High Confidence Groundwater Reserve Determination Study in the Berg Catchment

WP1139
Gap Analysis Report

Report Number: RDM/WMA19/02/CON/COMP/0222

June 2022

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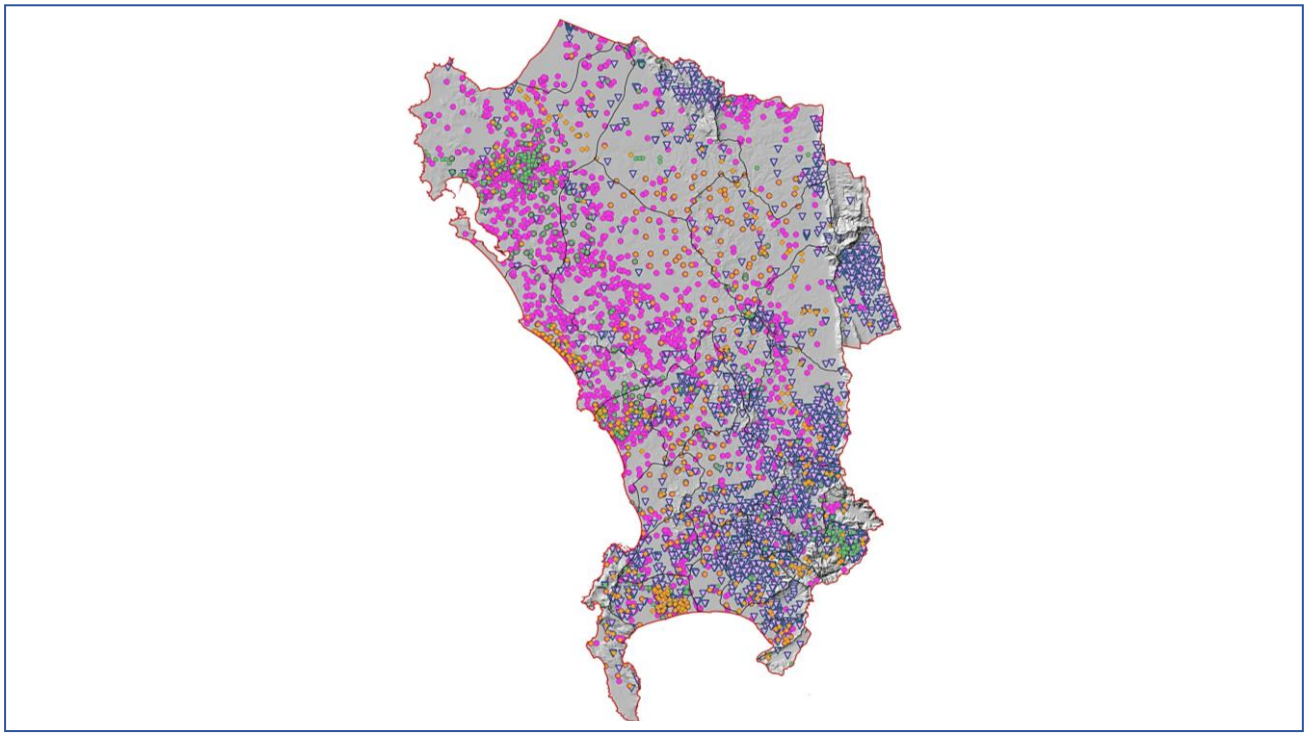

Report Number: RDM/WMA19/02/CON/COMP/0222

Version 1 – Final Draft

Prepared for:

Department of Water and Sanitation

Chief Directorate: Water Ecosystems Management

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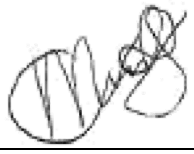

