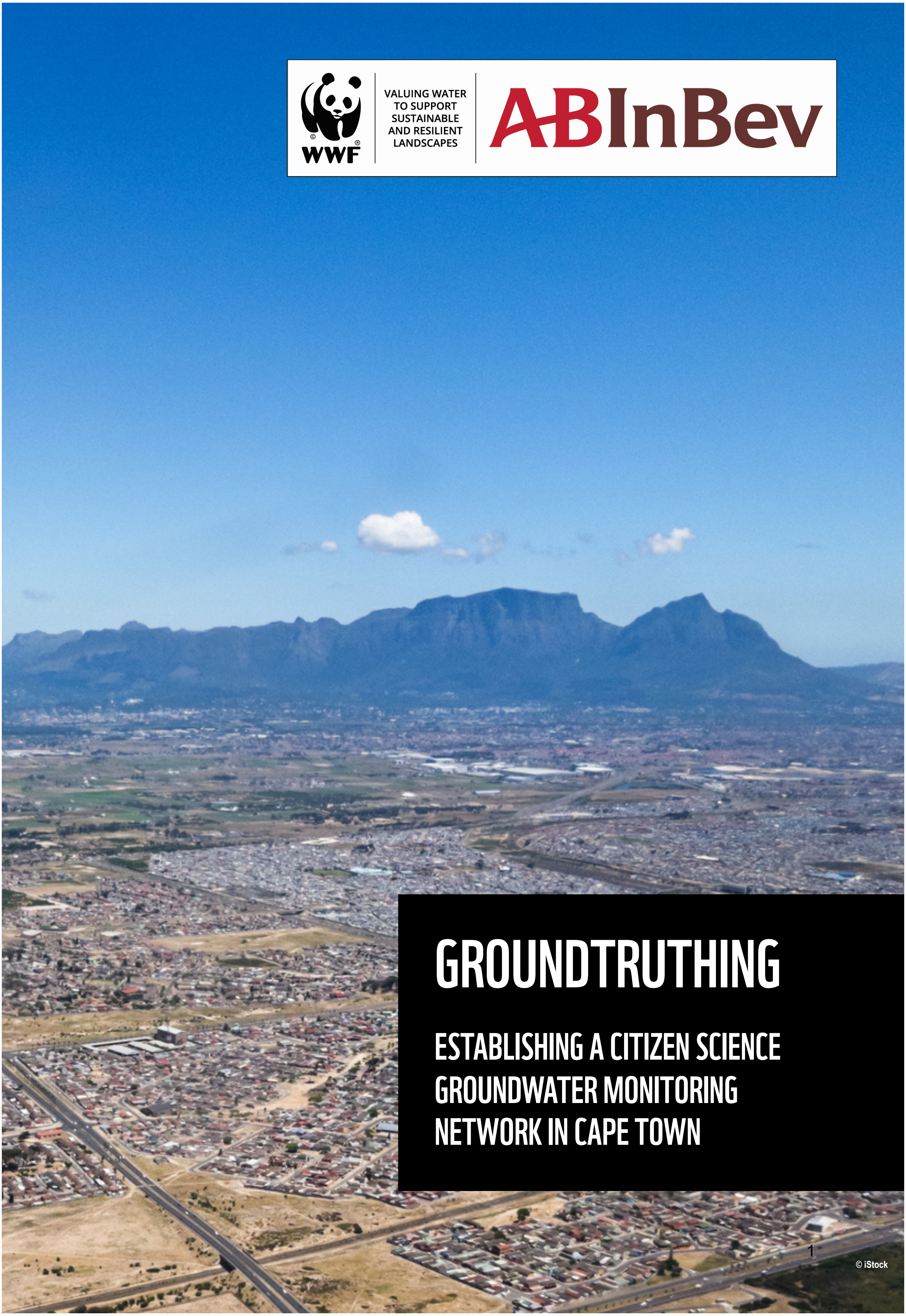

VALUING WATER TO SUPPORT SUSTAINABLE AND RESILIENT LANDSCAPES

GROUNDTRUTHING

ESTABLISHING A CITIZEN SCIENCE GROUNDWATER MONITORING NETWORK IN CAPE TOWN

Funder: This project was funded by WWF's partner, AB InBev

Author: GEOSS South Africa (Report number 2019/11-02)

GEOSS South Africa is an earth science and groundwater consulting company that specialises in all aspects of groundwater development and management.
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GROUNDWATER AND EARTH SCIENCES
GEOSS
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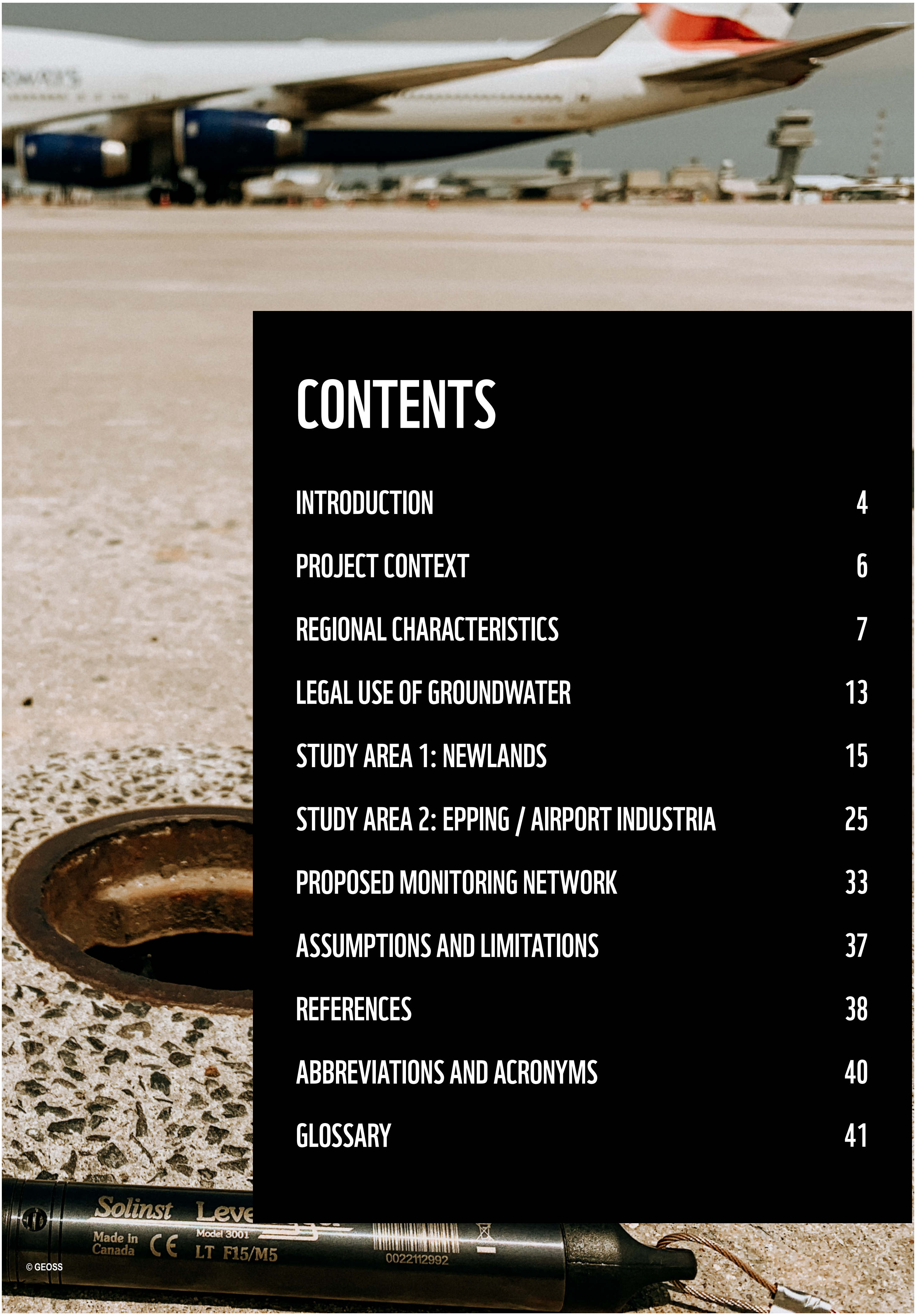
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INTRODUCTION

GROUNDWATER: WHAT'S THE BIG ISSUE?

Unsustainable groundwater abstraction, current and future, represents a critical risk to water resources, groundwater-dependent ecosystems (like wetlands) and the water resilience of the people of Cape Town.

WHAT'S THE DROUGHT GOT TO DO WITH IT?

The Western Cape and the City of Cape Town experienced a severe drought between 2015 and 2019, resulting in a sudden increase in the number of boreholes and well points that were created. Associated with this is an unquantifiable increase in the number of groundwater users and the volume of groundwater abstracted in the City of Cape Town.

WHAT RELEVANCE DOES THIS HAVE FOR WATER SECURITY?

According to 2016–2018 research, South Africa has 22 surface water source areas that account for 10% of land yet provide half of our country's water. There are also 37 groundwater water source areas around the country, which overlap with key aquifers. These surface and underground water reserves are strategically important for South Africa's water and economic security – and they require specific attention.

Cape Town and surrounding areas fall within two overlapping strategic water source areas – the surface Table Mountain Water Source Area and the groundwater Cape Peninsula and Cape Flats Water Source Area. Groundwater is typically a fall-back resource in times of drought. Hence unmonitored and unregulated abstraction of groundwater, especially under an uncertain changing climate, poses a risk to this water supply source.

As the City of Cape Town diversifies its bulk water, it looks to tap three underground water reserves in the vicinity of the city: the Table Mountain Group, Cape Flats and Atlantis aquifers. The Cape Peninsula and Cape Flats Water Source Area (groundwater) overlaps with the primary Cape Flats Aquifer and the groundwater recharge area represented by the iconic Table Mountain outcrop of the Peninsula Formation. The Atlantis Aquifer (up the West Coast) and the Table Mountain Group Aquifer (now accessed near Steenbras Dam) lie outside the Cape Peninsula and Cape Flats Water Source Area yet provide important bulk groundwater contributions to the City of Cape Town.

WHAT IS WWF DOING?

With a focus on South Africa's high-rainfall water source areas, WWF is committed to building partnerships, strengthening good governance of shared water resources and collectively addressing the key threats.

WWF is working with communities and public and private sector partners to enable better understanding of the groundwater situation in Cape Town, the sustainable limits to use and the drivers of responsible groundwater management. As such, there is a need to build on a 2018 assessment of groundwater use and improve the understanding of current monitoring and management practices and culture among a diversity of borehole owners and groundwater users.

In 2019, WWF appointed the hydrogeology consultants GEOSS South Africa to establish a citizen science groundwater monitoring network in two pilot areas in Cape Town. The first study area is Newlands because it is a residential suburb with several natural springs and is thought to host some industrial groundwater use in addition to mostly private groundwater use. The Newlands area saw an increase in boreholes drilled over the drought period. The second study area is the mixed residential and industrial setting of Epping and the area around Cape Town International Airport, which also saw a rise in borehole numbers.

BOX 1: GROUNDWATER USE 101

Groundwater is a hidden resource and a national asset regulated by the state. The national Department of Water and Sanitation (DWS) controls all aspects of water use. This includes how much groundwater you can take out and what you will use it for. The municipality also has a say in what you are allowed to use this water for under their by-laws and water restrictions.

Unless you have been given a licence by DWS, you are not allowed to pump more than 400 m^3 of water per hectare per year in Cape Town (assuming your abstraction is in line with the general authorisation requirements as gazetted). This is equal to only about 100 litres per day on a 1 000 m^2 erf or property. You can use the water for basic household or garden needs.

Our current groundwater stores have been built up over multiple years of rainfall. But like any renewable resource, if we take out more than is going in over the long term, groundwater can be depleted. To ensure that there is a fair share of this hidden resource for everyone for a long time, we need to measure how much we use, monitor the water levels and be sparing.

GROUNDWATER IN CAPE TOWN

Groundwater is found beneath much of Cape Town and feeds the springs around the city. The geology under a property determines whether there is likely to be an aquifer (underground water supply).

