dynamics can change the nature of flow regimes albeit directly through energy dynamics (Wainwright et al., 2008) or indirectly through slope/ soil moisture variations (Huang et al, 2002).

Lastly, the influence of sediment dynamics has a variable influence on the aquatic ecology stretching from water quality as a result of nutrient inputs via sediment (Baird et al.,2021), establishment of riparian vegetation (Kemper et al.,2022) and even spawning and distribution of aquatic fauna (Scorpio et al., 2016 and Donohue & Molinos,2009). Specifically, Baird et al., 2021, found that anthropogenic catchment loads increased chlorophyll concentrations in the Great Barrier Reef from 16 river plumes. Kemper et al., 2022, found that the establishment of cottonwood forests downstream of the Yampa and Green Rivers in Utah and Colorado was a function of increased sediment load and heightened channel migration. Lastly, a study by Scorpio et al., (2016) and a separate review by Donohue & Molinos, (2009) described the influence of channel adjustments and the continuity of river processes on the presence of Eurasian Otters and the influence of sediment characteristics and concentrations on the assemblages and overall population of zooplankton, marco-invertebrates and fish respectively.

Although often overlooked in hydrological assessments, sediment connectivity plays a crucial role in catchment-scale hydromorphology, water quality, and ecological dynamics, with direct implications for the management of Strategic Water Source Areas (SWSAs). This research aims to highlight the complex interactions between land use changes, sediment fluxes, and hydrological processes, which must be considered in SWSA protection, monitoring, and rehabilitation efforts.

Aim:

The project aims to determine sediment (dis) connectivity in the Kuils River and Sand River Catchments using geospatial and empirical techniques to determine specifically the longitudinal and lateral (dis) connectivity of the aforementioned catchments.

The Objectives of the study are as follows:

1. Determine the longitudinal and lateral connectivity of the Zandvlei Catchment and Kuilsriver Catchment through geospatial analysis.
2. Identify and map “hotspots” of sediment deposition and/or erosion in the form of barriers, boosters and buffers.
3. Determine the relative contribution of diffuse and point source systems to the supply of sediment-associated chemical species across the catchments studied.
4. Evaluate the relative effects of surface (agricultural fields) and network (stormwater and urban canal networks) dispersal systems on the dynamics of sediment and associated adsorbed chemical species using a combination of empirical parameters and geospatial techniques to produce a composite modelling framework.
5. Determine the influence of sediment deposits in depositional areas on the environment through chemical analysis.
6. Identify and map potential areas of vertical connectivity based on geospatial attributes such as geology, lithology, and terrain metrics.

Approach and Method:

Lateral Connectivity

Lateral connectivity for the Kuils River and Zandvlei Catchment will be assessed using the Index of Connectivity (IC) via SedInConnect, following Crema & Cavalli (2018). This method refines the Borselli et al. (2008) approach, incorporating:

- Slope computation: Adjusted for flow direction to filter out bias from steep slopes.
- Contributing area: Uses the D-infinity approach (Tarboton, 1997) for improved flow path representation.
- Weighting factor: Derived from digital terrain models (Cavalli & Marchi, 2008) to estimate surface roughness as a proxy for sediment impedance.
- Additionally, riparian vegetation will be integrated into the model using Manning’s equation (Grenfell et al., 2022) to account for hydraulic roughness and buffering effects.

Longitudinal Connectivity

Longitudinal connectivity will be modelled empirically using geospatial techniques to extract key sediment flux parameters:

- Slope & Discharge: Assessed via Manning’s equation to identify zones of high runoff and deposition.
- Shields Parameter: Evaluates flow conditions required to mobilize sediment particles, factoring in rainfall-driven sediment transport.

- Soil Moisture & Lithology: Contributes to characterizing sediment movement and storage. The model will incorporate urban stormwater network contributions, estimating their discharge impact on river flow dynamics and sediment transport.

Sediment Sampling and Analysis
Sediment sampling will include trace metal analysis (ICP-MS) to evaluate pollution risks from deposited sediments that may become re-suspended due to increased connectivity.

i. **Sampling Strategy:**

Distributed across catchments and river drainage networks to capture sediment variability.
Focus on depositional zones with fine sediment fractions, known for high adsorptive capacity.
Sink areas (e.g., Zandvlei estuary) sampled to track sediment source dynamics.

ii. **Sampling Methods:**

Channel bed sediments: Suction corer.
Dry bed sediments: Trowel.
Lakes & estuary samples: Boat and grab sampling.

iii. **Storage & Analysis:**

Samples stored in 250 ml plastic jars, dried, and kept in cold storage before laboratory testing.