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Report Index

Index	DWS Report Number	Deliverable Title
1	RDM/WMA19/02/CON/COMP/0122	Inception Report and Capacity Building Programme
2.1	**RDM/WMA19/02/CON/COMP/0222**	**Gap Analysis Report**
2.2	RDM/WMA19/02/CON/COMP/0322	Inventory of Water Resource Models
3.1	RDM/WMA19/02/CON/COMP/0322	Delineation of Water Resource Units Report
3.2	RDM/WMA19/02/CON/COMP/0422	Ecological Reference Conditions Report
3.3	RDM/WMA19/02/CON/COMP/0123	BHN and EWR Requirement Report
3.4	RDM/WMA19/02/CON/COMP/0223	Operational Scenarios & socio-economic and ecological consequences Report
3.5	RDM/WMA19/02/CON/COMP/0323	Stakeholder engagement of operation scenarios Report
3.6	RDM/WMA19/02/CON/COMP/0423	Monitoring Programme Report
3.7	RDM/WMA19/02/CON/COMP/0124	Groundwater Reserve Determination Report
3.8	RDM/WMA19/02/CON/COMP/0224	Database of all information and data (including spatial)
3.9	RDM/WMA19/02/CON/COMP/0324	Gazette Template

Executive Summary

The Department of Water and Sanitation (DWS) Chief Directorate: Water Ecosystems Management has initiated a "High Confidence Groundwater Reserve Determination Study for the Berg Catchment" in support of the gazetted Water Resource Classes and Resource Quality Objectives (RQO) for the Berg catchment. Due to the increasing number of groundwater water use licence applications (WULAs), the associated impacts that the proposed developments might have on the availability or quality of water, the conservation status of various resources within the Berg catchment, and the complexity of geological and hydrogeological characteristics make it increasingly impossible to assess applications using a low confidence desktop groundwater Reserve. The Reserve will assist the DWS in making sound management decisions regarding stressed or over-utilised catchments, and ensuring that water resources are afforded a level of protection that will assure a sustainable level of utilisation in the future.

The aim of this report is to review all available and relevant datasets as well as any literature (including any sensitive information and data) to accurately assess the data integrity, reliability and representativity for a high confidence Reserve determination. The results of the Gap Analysis Report will contribute to Step 1 of the eight-step GRDM: Reserve (outlined by WRC (2013).

REVIEW OF DATA AND INFORMATION

Surface Water

The scope of this project does not require a re-evaluation of the surface water resource units. The surface water data review and understanding were undertaken in the "Determination of Water Resource Classes and Resource Quality Objectives in the Berg catchment" study (DWS, 2016), which informed the gazetted Water Resource Classes and Resource Quality Objectives (RQO) for the Berg catchment (DWS, 2019). The outcomes will be contextualised from a groundwater perspective and will used as inputs into the groundwater Reserve determination. Data from DWS: Resource Quality Information Services (RQIS), hosting surface water quality results for rivers, dams, and lakes; will be incorporated into an updated understanding of the surface-groundwater interactions in the project.

Groundwater

National groundwater datasets, available via DWS request, include groundwater levels, groundwater quality, localised borehole information, test pumping and water use records. In addition to monitoring data from DWS databases (NGA, WMS, WARMS and Hydstra); groundwater level and quality monitoring carried out by the City of Cape Town at various sites across the Cape Flats Aquifer, the Atlantis aquifer and TMGA; as well as by the West Coast District Municipality for Langebaan Road wellfield, has been sourced to support the Reserve determination. The Berg Water Availability Assessment Study (WAAS) project forms the basis for most of the groundwater understanding in the DWS (2016) study, in terms of aquifer types, aquifer delineation, aquifer characteristics, conceptual understanding and regional groundwater flow, recharge, and water quality.

INFORMATION GAPS

Surface Water

Surface hydrology models and data were comprehensively assessed in the DWS (2016) study, and no data gaps for the surface water assessment were identified, except the need for collecting additional data for the biophysical nodes. However, there are some gaps regarding the selection of EWR sites with respect to establishing the groundwater contribution. EWR sites and nodes were established based on surface water considerations, therefore, from a groundwater perspective some additional nodes may be identified.

It appears that the spatial extent of wetlands, especially in the high mountains on the eastern boundary of the Berg catchment, as well as the groundwater dependency of these wetlands have not been mapped sufficiently. This would need to be addressed in this study.

It is noted that there are *significant* digital and spatial datasets that were developed as part of the DWS (2016) study. As the initial study forms the foundation, especially for the ecological and surface water components, to this study, it is requested that the digital and GIS database be provided to the PSP.

Groundwater

The DWS groundwater databases and City of Cape Town's New Water Programme provide a wealth of point data sources. Various limitations and corrections of the DWS groundwater datasets are required, in terms of point data supplementation, spatial distribution, site co-ordinate verification, spatial distribution of timeseries data and limitations with associated metadata. All groundwater datasets will be updated based on the most current results and incorporated for an updated project understanding.