If on sand, calcrete or hard-fractured sandstone, there is likely to be groundwater. Where there is thick clay, it is unlikely that there will be enough groundwater to pump. Granites can be high-yielding where there is faulting. So it's the lithology (type of rock) and the structural geology (presence of faulting/fracturing) that determine whether groundwater is available in a meaningful volume.

The City of Cape Town Metropolitan Municipality gets most of its groundwater from three aquifers:

- **Table Mountain Group Aquifer:** A huge aquifer found beneath the mountain ranges of the Western Cape
- **Cape Flats Aquifer:** A shallow aquifer, in excess of 400 km^2, stretching from False Bay to Tygerberg Hills and Milnerton.
- **Atlantis Aquifer:** An aquifer of about 130 km^2 in size, stretching inland from the Atlantic Ocean to the town of Atlantis.

PROJECT CONTEXT

A feasibility study of groundwater use was completed by Ramboll (2018) to assess the augmentation of bulk water supply with private boreholes in times of drought. It comprised a technical baseline study, where existing groundwater data was collected and analysed. Based on the analysis, potential high-yielding groundwater areas and areas with an expected good water quality were delineated. Furthermore, nearly 10 000 addresses of private boreholes and well points were converted to coordinates. Out of the 10 000 boreholes, five clusters located in potential high-yielding groundwater areas and close to the distribution grid were identified, and business cases for implementation of three of the clusters were conducted (Ramboll, 2018).

The business cases showed that it could be feasible to supplement the water supply with groundwater from private boreholes. However, whether existing private boreholes can serve as a reliable source in emergency situations is highly dependent on the quality of the groundwater from these boreholes. Fieldwork indicated that the water quality varies greatly and in some areas the boreholes are too shallow for use in an emergency or for long-term groundwater abstraction.

In terms of the legislation regarding the possibility of utilising the water supply and obtaining access to boreholes on private land, it is important that the private landowner gives consent.

Based on the technical and legislative investigations, guidelines were developed on how to implement groundwater from private boreholes in the public water supply. These are generic and can be adjusted to fit site-specific contexts and needs.

PROJECT OBJECTIVES

Building on the previous research, and in line with the priorities of WWF South Africa, the main objectives of this project are to:

- Assess the quality of groundwater monitoring
- Identify potential monitoring points
- Characterise the groundwater resources in the study areas
- Install a monitoring network in the Newlands and Epping areas.

REGIONAL CHARACTERISTICS

REGIONAL SETTING

Cape Town (the legislative capital of South Africa) is a port city located on the south-western tip of Africa, forming part of the Berg River Water Management Area. It has some of the richest biodiversity in the world and is commonly known by the iconic features of Table Mountain and Robben Island, among others. Although Cape Town is a popular tourist destination, its residential and industrial areas continue to expand, associated with the increased need for resources and development. The study area, within a regional context, is shown in Figure 1.

Figure 1: Location of the study areas within a regional setting

The City of Cape Town (CoCT) derives all its water from strategic water source areas (SWSA). SWSAs are now defined as areas of land that either:

- Supply a disproportionate (i.e. relatively large) quantity of mean annual surface water runoff in relation to their size and so are considered nationally important
- Have high groundwater recharge and where the groundwater forms a nationally important resource
- Meet both criteria above (Le Maitre et al., 2018).

In 2015, 81% of the City of Cape Town's main water supply came from the Boland SWSA and the Western Cape Water Supply System, with a minor 1,7 % coming from dams within the Table Mountain SWSA (TM-SWSA). In 2019 the sources for the main supply system included new augmented sources with increased supplies from groundwater.

Table 1 shows the water sources that supply the City of Cape Town metropole.

Table 1: City of Cape Town water supply sources

Source	Resource	SWSA
Cape Town dams	Surface water	Table Mountain SWSA
Albion Springs	Groundwater	Table Mountain SWSA
Cape Flats Aquifer	Groundwater	Cape Flats SWSA
Atlantis Aquifer	Groundwater	
Voëlvlei Dam	Surface water	Boland SWSA
Wemmershoek Dam	Surface water	Boland SWSA
Berg River Dam	Surface water	Boland SWSA
Theewaterskloof Dam	Surface water	Boland SWSA
Steenbras Dam (upper and lower)	Surface water	Boland SWSA

Figure 2 show levels of consumption from the City of Cape Town Water Supply Scheme since 2010.

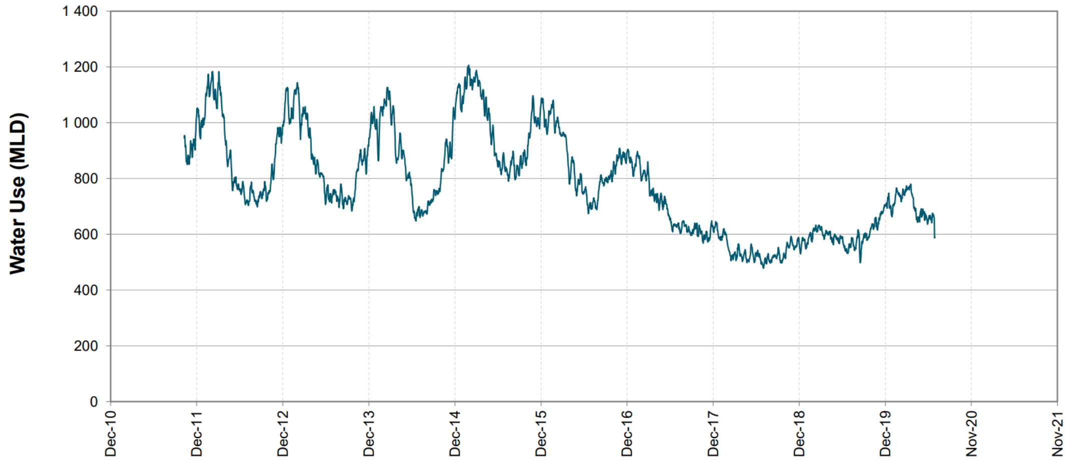

Figure 2: Time-series of water usage

Source: CoCT weekly water dashboard, 29 June 2020

The level of consumption of water supplied by the municipality in the City of Cape Town has not rebounded to pre-drought levels and remains at approximately 700 ML/day. Whereas improvements in efficiency of use and leakage reduction have contributed to this decline, the use of alternate sources such as grey water, rainwater and groundwater by households and businesses has replaced some municipal supply consumption.

CLIMATE

Cape Town has a Mediterranean Climate with mild wet winters and warm dry summers. Figure 3 shows the rainfall distribution for the general Cape Town area in 2019 (CSAG, 2019). The long-term (1950–2000) mean annual precipitation for Cape Town is approximately 475 mm/a, and 1 548 mm/a for the Table Mountain SWSA (Schulze, 2009). The rainfall exceeds evaporation specifically in the winter months (April to September) and the peak groundwater recharge period will thus be in winter.

Industrial groundwater use is typically throughout the year, while private groundwater users increase abstraction during the summer months.

Predicted changes in climate for the Table Mountain SWSA and the Boland SWSA, according to CSAG (2020), will follow the trend seen over the past year, with a slight increase in rainfall over the winter months.

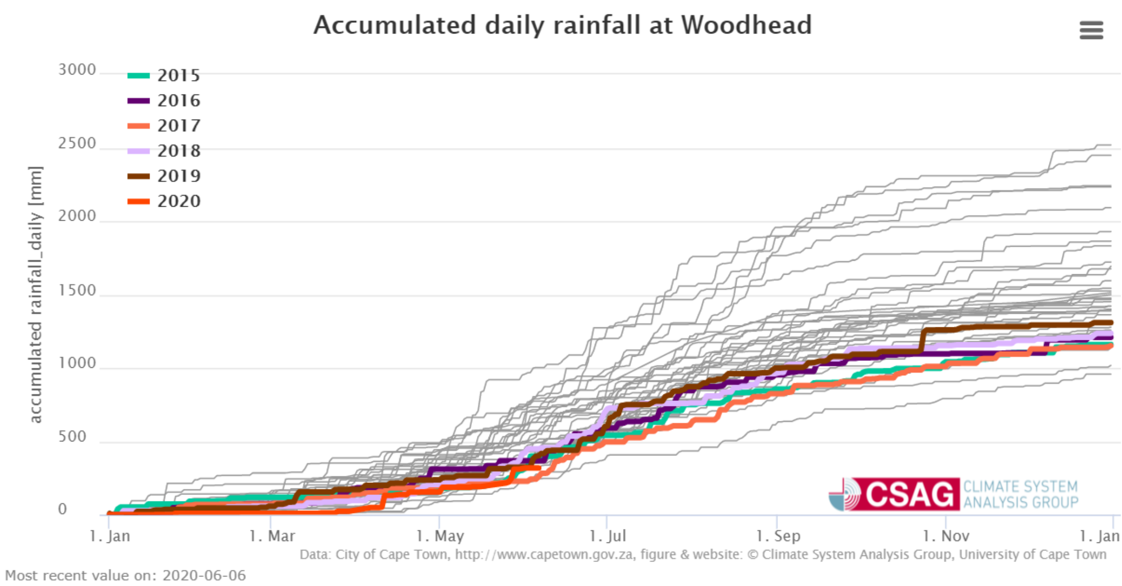

Figure 3: Accumulated daily rainfall for the Table Mountain area

Source: CSAG, 2020

HYDROLOGY

Cape Town forms part of the Berg River catchment area. The Berg River extends from the Franschhoek mountains and enters the Atlantic Ocean at Velddrif on the west coast. In the municipal area, the rivers of significance are the Diep River and the Kuils River, which drain out to the western and southern coastlines respectively.

The Table Mountain SWSA overlies the Peninsula Formation of the Table Mountain Group Aquifer. A large portion of Cape Town's southern suburbs is located overlying the overlap between the Table Mountain SWSA and the Cape Flats Aquifer.

The interaction between groundwater and surface water occurs when and where groundwater emerges at the surface or discharges to a surface water body, or where surface water passes into groundwater (Saayman et al., 2004). Where groundwater and surface water occur in close association, it is the elevation of the groundwater table relative to the surface water level that controls the direction and quantity of flow in or out of the surface water system. The relation between these two systems is, in part, influenced by climate (discharge volumes and patterns), geology (aquifer properties and changes in topography), and cultural activity (land use, groundwater abstraction and the damming of rivers) (Lerner, 1996). Changes in these factors along the reach of a river will influence the relative elevation of the water table, and so dictate the type and extent of the groundwater/surface water interaction. Given the variation in water levels across the Cape Town area and variability in geology, the nature of the groundwater–surface water interaction is expected to be variable.

GEOLOGY

The Geological Survey of South Africa (now the Council for Geoscience) has mapped the area at 1:250 000 scale (3318, Cape Town). The main geology of the study areas is listed in Table 2 and Table 5 and the geological setting of the study is shown in Figure 4.

The Cape's geology is highly variable and changes over relatively short distances. On a regional scale, the Cape Town area comprises rocks of the Malmesbury Group and Cape Granite Suite as the basement rocks, which are overlain by rocks of the Cape Supergroup. The Cape Supergroup is constituted by the very important Table Mountain Group (TMG), which hosts significant volumes of groundwater in high-yielding aquifers, and the Bokkeveld Group. The Table Mountain Group outcrops towards the south-western tip at Cape Point, extending through to the city centre and again further east, near Gordon's Bay and the upper Steenbras Dam. Quaternary deposits cover the basement geology in much of the central area, i.e. the Cape Flats.