Current main findings:

Particle size distribution and connectivity:
Majority of the sample sites for Kuils River and Zandvlei based on the particle distribution sizes (D50) fall within the Medium to fine sand particle size. When comparing the wet season to the dry season the samples sites act very different, with some sites such as CR 06 showing a slight increase in particle size distribution in the dry season as opposed to the wet season and sites such as CR 07 and CR 08 showing a marked increase in particle size distribution in the wet season as compared to the dry season. These sites are all along the Keyers River, with CR 06 and CR 08 representing tributaries joining the Keyers River, whilst CR 07 form part of the main stem of the Keyers River. Potential reasons for these disparities in sites along the same river is directly linked to their functional and structural connectivity and the following relationships discussed below are a proxy for what can be expected from other sample sites and how the expectant model will respond. For example, sites such as CR 07 and CR 08, which increase during the wet season is a function of newly eroded sediments being transport due to higher flows and thus suggests that these rivers are well connected upstream and should argumentatively contribute to the final sediment budget. CR 08, in particular, is situated in the Tokai Forest and the surrounding land cover impacts features deforestation which leads to a destabilisation of sediments and thus increased erosion. Sample sites such as CR 06 which show an increase in sediment particle size during the dry season could suggest that this site acts as a sediment store and thus as flows decrease sediments from upstream settle out here because of a shift in energy dynamics. The river and its banks at CR 06 feature mature stands of *Typha Capensis* and *Myriophyllum aquaticum* which influences the hydraulic roughness of the river bed forcing sediments to settle out unless flow dynamics are energetic enough.

Metal and organic carbon concentrations:
With regards to metal and organic carbon concentrations the consensus is that these constituents should increase with a decrease in sediment particle size allowing for greater adsorption. However, sample sites are impacted based on where they are spatially and their surrounding land cover impacts. Upstream, headwater streams should be less impacted then downstream rivers. I suspect this hypothesis to remain true with the exception of storm water canals and wastewater treatment work discharge points. As an example, CR 06 (10.751 µm) showed a significantly D50 particle size distribution in the wet season as compared to CR 07 (445.838 µm) and CR 08 (341.074 µm). This contrast is also shown in their respective organic carbon concentrations, with CR 06 having 7.60 % and CR 07 and CR 08 having 0.54% and 1.07 % respectively.

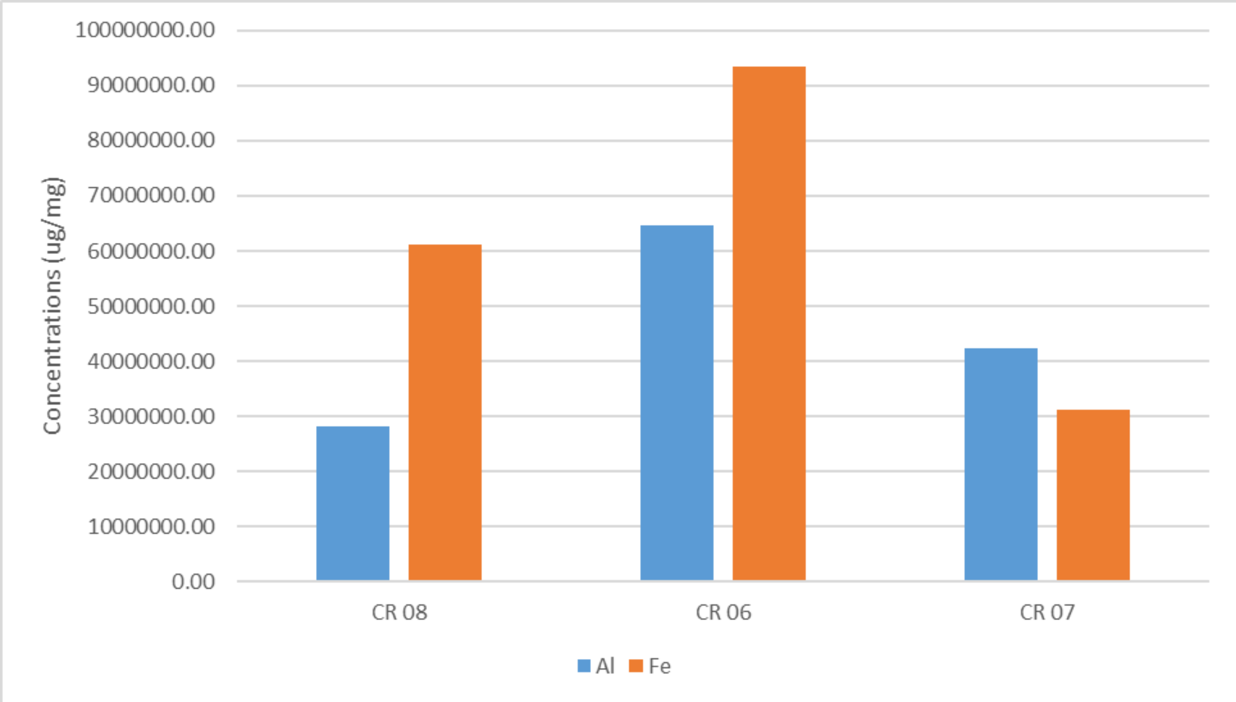

Figure 1: Sediment metal concentrations for Aluminium and Iron in the Keyers River system