Additionally, the recently updated 1:50 000 scale geological maps from the Council for Geoscience (CGS) in shapefile format will be a key data input required for the delineation of GRUs. The 250 000 geological maps are at a coarser scale and less representative than the more refined 1:50 000 maps which reproduce the mapping of the area more accurately.

Table of Contents

List of Tables

List of Figures

List of Abbreviations

%	-	percentage
~	-	approximately
BGCMA	-	Breede-Gouritz Catchment Management Agency
BHN	-	Basic Human Needs
BRBS	-	Breede River Basin Study
CBA	-	Critical Biodiversity Area
CD:WEM	-	Chief Directorate: Water Ecosystems Management
CFA	-	Cape Flats Aquifer
CGS	-	Council for Geoscience
CMB	-	Chloride mass balance
CoCT	-	City of Cape Town
CRD	-	Cumulative rainfall departure
DWA	-	Department of Water
DWAF	-	Department of Water Affairs and Forestry
DWS	-	Department of Water and Sanitation
D:RD	-	Directorate: Reserve Determination
EI	-	Ecological Importance
e.g.	-	For example
EGSA	-	Ecosystems goods, services and attributes
ES	-	Ecological Sensitivity
ESA	-	Ecological Support Areas
et al.	-	and others
etc.	-	etcetera
EWR	-	Ecological water requirements
GIS	-	Geographic Information System
GRDM	-	Groundwater Resource Directed Measure
H	-	High
HGM	-	Hydrogeomorphic unit
ISP	-	Internal Strategic Perspective
GRAII	-	Groundwater Resource Assessment
GRU	-	Groundwater Resource Unit
i.e.	-	That is
IUA	-	Integrated unit of analysis
m	-	metre
M	-	Moderate
MAP	-	Mean annual precipitation
MSI	-	Moisture Stress Index
NFEPA	-	National Freshwater Ecosystems Priority Areas
NGA	-	National Groundwater Archive
NGwQMP	-	National Groundwater Quality Monitoring Programme
NWA	-	National Water Act
NWP	-	New Water Programme
PES	-	Present Ecological State
PS	-	Present Status
PSP	-	Professional Service Provider
RDM	-	Resource Directed Measure
REC	-	Recommended Ecological Category
RU	-	Resource unit
RQIS	-	Resource Quality Information Services
RQO	-	Resource Quality Objective
SA	-	South African

SANBI	-	South African National Biodiversity Institute
SAWS	-	South African Weather Service
SVF	-	Saturated Volume Fluctuation
TEC	-	Target Ecological Category
TMG	-	Table Mountain Group
TMGA	-	Table Mountain Group Aquifer
U	-	Undefined
VH	-	Very High
WAAS	-	Water Availability Assessment Study
WARMS	-	Water Use Allocation and Registration Management System
WCWSS	-	Western Cape Water Supply System
WGS	-	World Geodetic System
WMS	-	Water Management System
WR	-	Water Resources of South Africa Study
WRC	-	Water Research Commission
WULA	-	Water Use License Application

1. INTRODUCTION

1.1. Background to the study

The Department of Water and Sanitation (DWS) Chief Directorate: Water Ecosystems Management (CD: WEM) has initiated a "High Confidence Groundwater Reserve Determination Study for the Berg Catchment". The project will support the gazetted Water Resource Classes and Resource Quality Objectives (RQO) for the Berg catchment (Gazette No.42451:121 of 10 May 2019; hereafter referred to as DWS, 2019: 121). Due to the increasing number of groundwater water use licence applications (WULAs), the associated impacts that the proposed developments might have on the availability or quality of water, the conservation status of various resources within the Berg catchment, and the complexity of the study site's geological and hydrogeological characteristics make it increasingly impossible to assess applications using a low confidence desktop groundwater Reserve.