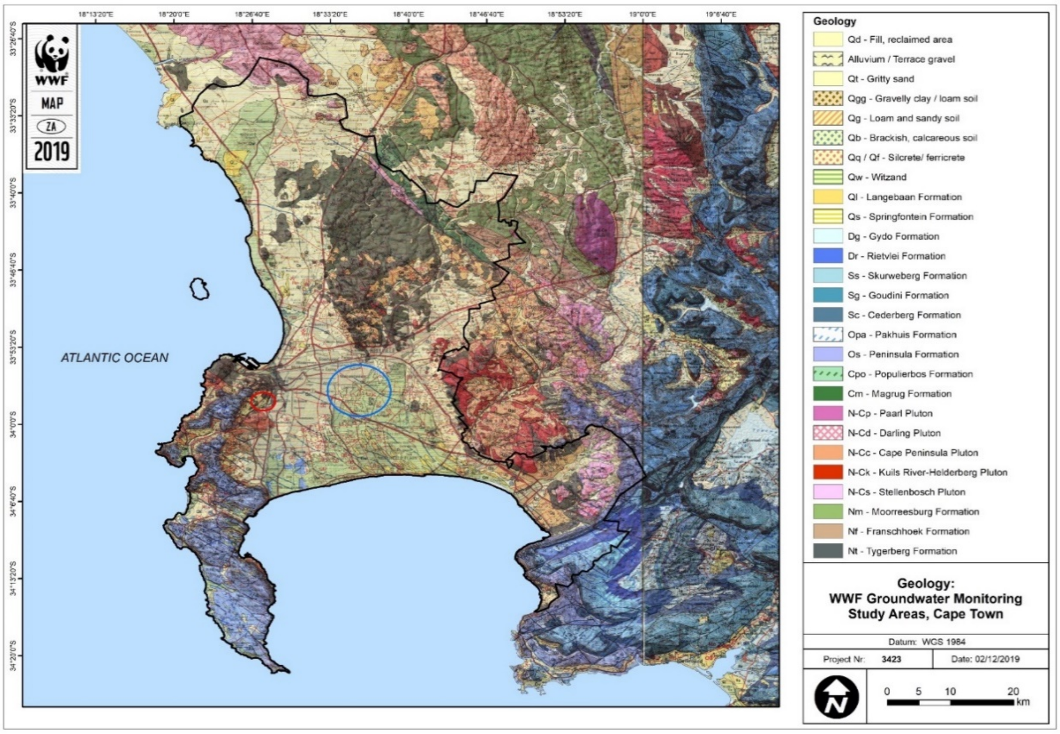

Figure 4: Geological setting of the City of Cape Town municipality, showing the two study areas (3318, Cape Town)

Source: CGS, 1990

HYDROGEOLOGY

The aquifer yield and aquifer quality classifications are based on regional datasets and therefore only provide an indication of conditions to be expected. The geological setting of the study area is complex, with a variety of lithologies. This complex geological setting is reflected in the geohydrology of the area. There are both primary porosity and fractured rock aquifers in this area. Recharge rates and mechanisms are variable throughout the area. Flow paths and mechanisms also differ throughout the area.

Geology plays a major role in controlling geohydrological conditions. For this reason, groundwater response units do not conform to surface water catchment boundaries. In addition, the amount of groundwater inflow and outflow also needs to be taken into account when carrying out water balance equations for the area. The hydrogeology section outlines some of the key geohydrological characteristics of the area.

AQUIFER YIELD

According to the 1:500 000 scale groundwater map of Cape Town (3318) the area hosts fractured aquifers (i.e. the bedrock constitutes an aquifer), intergranular aquifers and a combination of the two, with average borehole yields ranging between 0.0 and 0.1 L/s to 5 L/s (Figure 5) (Meyer, 2001). Groundwater in the primary intergranular aquifers store water moving through pore spaces, while groundwater in fractured aquifers are characterised by water stored and moving through fractured host rock.

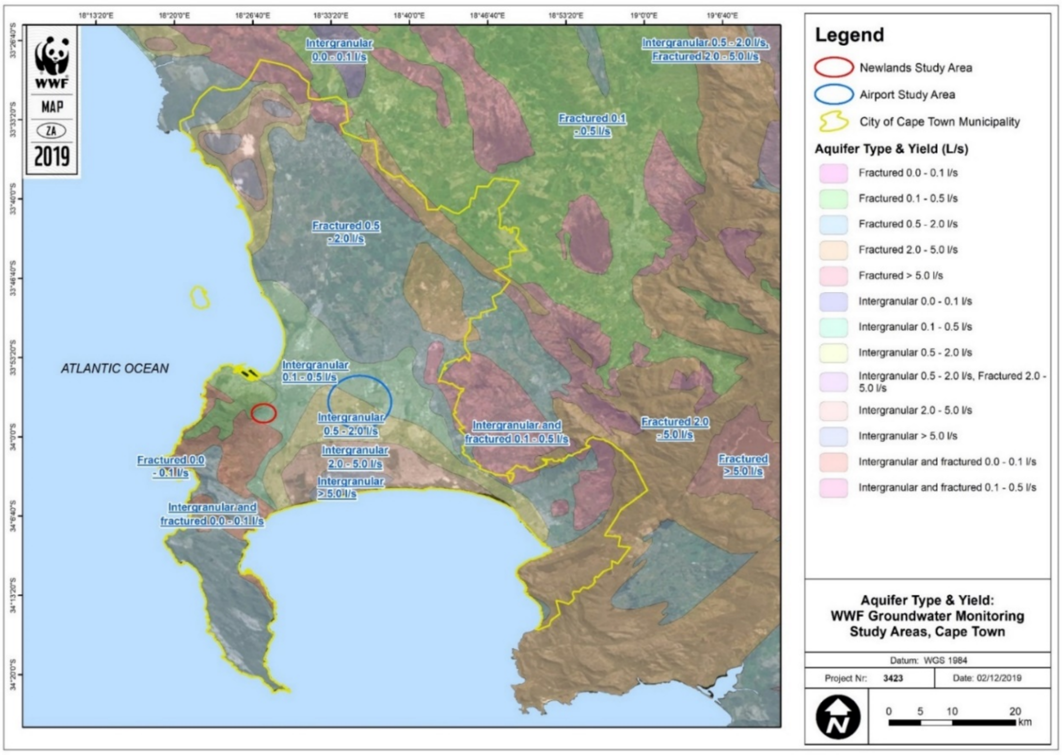

Figure 5: Regional aquifer yield from the 1:500 000 scale groundwater map (3318, Cape Town) showing the two study areas

Source: DWAF, 2000

The Table Mountain SWSA comprises the Table Mountain Group (TMG) Aquifer, a regional fractured rock aquifer. The medium to coarse grain size and relative purity of some of the quartz arenites of the Table Mountain Group, together with their well-indurated nature and fracturing due to folding and faulting in the fold belt, enhance both the quality of the groundwater and its exploitation potential for water supply. It also supports the flow of numerous streams, seeps and springs. There have been a reported 501 springs in the Table Mountain Group area, of which 103 are recognised as TMG-related springs according to their geographical position within the formation (Duah, 2010).

The groundwater landscape sharply changes east of Newlands to the Cape Flats Aquifer, which extends over much of the central areas of the municipality, approximately 400 km^2. It has been proposed that the groundwater of the Cape Flats Aquifer flows in a north–south direction towards the

False Bay coastline, with flow concentrated along paleochannels (DWAF, 2008). The Cape Flats Aquifer is a primary aquifer situated in the Quaternary sands of the Cape Flats. These sand deposits include fluvial, marine and aeolian deposited sands, underlain by Malmesbury Group as well as the Cape Granite basement rock (DWAF, 2008). The bedrock of the Cape Flats Aquifer shows a unique channel formation or 'paleochannel' extending in a north–south direction through the central parts of the Cape Flats.

AQUIFER QUALITY

Electrical conductivity (EC) is a measure of the ability of groundwater to conduct electricity. This is directly related to the concentration of ions in the water. This parameter is used as an indication of the quality of the groundwater.

The groundwater map in Figure 6 indicates that the aquifers have water qualities, as indicated by electrical conductivity, ranging from 0–70 mS/m (good quality) (mainly in the south-western region) to 300–1 000 mS/m (poor quality) on the west coast in the Bloubergstrand/Melkbosstrand areas. In terms of domestic supply, quality in the range of 0–70 mS/m would be ideal. However, treatment may still be required (DWAF, 1998).

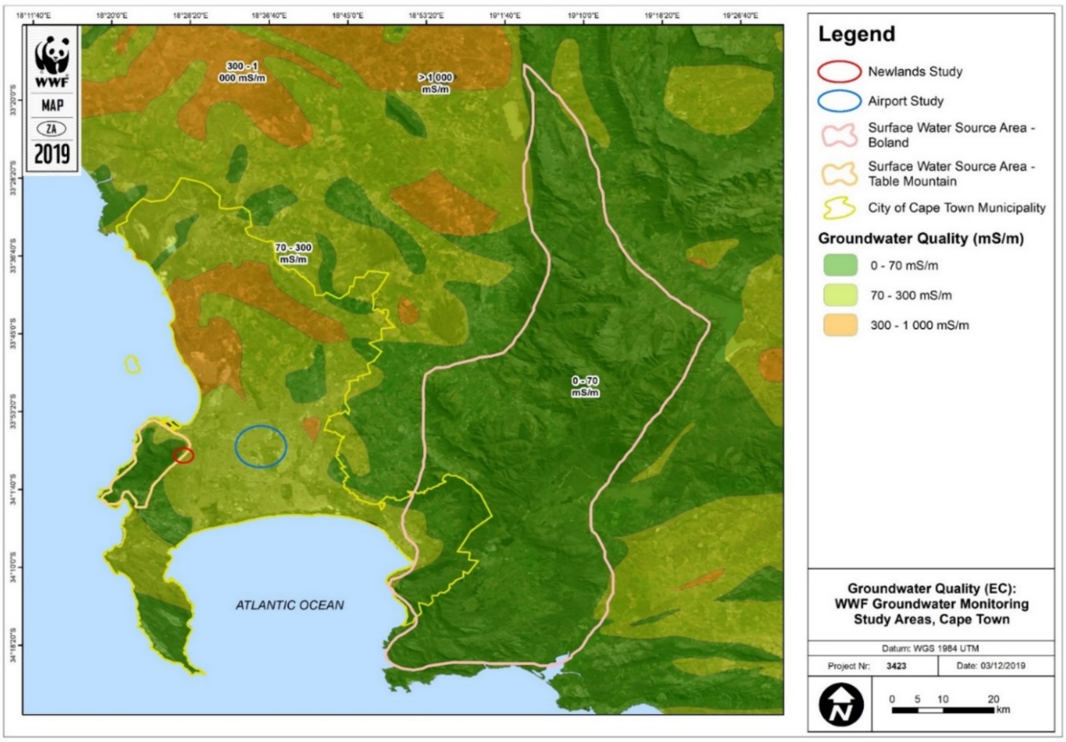

Figure 6: Regional groundwater quality (EC in mS/m) from showing the two study areas

Source: WRC, 2012

LEGAL USE OF GROUNDWATER

Groundwater use in the City of Cape Town area has grown significantly during the recent drought experienced across the Western Cape.

Most of the City of Cape Town metropole is subject to a general groundwater abstraction authorisation limit of 400 m^3/ha/a, with the exception of the northern reaches, which are characterised by limits of 150 m^3/ha/a. The City of Cape Town also promulgates by-laws with regard to private water use. These are in the form of commercial use agreements applicable where alternative water supply is used for drinking, or the commercial entity wishes to go off the grid, i.e. completely cut off municipal supply. In these instances, relevant entities must apply to sink a borehole or well point, register this abstraction point with the City of Cape Town, and in some instances complete an application to become a Water Services Intermediary (WSI).

The highest amount of groundwater abstraction is currently taking place from the Atlantis Aquifer in the northern part of the municipal area and from the southern part of the Cape Flats Aquifer, around Philippi. The total licensed groundwater abstraction within the City of Cape Town is currently around 23 million m^3/a based on data from the WARMS database (Ramboll, 2018). This data is based on authorisations granted prior to June 2018. It is also important to note that, due to residential groundwater use not needing to be licensed, it is not likely to appear on the government's WARMS database. More recent data for the Berg River Water Management Area was requested from the DWS WARMS database, but no response was received. Groundwater use in particular has increased rapidly in residential areas and commercial, agriculture and industrial settings.

In the Newlands area, at the base of Table Mountain, there are three naturally occurring springs, i.e. Albion Spring, Newlands Spring and Kommetjie Spring. The Newlands Brewery has existing authorisation for water use from all these springs but the Kommetjie Spring is not used as regularly. The Newlands Spring also serves as a source of water to the public (Figure 7) for general domestic use. In addition to the springs, the brewery is also authorised to use groundwater from boreholes.

Figure 7: Outlet point where the Newlands Spring water is available to the public


BORE-HOLE WATER

STUDY AREA 1: NEWLANDS

The southern suburb of Newlands was selected as one of the study areas. This area was selected because it is home to the oldest commercial brewery in South Africa – Newlands Brewery – and WWF. In addition, this residential area saw a large increase in boreholes drilled over the drought period. Newlands is located within quaternary catchment G22C and forms part of the Table Mountain SWSA. The following subsections will give a brief overview of the local characteristics of the study area.