As discussed previously, metal concentrations unlike organic carbon is less dependent purely on sediment particle size but is equally dependent on surrounding land cover impacts and natural availability of metals in the reference soils/geology. This is what will be expected for most of the results for Zandvlei and Kuils River alike. As an example, CR 06 which has the smallest particle size distribution shows the highest concentrations of iron and aluminium (Figure 1) as compared to CR 08 and CR 07 (Figure 1) and this is likely because of a greater adsorption capacity. However, in CR 08 as compared to CR 07 the adsorption capacity resulting from a comparatively smaller particle size does not entirely explain the concentrations witnessed (Figure 1). CR 07, which has a comparatively larger particle size distribution, shows a considerably greater concentration of aluminium than CR 08 (Figure 1). Whereas CR 08 shows a considerably greater concentration in iron than CR 07 (Figure 1). Potential reasons for these disparities can be explained by a possible industrial pollution source at CR 07 allowing aluminium to be more readily available. Another potential reason can be explained by pH and redox reactions, aluminium and iron precipitates differently based on the chemical conditions present (Guerra et al., 2022). Lastly, natural geology and the availability of iron or aluminium within source rocks can also influence the natural distribution and availability of aluminium and iron which is abundantly available in the earth's crust. Further statistical analysis such as spearman correlation can greatly add the conclusion drawn from the metal concentrations but further work in the PhD is required before more key findings can be described.

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Research Intern: Linda Rulumeni

As part of the project's commitment to human capacity development, research intern Linda Rulumeni was assigned as a team member on this WRC project from July 2023, gaining valuable skills across multiple domains:

- Project Management: Developed skills in coordinating tasks, managing timelines, and ensuring project milestones were met under the guidance of the project leader and team.
- Facilitation: Assisted in organizing materials and led discussion and feedback sessions during workshops with the City of Cape Town and Witzenberg Local Municipality.
- Presentation Skills: Prepared and delivered a presentation at SANBI's 4th Catchment-based Indaba (29 Oct – 1 Nov 2024), gaining experience in public speaking, audience engagement, and visual communication.
- Report Writing: Contributed to final project reports by compiling data, analyzing information, organizing glossary and reference lists, and drafting sections on monitoring and indicators.
- Team Collaboration: Worked effectively within a multidisciplinary team, sharing responsibilities and contributing to collective project goals.
- Research & Analysis: Conducted data collection, research, and analysis to support project decision-making and outcomes.
- Problem-solving: Developed solutions to project challenges, such as designing an illustrative graph to represent complex processes based on team discussions.
- Stakeholder Engagement: Engaged with municipal representatives gaining insight into their needs and concerns while fostering productive collaboration.

These skills significantly enhanced Linda's professional development while contributing to the project's success.

APPENDIX 3: RESEARCH DISSEMINATION

Effective research dissemination is crucial for maximizing the impact of the project findings, as it ensures that knowledge reaches relevant stakeholders and drives meaningful change. The talks and seminars presented by the project team during 2024 are listed in Table 1.

Table 1: Talks presented by members of the project team

Date	Platform	Topic	Project team member(s)
31 July 2024	SWSAs Government Authorities Committee (GAC)	CSIR Initiatives on SWSAs	Lindie Smith-Adao
31 October 2024	SANBI's 4th Catchment-based Indaba	Keynote address: Shaping the future of our water resources: Past achievements, current research and future actions in SWSAs	Lindie Smith-Adao and Ilse Kotzee
14 November 2024	Freshwater Ecosystem Network (FEN) Meeting	Strategic Water Source Areas Framework for municipalities	Ilse Kotzee

Popular Science Article

A popular science article was published in the Water Wheel (Jan/Feb 2025 issue), led by Earl Graham, a PhD student on this WRC project (Appendix 1) and research intern at the City of Cape Town Metropolitan Municipality. The article was co-led by Dr Chantel Petersen, Senior Professional officer at Scientific Services, Research and Development at the City of Cape Town, and a member of the project team.

Graham, E., Petersen, C., Smith-Adao, L., Kotzee, I., Audouin, M., Rulumeni L., and Davies S. 2025. Water factories: The intrinsic value of a critial resource in water-scarce cities. https://www.wrc.org.za/mdocs-posts/water-factories-the-intrinsic-value-of-a-critical-resource-in-water-scarce-cities/

As part of PhD student Mr Earl Graham's contract with the CSIR, he will produce

- A PhD thesis submitted in accordance with the requirements of the degree Doctor of Philosophy in Environment and Water Science.
- A minimum of one publication in SAPSE accredited peer reviewed journals and one popular article. The popular article is complete (see above).
- Presentation at a minimum of one local or international conference.