Figure 1-1 outlines the Integrated Unit of Analysis (IUAs) and associated Water Resource Classes that have been delineated for the Berg catchment (DWS, 2019: 121) as outcomes from the "Determination of Water Resource Classifications and Resource Quality Objectives in the Berg Catchment" study completed by Aurecon (Pty) Ltd from 15 April 2016 to 15 October 2018 (hereafter referred to as DWS, 2016). The Gazette (DWS, 2019: 121) included both recommendations for Water Classes for IUAs (in terms of Section 13(4)(a)(i)(aa) of the NWA, 1998) and RQOs for Resource Units (RUs) (in terms of Section 13(4)(a)(i)(bb) of the NWA, 1998) for water resources within the catchment. This study/gazette outlined:

- IUAs classified into water resource classes and catchment configurations. Water resource classes are classified into Class I (high environmental protection and minimal utilisation), Class II (moderate protection and moderate utilisation), or Class III (sustainable minimal protection and high utilisation).
- RQOs are defined for prioritised surface water RUs for each IUA in terms of water quantity, habitat and biota, and water quality. RQOs were established for (RUs & biophysical nodes are observed in **Figure 1-1** and **Figure 1-2**):
    - Ecological Water Requirements (EWR) sites
    - Rivers
    - Estuaries
    - Dams
    - Wetlands
- In addition to this, the study also delineated priority groundwater Resource Units (GRUs) and defined RQOs for these (see **Figure 1-1, Figure 1-2** and **Section 2.2.2**).

This study will need to determine the required groundwater contribution, in terms of quantity and quality, to satisfy the Basic Human Needs (BHN) Reserve and EWR for the Berg catchment. It is understood from the Inception Report (DWS, 2022a), the outcomes from the DWS (2016) study will provide the framework for the socio-economic, surface water (rivers, dams, estuaries, and wetlands) and ecological understandings for this project.