LAND COVER

As mentioned before, rainfall is relatively high in the Newlands area, particularly during the winter months. As such, most of the suburb and surrounds are covered in lush natural vegetation and trees. The Newlands reservoir, north of the suburb, catches excess run-off from the mountain and sufficient precipitation feeds the Newlands Forest against the foot of Table Mountain. The study area is known as one of the wettest residential areas in the country. The area is characterised by mainly residential and light commercial land use. Newlands also hosts a number of schools and community facilities (Figure 8 and Figure 9), the Newlands cricket ground being the most notable.

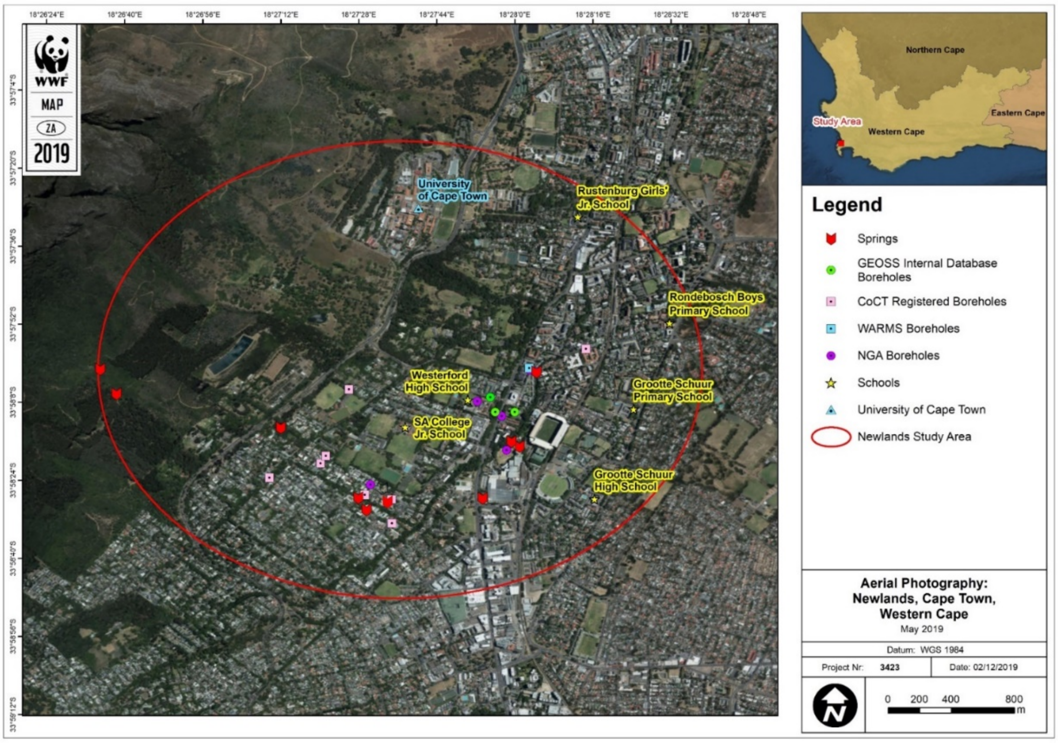

Figure 8: Aerial photograph of the study area showing existing boreholes and stakeholders

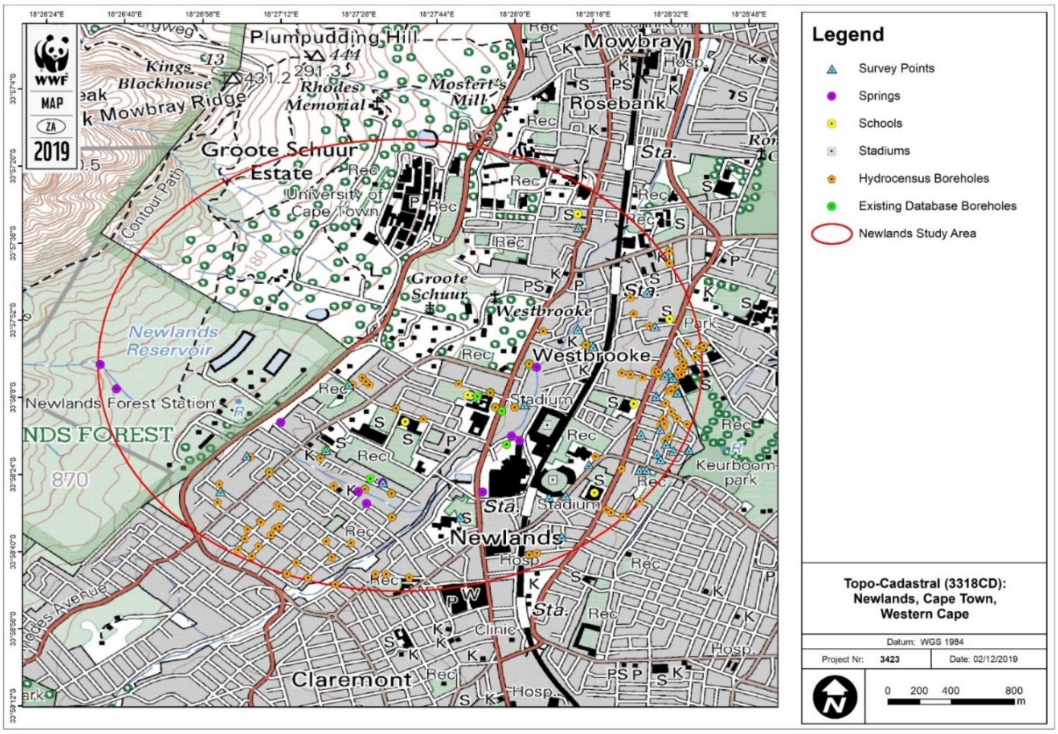

Figure 9: Topo-cadastral map (3318, Cape Town) of the study area, showing boreholes from the existing database and hydrocensus boreholes

GEOLOGY

The Geological Survey of South Africa (now the Council for Geoscience) has mapped the area at 1:50 000 scale (3318, Cape Town). The main geology of the area is listed in Table 2 and the geological setting is shown in Figure 10.

Table 2: Geological formations within the study area

Code	Formation/Pluton	Group/Suite	Description
	–	Sandveld Group	Alluvium
Qt	–		Scree and gritty sand
Qg	Springfontein Formation		Light-grey to pale-red sandy soil
Op	Peninsula Formation	Table Mountain Group	Grey to reddish quartzitic sandstone with minor grit, conglomerate and reddish shale lenses
Og	Graafwater Formation		Thinly bedded sandstone, siltstone and mudstone, mainly reddish
Єc	Cape Peninsula Pluton	Cape Granite Suite	Coarse-porphyritic granite
Nt	Tygerberg Formation	Malmesbury Group	Phyllite, greywacke and quartzitic sandstone

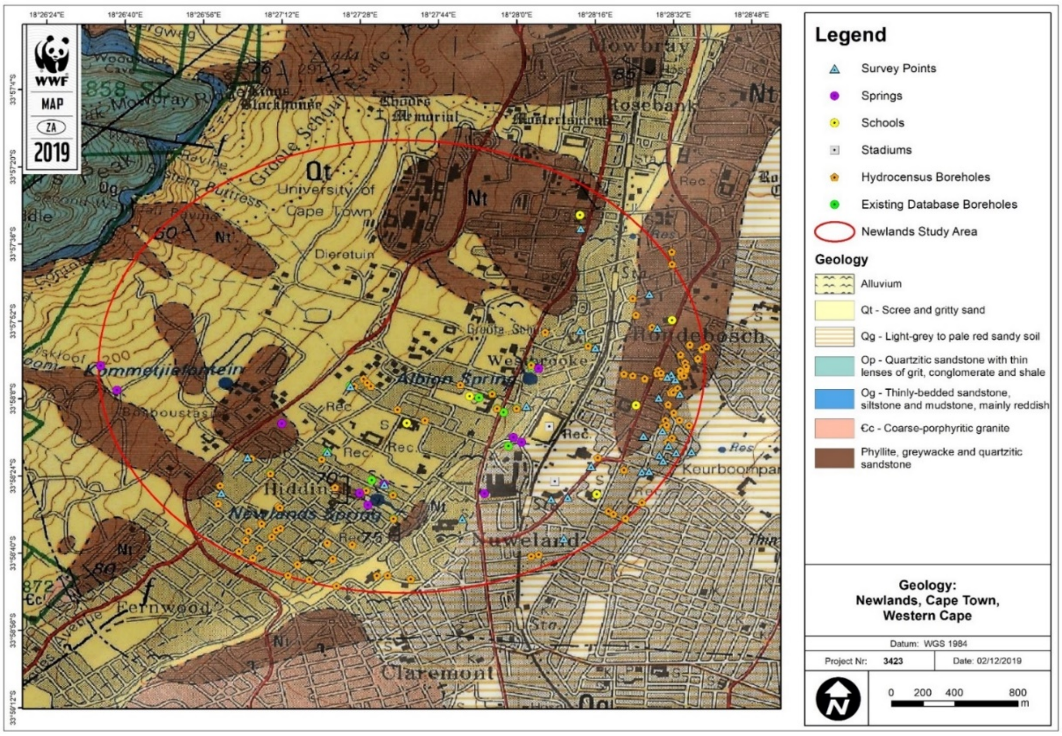

Figure 10: Geological setting of the study area, showing springs, boreholes and amenities of the Newlands suburb in the context of the study area (3318, Cape Town)

Source: CGS, 1984

The local geology directly underlying the site is composed of phyllite and greywacke sandstone of the Tygerberg Formation which was intruded by the Cape Peninsula granite pluton (N-Cc) of the Cape Granite Suite. The study area is flanked and overlain in the west by the Peninsula (Op) and Graafwater (Og) Formations of the Table Mountain Group (TMG). Alluvial deposits of quaternary age cover most of the area, flattening out downgradient from the base of the mountain. A number of northwest–southeast-trending faults have been mapped across Table Mountain through the Peninsula Formation, indicating the fracturing in this unit.

HYDROGEOLOGY

According to the 1:500 000 scale groundwater map of Cape Town (3318) the area hosts an intergranular and fractured aquifer which ranges between 0.0 L/s and 0.1 L/s (Figure 11) (Meyer, 2001). Further north of the site yields increase slightly to between 0.1 L/s and 0.5 L/s. The lower yields are probably associated with the intrusive granite pluton and associated weathering products underlying the alluvial deposits of the Sandveld Group. In terms of water quality, the area is classified as having electrical conductivity in the range of between 70 and 300 mS/m (Figure 12). This is considered marginal quality in terms of domestic use.

With reference to the spring systems existent in the Newlands area, Figure 13 is of relevance. Direct vertical recharge into fractures of the Peninsula Formation sandstone, constituting the top of Table Mountain, penetrate through the fracture networks. Seasonal seepage springs may appear above the shale and siltstone of the Graafwater Formation, while artesian perennial springs occur lower down from the Tygerberg Formation.

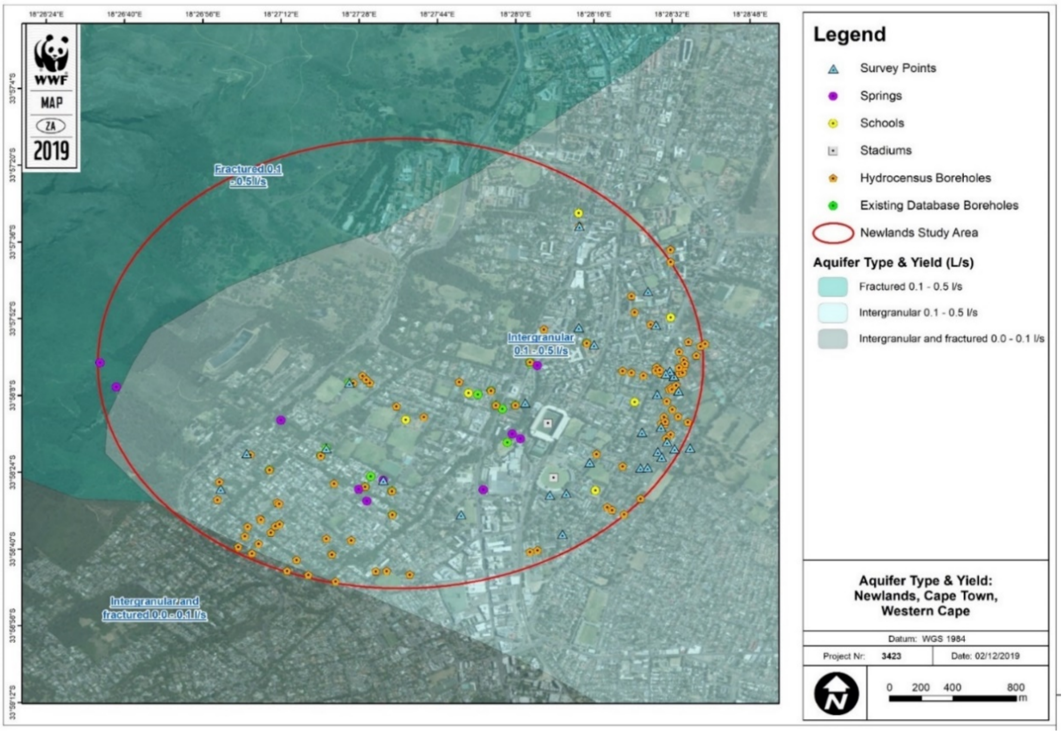

Figure 11: Regional aquifer yield from the 1:500 000 scale groundwater map (3318, Cape Town) showing hydrocensus boreholes and boreholes from existing databases

Source: DWAF, 2000

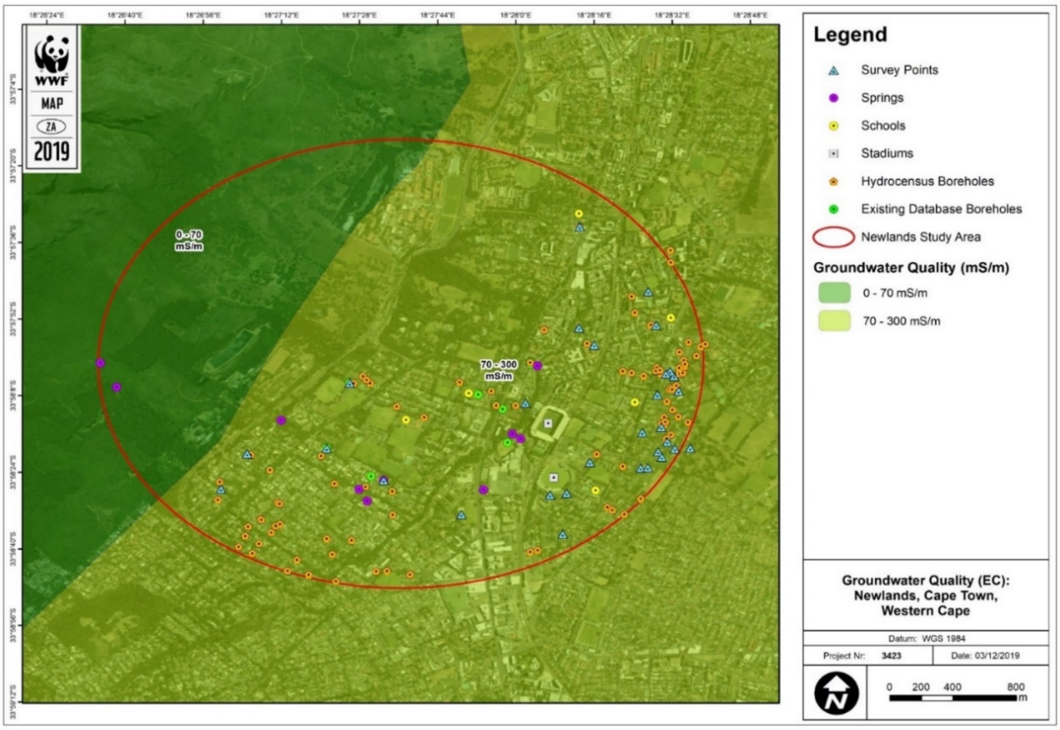

Figure 12: Regional groundwater quality (EC in mS/m), showing hydrocensus boreholes and boreholes from existing databases

Source: WRC, 2012

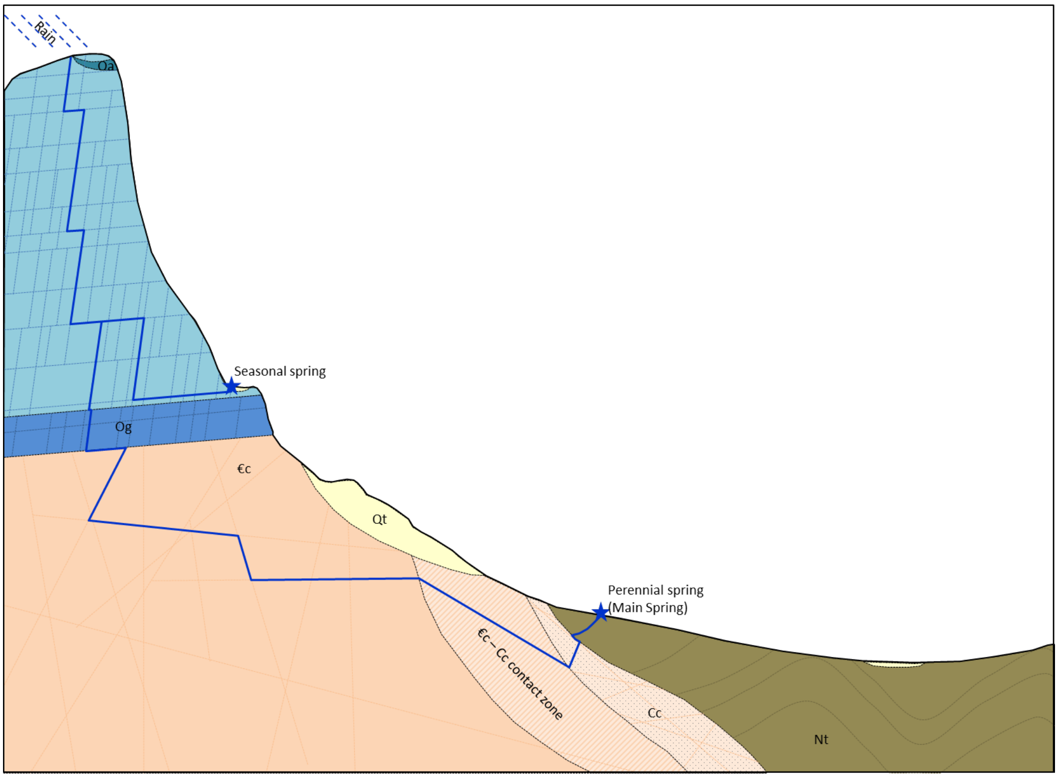

Figure 13: A schematic and conceptual section of the water source area and springs

Source: GEOSS, 2014

EXISTING GROUNDWATER USE IN NEWLANDS

A desktop hydrological study was carried out in the study area to determine if there are any groundwater users in the area. This part of the study did not include any fieldwork; it was completed by studying and inquiring from existing databases that contain groundwater information. A search of the National Groundwater Archive (NGA), which provides data on borehole positions, groundwater chemistry and yield, when available, was carried out to identify proximal boreholes. These sites are typically verified in the field and provide background information on the area. In addition to the NGA, the Water Authorisation and Registration Management System (WARMS) database was also consulted (last updated June 2016). This refers only to those water users who use water for commercial or industrial use and not for small-scale domestic use. Further to this, the boreholes registered with the City of Cape Town Metropolitan Municipality were considered along with GEOSS's own database of known boreholes in the area. The boreholes were plotted in the study area maps and in this section of the report. The current City of Cape Town data was obtained through the Ramboll (2018) study.

All the boreholes identified through the databases are collectively referred to as existing database boreholes. Due to Newlands largely being a residential area, very few WARMS boreholes were identified in the search (Table 3).

Table 3: Details of active WARMS sites in the study area

WARMS ID	Latitude	Longitude	Entity type	Source	Use	Volume (m^3/a)
22060564	-33.967175	18.467406	Water Services Provider (CoCT)	Albion Spring	Water supply	1 500 000
22139080	-33.965010	18.460494	National Department	Borehole	Agriculture irrigation	20 800
22140014	-33.973859	18.459095	Water Services Provider (CoCT)	Spring	Water supply	223 745

GROUNDTRUTH DATA FOR NEWLANDS

A hydrocensus was conducted in the study area on 17–21 June 2019. This involved visiting the identified boreholes and land owners/groundwater users. Information pertaining to the abstraction, yield and quality of groundwater was sought.

Despite the hydrocensus having taken place over a number of days, which included weekdays and a public holiday, many residents were not home during the time of the site visit. Therefore, although borehole and well point signs may have been indicated outside the properties, more detailed information could not be obtained. In these instances, public letters were left in post boxes. Residents who were on site during the hydrocensus were able to provide information relating to their water use, summarised in Table 4.

A total number of 105 properties were visited during the course of the hydrocensus. A property was visited if there was a borehole/well point sign placed outside the property. Of this number, 29% were available to complete a hydrocensus survey.

Table 4: Hydrocensus data obtained in the study area

Site	Type	Age	Depth (m)	Volume	Comment on concerns with groundwater use in the area
1	Borehole	6 years	25	6 000 L/day	None so far
2	Borehole	>10 years	Collapsed	0	None so far
3	Well point	3 years	Not very deep	Jojo tank storage	None so far Must be used sustainably
4	Borehole	>25 years	–	Switched on for 4–8 minutes	None so far
5	Borehole	~20 years	60	Pumps at 150 000 L/h	Drought restrictions led to no shortage
6	Borehole	>5 years	–	–	Full of iron and affects the walls

Site	Type	Age	Depth (m)	Volume	Comment on concerns with groundwater use in the area
7	Borehole	15 years	60	30 min/day Fills the watering can in 30 seconds	Yes, very concerned Lots of iron
8	Borehole	Very old	60	Husband knows (email)	Not really
9	Well point	18 months	Shallow	<5000 L/month	None
10	Well point	1 year	2	In summer, 1 hour/ day	None
11	Borehole	>6 years	80	Pumps for about an hour	People being silly with groundwater usage, and selfish
12	Borehole	2 years	47	1 500 L/week	None, except for all the new users
13	Borehole	–	–	–	–
14	Borehole	15 years	40	–	None
15	Borehole	>10 years	60–70	1 000 L/day	Southern well points are becoming dry, is there really much water?
16	Borehole	18 months	30	5 000 L tank	Historical well point gone dry, slow flow No other concerns
17	Borehole	18 months	96	Varies, dependent on occupancy	None
18	Borehole	>20 years	–	Unknown, flow meter measuring on the borehole	None, similar quality to Newlands spring
AAA	Spring	Very old	–	30 000 L/day	None
AAB	Borehole	8 years	–	–	BP possibly could leak petrol into groundwater
AAC	Borehole	3 years	–	–	Yes, overuse of the groundwater
AAD	Borehole	A few months	–	Nothing	–
I	Borehole	1 month	45	–	No
II	Borehole	±3 years	–	–	Quantity
III	Well point	2 years	3–7	–	Yes, quantity and quality
IV	Well point	40 years	5	–	No
V	Borehole	3 months	55	Don't know	No

Site	Type	Age	Depth (m)	Volume	Comment on concerns with groundwater use in the area
VI	Borehole	10+ years	+200	No	No
VII	Borehole	12 years	90	No	Yes
VIII	Well point	2 years	+2	–	Yes, consequences of the drought
RGHS	2 Boreholes	2012/2013 and 2018	~60 m	~10 000 L/day	Quality, too much use, irresponsible citizens

KEY STAKEHOLDERS

Key stakeholders in and around the study area were contacted telephonically and invited to attend the public meeting held on 5 August 2019 at Rustenburg Girls High School in Newlands. Few RSVPs were received. WWF and GEOSS gave presentations to the public about the various aspects of groundwater and the importance of monitoring. Stakeholders who were present appeared to be amenable to monitoring and asked many relevant questions.