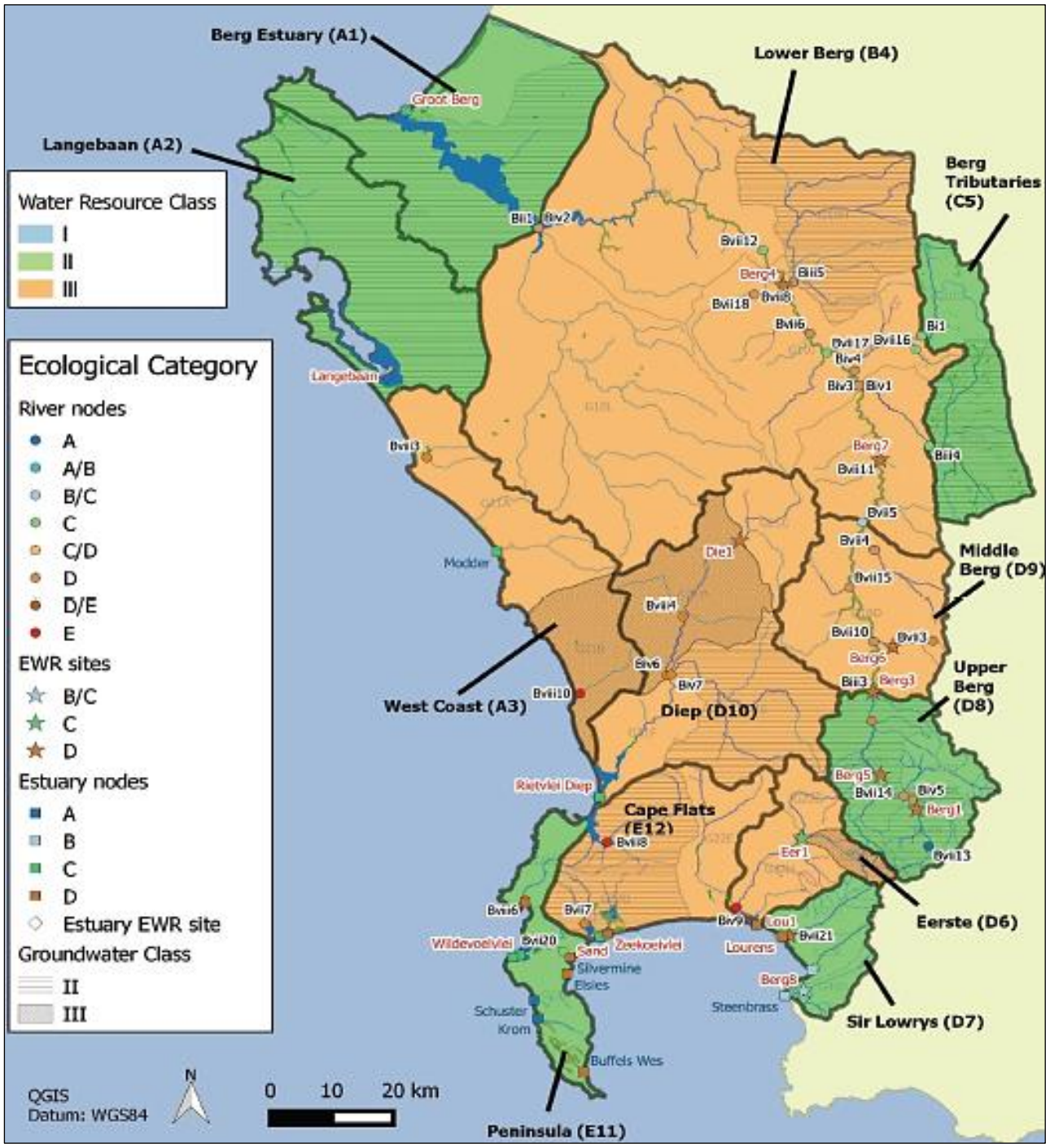

Figure 1-1 **Proposed Water Resource Classes including 12 IUAs, ecological category of each biophysical and allocation node, and groundwater class for each GRU identified (DWS, 2019: 121).**