MONITORING REQUIREMENTS FOR A NUMERICAL GROUNDWATER MODEL OF THE NEWLANDS AREA

Numerical groundwater models are helpful to predict scenarios of water use, aquifer recharge and depletion under different climatic and abstraction regimes. However, they are only as good as the data on which they are based. Simply put, a numerical groundwater model is a simplification of a groundwater system. Numerical models break up the model domain and/or time into discrete units to which parameters, boundaries and governing equations can be specified. This can then be solved to provide a potentially realistic representation of the system (Barnett et al, 2012).

Groundwater models are useful for gaining an understanding of the behaviour of groundwater and can be used to further develop conceptual understanding and forecast future behaviour to support management and decision-making (Barnett et al, 2012). A groundwater flow model focuses on hydraulic heads and flow rates within the chosen system – providing estimates of water balance and travel times along flow paths (Barnett et al, 2012).

A numerical model of the Newlands area would be beneficial to provide quantitative estimates of drawdown, loss of base flow and reduction in water availability to groundwater-dependent ecosystems for various levels of groundwater extraction and variations in climate and rainfall.

The confidence level classification of a model is often constrained by the available data. In order to set up a numerical model for the Newlands area that could confidently predict changing groundwater storage, flows and discharge, it would be important to have the relevant information and detail. The establishment of the model in the steady state would require detailed information on the aquifer, including:

- Geological conceptualisation of the model domain
- Water level data (surveyed elevations)
- Aquifer parameters (hydraulic conductivity and storage)
- Rainfall and recharge volumes
- Abstraction and discharge locations, and volumes

- Water chemistry data for improved characterisation.

The model would be established in steady state, and would typically be calibrated using the hydraulic conductivity and recharge volumes. In order for the established model to then be used for predictive analysis of stresses applied to the aquifer, it is necessary to undertake a transient calibration. Water level responses to stresses on the system are used to calibrate the aquifer storage, in addition to other aquifer parameters. The following monitoring data is necessary for the transient calibration:

- Water level data (surveyed elevations)
- Abstraction volumes
- Rainfall data
- Water quality data.

It is desirable to have temporal data that extends over multiple years for improved calibration. A model is a groundwater management tool that can be improved and updated as data becomes available. The establishment of a monitoring network would support the development and calibration of a model for the study area.


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STUDY AREA 2: EPPING / AIRPORT INDUSTRIA

The second study site, i.e. Epping and the Cape Town International Airport industrial area, was selected because it is a highly industrial setting overlying part of the Cape Flats Aquifer. This area is significant in terms of its history and the production processes that take place in the City of Cape Town.

LAND COVER

The study area forms part of the Cape Flats Aquifer, an expansive low-lying area. It is a mix between heavy industrial and residential land use. Rainfall predominantly occurs during winter months. Due to the Cape Flats being covered by aeolian sand, rainfall recharges the sand through direct vertical recharge.

The study area lies in quaternary catchment G22C and also hosts a number of schools and community facilities, mostly for low- and middle-income groups. Figure 14 and Figure 15 show an overview of the study area.

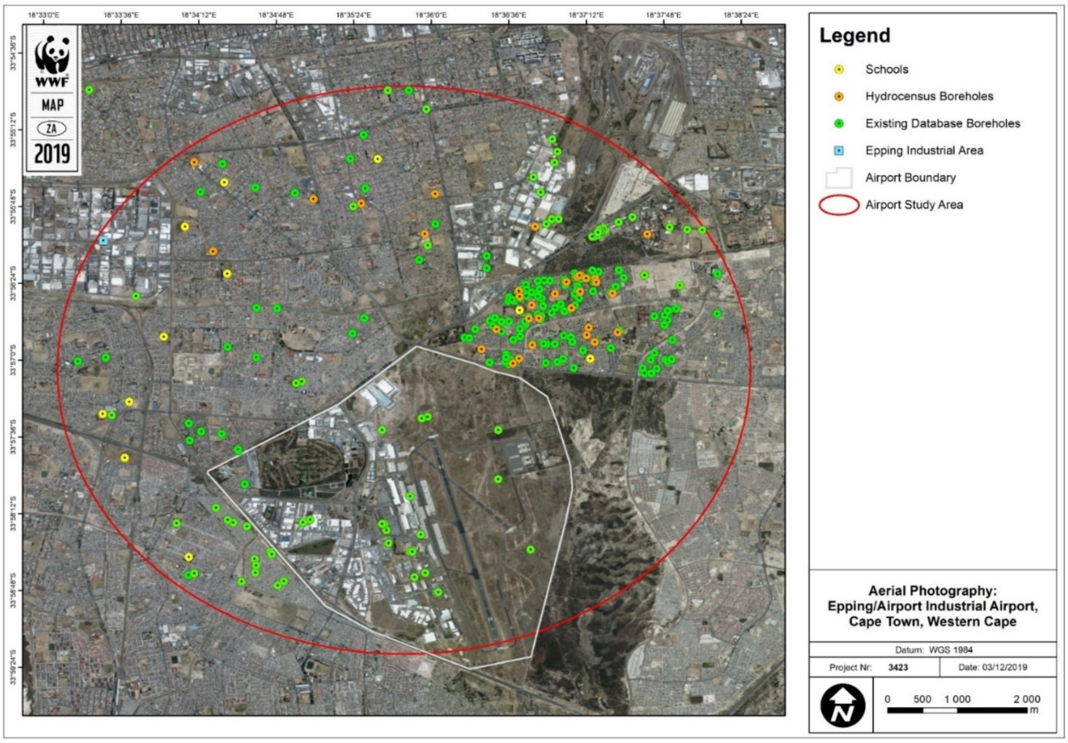


Figure 14: Google Earth aerial imagery of the study area, showing boreholes from the existing databases and hydrocensus boreholes

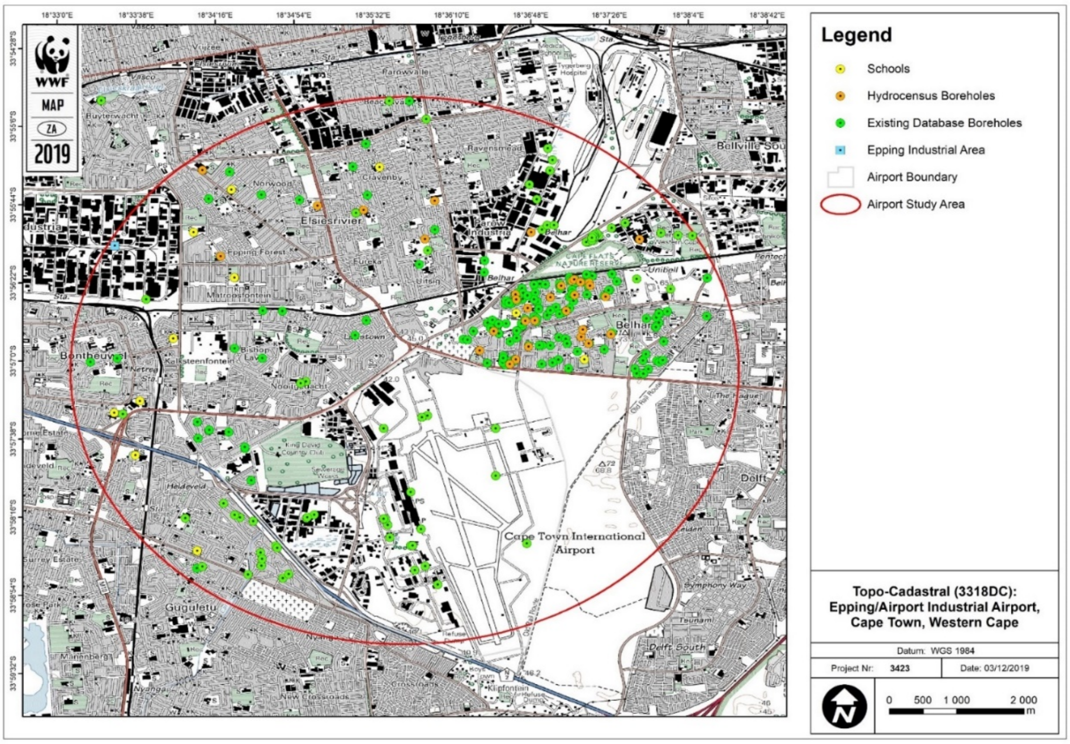


Figure 15: Topo-cadastral map (3318DC) of the study area, showing boreholes from the existing databases and hydrocensus boreholes

GEOLOGY

The Geological Survey of South Africa (now the Council for Geoscience) has mapped the area at 1:250 000 scale (3318, Cape Town). The main geology of the area is listed in Table 5 and the geological setting is shown in Figure 16.

Table 5: Geological formations within the study area

Code	Formation/Pluton	Group/Suite	Description
Qf	Quaternary Deposit		Ferricrete
Qw	Witsand Formation	Sandveld	White to light-grey calcareous sand
Qs	Springfontein Formation	Sandveld	Light-grey to pale-red quartzose sand and dune sand
Nt	Tygerberg Formation	Malmesbury Group	Quartzose greywacke and mudrock

The site is situated on Cenozoic deposits of the Springfontein (Qs) and Witsand (Qw) formations, which consist of fine to medium quartzose sands with thin lenses of calcareous clay. The formation is generally uniform in the area; however, grain size can often increase with depth (Roberts et al., 2006). The quaternary sedimentary deposits are usually composed of interbedded sands, clay, clayey sand, peats and some coarser quartz gravels. The quaternary sand deposits are saturated below the water table and from the Cape Flats Aquifer (Wright and Conrad, 1995).

The thickness of the sand is expected to be between 15 and 20 m. The average thickness of saturated sands in the area is estimated to be between 10 and 15 m. During recent drilling projects in the area, some boreholes displayed sand thicknesses from 6 m up to 40 m.

The quaternary deposits are underlain by the greywacke and mudrock (shale lithologies) of the Tygerberg Formation (Nt). The fractured greywacke of the Tygerberg Formation constitutes the lower fractured aquifer. There are no faults or other structures mapped in the area. The contact between the sand (Cape Flats Aquifer) and the Tygerberg Formation is a gradual one as the clay content increases with depth. A layer of clay typically separates the upper Cape Flats Aquifer from the lower fractured aquifer.

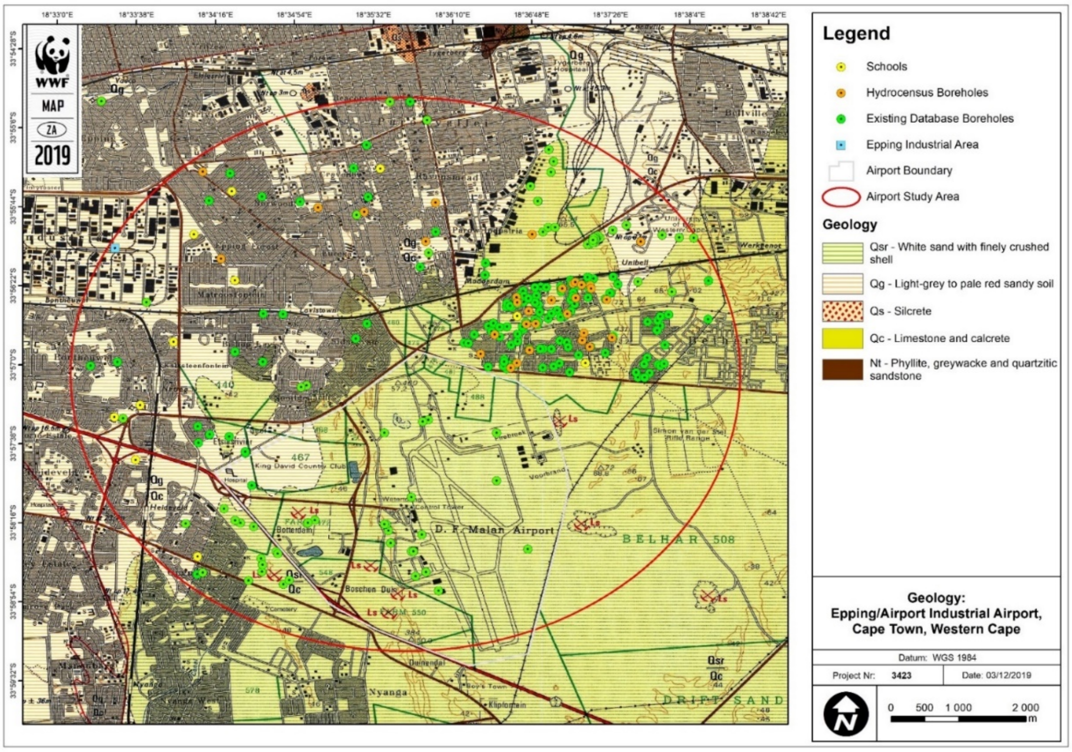


Figure 16: Geological setting of the study area, showing boreholes of the existing databases and hydrocensus boreholes and amenities in the context of the study area (3318, Cape Town)

Source: CGS, 1984

HYDROGEOLOGY

According to the 1:500 000 scale groundwater map of Cape Town (3318) the area hosts an intergranular aquifer which ranges between 0.5 L/s and 2 L/s (Figure 17) (Meyer, 2001). Yields increase slightly further south towards the coast and are probably associated with the alluvial deposits of the Sandveld Group. In terms of water quality, the area is classified as having electrical conductivity in the range of between 70 and 300 mS/m (Figure 18). This is considered marginal quality in terms of domestic use.

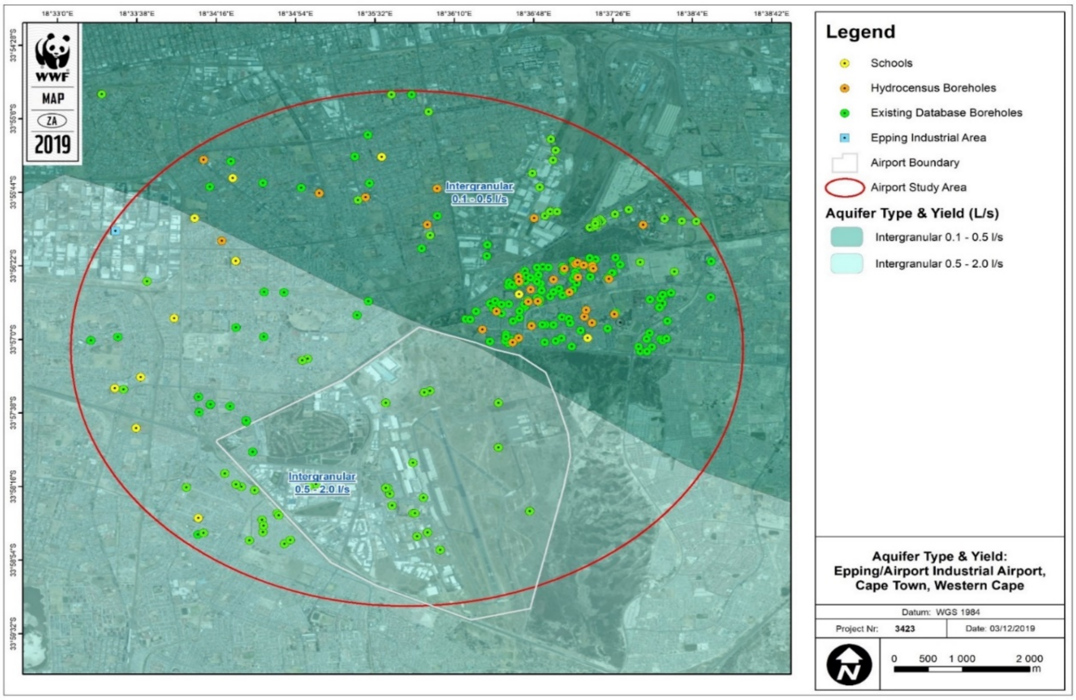


Figure 17: Regional aquifer yield from the 1:500 000 scale groundwater map (3318, Cape Town) showing hydrocensus boreholes and boreholes from existing databases

Source: DWAF, 2000

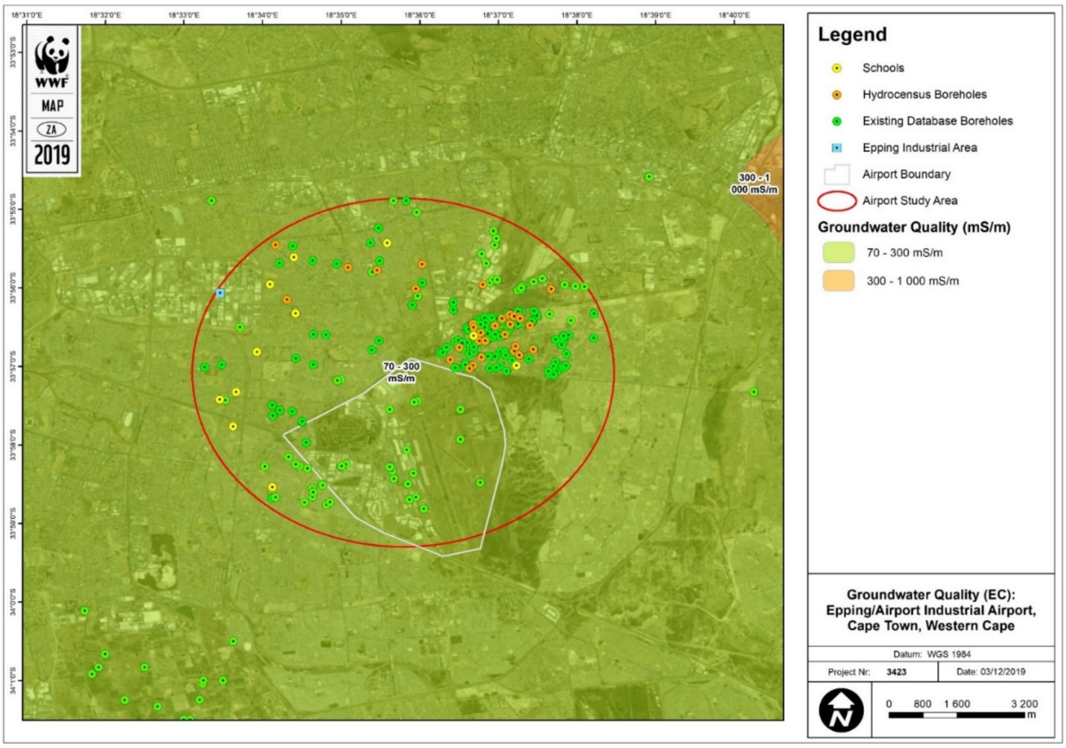


Figure 18: Regional groundwater quality (EC in mS/m), showing hydrocensus boreholes and boreholes from existing databases

Source: WRC, 2012

EXISTING GROUNDWATER USE IN EPPING INDUSTRIA

A desktop hydrological study was carried out in the study area to determine if there are any groundwater users in the area. This part of the study did not include any fieldwork but was completed by studying and inquiring from existing databases that contain groundwater information. A search of the National Groundwater Archive (NGA) was carried out to identify boreholes. These sites are typically verified in the field and provide background information on the area, should they exist. In addition to the NGA, the WARMS database was also consulted (last updated June 2016). This refers only to those water users who use water for commercial or industrial use and not for small-scale domestic use. Further to this, the boreholes registered with the City of Cape Town Metropolitan Municipality was considered along with GEOSS's own database of known boreholes in the area.

All the boreholes identified through the databases are collectively referred to as existing database boreholes.

GROUNDTRUTH DATA FOR THE AREA

A hydrocensus was conducted in the study area between 25 July and 1 August 2019. This involved visiting any identified boreholes and land owners/groundwater users in the area. Any information pertaining to the abstraction, yield and quality of groundwater was sought.

Despite the hydrocensus having taken place over a number of days, many property owners were not available during the time of the hydrocensus. Therefore, although borehole and well point signs may have been indicated outside the properties, information could not be obtained.

Public participation letters were left at all sites visited. A heavy police and military presence was felt due to widespread gang-related violence which escalated at the time of the hydrocensus. Fieldwork was therefore limited to certain areas, and to date no feedback on the letters has been obtained. All data obtained during the hydrocensus is presented in Table 6**.**

Table 6: Hydrocensus data obtained in the study area

Site	Type	Age	Depth (m)	Volume and use	Comment on concerns with groundwater use in the area
1	Borehole	2 yrs	–	Irrigation and domestic	Quality/volumes
2	Borehole	+10 yrs	–	Irrigation, daily (summer)	Quality
3	Borehole	+10 yrs	150	Domestic (toilet), irrigation (daily – summer)	No
4	Well point	+10 yrs	4–5	Irrigation/toilets – daily	Volume concerns
5	Borehole	+20 yrs	~50	Domestic, daily	No
6	Well point	15 yrs	~6	Irrigation, every second day	No
7	Well point	6 months	3	Irrigation, once a week	Yes, volumes

Site	Type	Age	Depth (m)	Volume and use	Comment on concerns with groundwater use in the area
8	Well point	15 yrs	~5	Ablution, irrigation, daily	Yes, not sufficient for our needs
9	Borehole	+20 yrs	–	Irrigation and domestic, daily	No
10	Borehole	+4 yrs	~10	Irrigation and domestic, summer (daily), 50 L	Quality
11	Borehole	2 yrs	5–6	Irrigation (daily) and domestic	No
12	Borehole	4 yrs	–	Irrigation	No
13	Borehole	+10 yrs	–	Domestic (daily) and irrigation	No
14	Borehole	+10 yrs	–	Irrigation – once a month (winter) / daily (summer)	No
15	Boreholes	~20 yrs (old one)	2x20, 30, 140, 108	Research/practical, once a month. 2 L/s for 4 hrs once a month	No
16	Boreholes	~2 yrs	4x40, 40 (Cams building)	Daily, production (H_2O supply). 12 L/s (all together); 0.5 L/s	No
17	Borehole	5 yrs	–	Daily, domestic and irrigation	–
18	None, but would like to know more	–	–	–	–
19	Well point	–	–	Irrigation, daily	Quality
20	Borehole	3–4 months	–	Irrigation, every second day	Quality (want to use it for more things)
21	Well point	+10 yrs	–	Irrigation, not currently in use	Quality
22	Well point	+20 years	5–6	Irrigation (season dependent) and domestic	Regulation
23	Borehole	+10 years	–	Daily (summer); domestic and irrigation. ~500 L	Quality

Site	Type	Age	Depth (m)	Volume and use	Comment on concerns with groundwater use in the area
24	Borehole	~10 years	–	Daily; domestic and irrigation	No
25	Borehole	1 year	–	Daily; irrigation, domestic and industry	No
26	Borehole	+5 years	–	Summer – weekly; irrigation	Quality
27	Borehole	+10 years	–	Not working; used to be 3 times/week for irrigation	No
28	Well point	~1 year	–	Daily; domestic	Quality
29	Borehole	±5 years	4 m	Irrigation and domestic (as needed)	No
30	Borehole	4 years	–	Daily; domestic and irrigation	Quality
31	Borehole	+25 years	–	Summer: often (daily) – irrigation	No
32	Well point	~15 years	+6 feet	Daily; irrigation	No
33	Well point	±50 years	–	Domestic	Yes
34	Well point	10 years	15 m	Daily; domestic and irrigation	No
35	Well point	5 years	3.5 m	±10 hrs/week	No

KEY STAKEHOLDERS

Key stakeholders within and around the study area were contacted telephonically and via email and invited to attend the public meeting held on 10 March 2020 at the University of the Western Cape, Parow. Most stakeholders contacted were from the surrounding industries. Few RSVPs were received. WWF and GEOSS gave presentations on the various aspects of groundwater and the importance of monitoring. Stakeholders who were present appeared to be amenable to monitoring and asked many relevant questions.


DRILLING
PROVINCE

PROPOSED MONITORING NETWORK

Groundwater monitoring networks were designed based on the background and field data collected during the study. The site selection was based on the availability of monitoring points, the willingness of home owners and businesses to participate in the study, and safe access to the sites.

MONITORING NETWORK FOR NEWLANDS

To date, a total of six Solinst Leveloggers have been deployed in the Newlands residential area (Figure 19). All six loggers were installed in boreholes between November and December 2019 (Table 7).

The data from the loggers was downloaded on 27 November 2019, with the exception of 3423-WWF-Mon_BH6, which had not been installed at that point. The data downloaded can be seen plotted in mamsl in Figure 20.

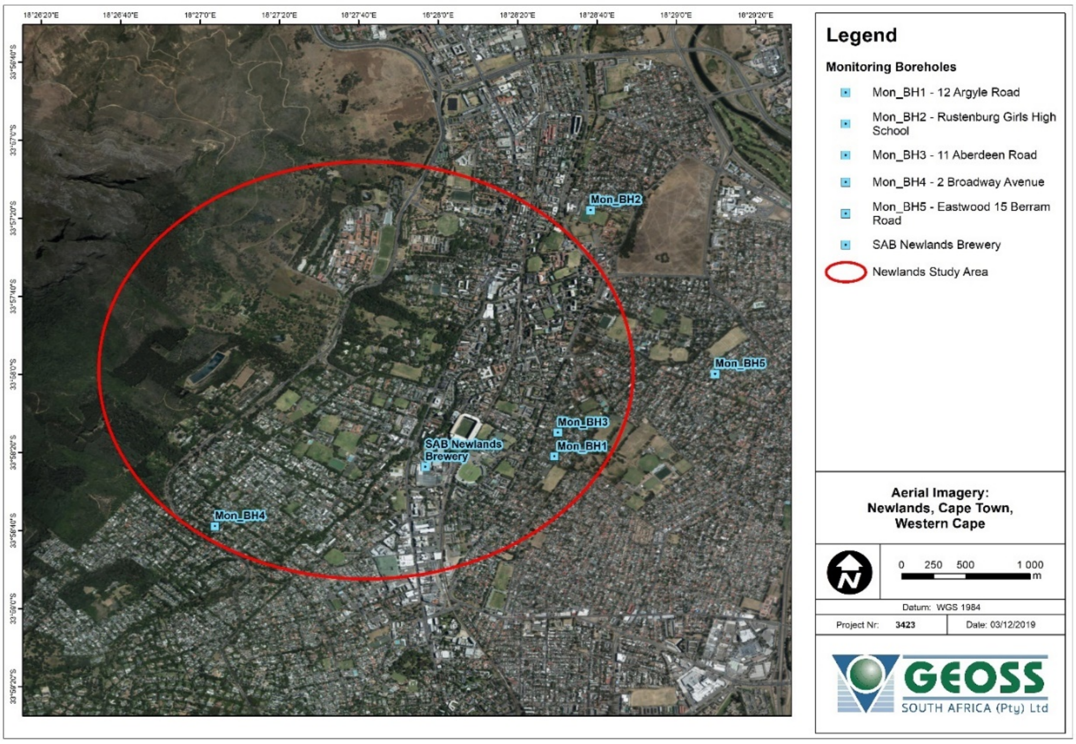


Figure 19: Monitoring borehole distribution in Newlands area

Table 7: Monitoring borehole distributions for the Newlands study area

Monitoring site name	Logger SN	Comments	Photograph
3423-WWF-Mon_BH1	62105832	Logger installed, WL = 8.9 mbgl	
3423-WWF-Mon_BH2	62107747	Barologger installed, WL = 8.35 mbgl	
3423-WWF-Mon_BH3	62107787	Logger installed, WL = 12.13 mbgl	
3423-WWF-Mon_BH4	62107767	Logger installed, WL = 4.32 mbgl	
3423-WWF-Mon_BH5	62107755	Logger installed, WL = 8.35 mbgl	
3423-WWF-Mon_BH6	62113019	Logger was lowered without the knowledge of oversized pump; logger is stuck in borehole	No photo available

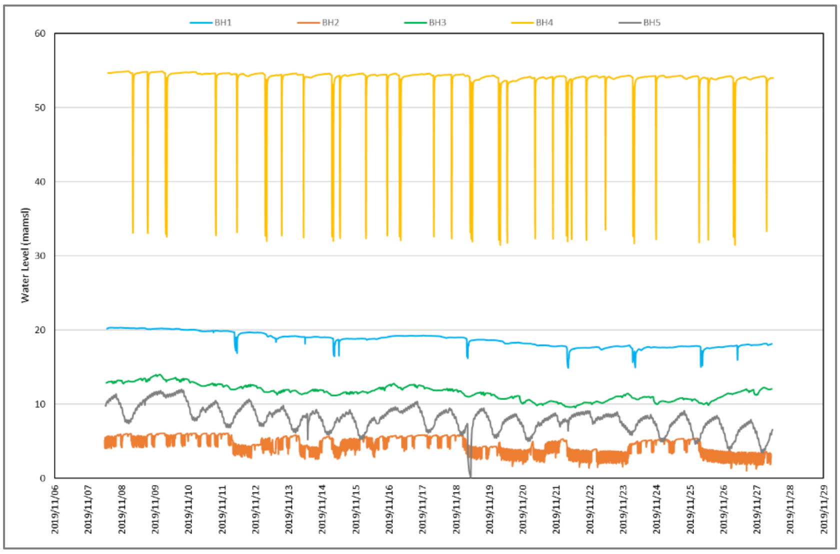


Figure 20: Newlands residential area water monitoring data from November 2019 from five of the six project monitoring boreholes

MONITORING NETWORK FOR EPPING AND AIRPORT INDUSTRIA AREA

To date, a total of six Solinst Leveloggers have been deployed in the Epping industrial area (Figure 21). All six loggers were installed into boreholes between February to March 2020 (with the exception of BH12, installed some years ago) (Table 8).

The Cape Town International Airport was contacted and two dataloggers were installed; one inside the airport and one on the periphery. An existing datalogger was located inside the airport precinct, which was intended as a water level monitoring point. This datalogger will be downloaded once the COVID lockdown has eased within the precinct.

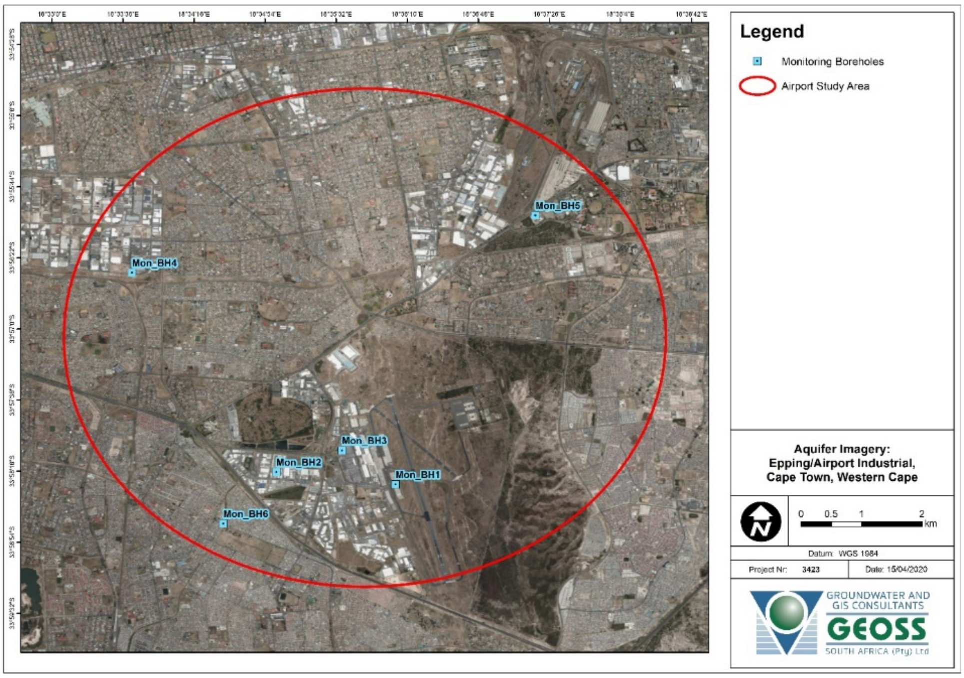
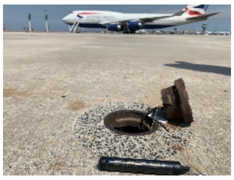


Figure 21: Monitoring borehole distribution in the Airport Industria area

Table 8: Monitoring borehole distributions for Airport study area

Monitoring site name	Logger SN	Comments	Photograph
3423-WWF-Mon_BH7	622112992	Aircraft parking bay well point	
3423-WWF-Mon_BH8	62116265	Sewer station monitoring point	
3423-WWF-Mon_BH9	62114034	All good in order	
3423-WWF-Mon_BH10	62065829	All good in order	
3423-WWF-Mon_BH11	62116271	Open monitoring hole	
3423-WWF-Mon_BH12	62076136	Old historical water level collecting WL trends	

ASSUMPTIONS AND LIMITATIONS

During this study, certain conditions limited the accuracy of the data acquired and the outcome of this report.

- All registered abstraction points (that could be obtained from the WARMS June 2016 data) were taken into account when completing the desktop search. This database is updated continuously; however, access to the latest data is limited and not easy. Thus, this study did not take into account any WARMS sites added after June 2016. DWS does not make the WARMS data readily available, much less updates of the data. GEOSS requested data for the Berg River Water Management Area but did not receive a response from DWS.

- The coordinates of the National Groundwater Archive boreholes were sometimes found to be inaccurate. Hence, it was difficult to incorporate the NGA data accurately into the field hydrocensus.

- Many residents or property owners were not home or at their premises during the hydrocensus. Therefore, only information obtained from residents who were available could be incorporated into the study.

- The information obtained from residents and property owners relating to groundwater use could not be verified as this was considered as reported by the water users.

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ABBREVIATIONS AND ACRONYMS

BH	Borehole
CFA	Cape Flats Aquifer
CGS	Council for Geoscience (Est. 1993; formerly the Geological Survey of South Africa)
CoCT	City of Cape Town Metropolitan Municipality
DD	Decimal degrees
DWA	Department of Water Affairs (pre-1994)
DWAF	Department of Water Affairs and Forestry (Est. 1994 up until May 2009)
DWS	Department of Water and Sanitation (Est. May 2009 until May 2019; then made part of the Ministry of Human Settlements, Water and Sanitation (Est. May 2019)
EC	electrical conductivity
GA	general authorisation
GIS	Geographic Information System
h/day	hours per day
ha	hectare
km	kilometre
km^2	square kilometre
L/h	litres per hour
L/s	litres per second
$L/s/km^2$	litres per second per square kilometre
m	metre
m^2	square metre
m^3/a	metres cubed per annum
m^3/day	metres cubed per day
$m^3/ha/a$	metres cubed per hectare per annum
$m^3/month$	metres cubed per month
mamsl	metres above mean sea level
MAP	mean annual precipitation
max	maximum
mbgl	metre below ground level
mg/L	milligram per litre
min	minimum
mm	millimetre
mm/a	millimetre per annum
Mm^3/a	million cubic metres per annum
mS/m	milliSiemens per meter
NGA	National Groundwater Archive
PVC	polyvinyl chloride
SANAS	South African National Accreditation System
SANS	South African National Standard
SWSA	Surface Water Source Area
TM-SWSA	Table Mountain – Surface Water Source Area
WARMS	Water Authorisation and Registration Management System
WGS84	Since 1 January 1999, the official coordinate system for South Africa
WL	water level
WRC	Water Research Commission
WULA	Water Use Licence Application

GLOSSARY

Aquifer: a geological formation, which has structures or textures that hold water or permit appreciable water movement through them (from the National Water Act 36 of 1998)

Borehole: includes a well, excavation, or any other artificially constructed or improved groundwater cavity which can be used for the purpose of intercepting, collecting or storing water from an aquifer; observing or collecting data and information on water in an aquifer; or recharging an aquifer (from the National Water Act 36 of 1998)

Drawdown: the distance between the static water level and the surface of the cone of depression (DWS, 2011)

Fractured aquifer: fissured and fractured bedrock resulting from decompression and/or tectonic action; groundwater occurs predominantly within fissures and fractures

Groundtruthing: a term used to refer to information obtained from direct observation (i.e. empirical evidence)

Groundwater: water found in the subsurface in the saturated zone below the water table or piezometric surface, i.e. the water table marks the upper surface of groundwater systems

Quaternary catchment: a fourth-order catchment in a hierarchal classification system in which a primary catchment is the major unit (DWS, 2011)

To champion the earth's capacity to provide a source of inspiration, sustainable food, water and clean energy for all.

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