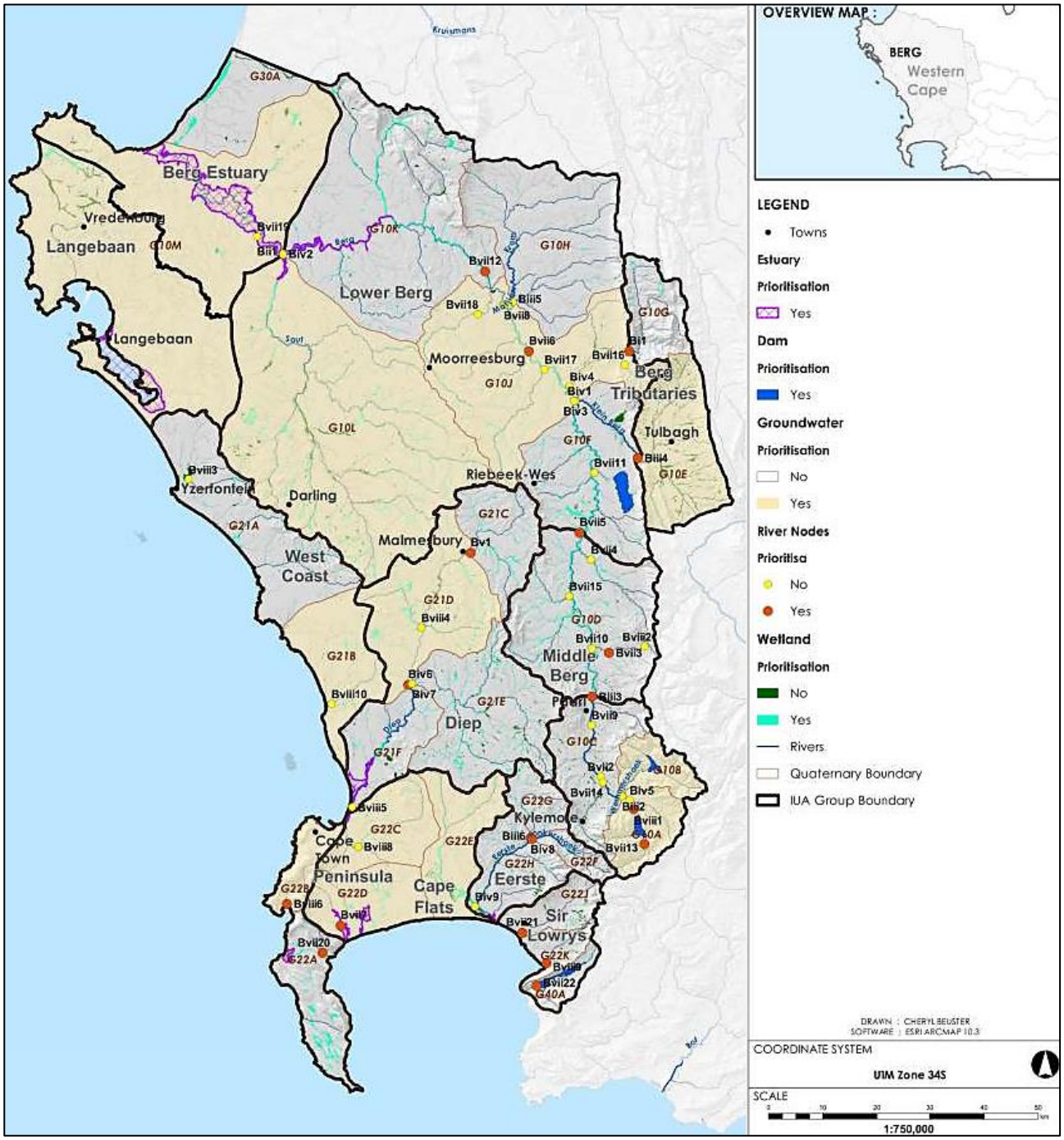

Figure 1-2 **Summary of prioritised RUs for the Berg catchment including 20 river nodes, 7 estuaries, 6 dams, 24 wetlands, and 11 GRUs (DWS, 2019: 121).**

1.2. Terms of reference

The Terms of Reference for the study, as provided by the DWS CD:WEM, stipulates the aim and objectives as follows:

> *"The primary objective of this study is to determine a high confidence groundwater Reserve requirements (quantity and quality) to satisfy the basic human needs and to protect aquatic ecosystems in different priority water resources within the Berg catchment"*

> *"Detailed determinations aim to produce high-confidence results, are based on site-specific data collected by specialists and are used for all compulsory licensing exercises, as well as for the individual licence applications that could have a large impact on any catchment, or a relatively small impact on ecologically important and sensitive catchments"*

The groundwater Reserve determination aims to support the gazetted Water Resource Classes and associated RQOs (DWS, 2019: 121) in completing the Groundwater Resource Directed Measures (GRDM) process as defined by Regulation 2(4) of the NWA (No. 36 of 1998; referred to as Regulation 2(4) hereafter). The Reserve will assist the DWS in making sound management decisions regarding stressed or over-utilised catchments, and also ensuring that water resources are afforded a level of protection that will assure a sustainable level of utilisation in the future.

The Terms of Reference indicate that the Reserve Determination process must follow the eight-step process outlined in the RDM manuals, namely the "Groundwater Resource Directed Measures" outlined by the Water Resource Commission (WRC, 2013). Additional GRDM manuals will also be consulted, such as the WRC (2007) "Groundwater Resource Directed Measures Manual" and the preliminary recommendations from an ongoing review of GRDMs by the WRC (if preliminary findings can be provided for this study) to ensure that groundwater Resource Units are adequately considered.

1.3. Aims of this report

The aim of this report is to review and analyse all available and relevant datasets as well as any literature (including any sensitive information and data) pertaining to the project area in the form of a desktop assessment. **The Gap Analysis Report is Deliverable 2.1** of Phase 2 of this study: Review of Water Resource Information and Data. A detailed overview of the study approach and the scope of work is outlined in the Inception report (DWS, 2022a) and summarised in **Table 1-1**.

To accurately assess the integrity, reliability and representativity of the data/information and all the available water resource models for a high confidence determination, all datasets were collated and standardised for a data quality assessment. Both the Gap Analysis Report and the Inventory of Water Resource Models Report (DWS, 2022b) include recommendations on how to overcome any data gaps or missing information required in Phase 3. Both reports contribute to Step 1 of the eight-step GRDM procedure (see **Section 2.1**) for determining the groundwater Reserve as outlined by WRC (2013).

All relevant geological and hydrogeological information, including relevant water resource models, will be collated and saved in a GIS dataset for future client use (input to **Deliverable 3.8 – Database**). The data will be evaluated for correctness, and data from different reporting institutions and companies will be collated for completeness and ease of use.

Table 1-1 Summary of project phases, tasks and associated deliverables. Reserve determination steps according to WRC (2013).

Phase 1	**Project Inception**		
Task 1	Inception		Deliverable 1: Inception Report
Phase 2	**Review of Water Resource Information and Data**		
Task 2.1	**Data collection and collation**		**Deliverable 2.1: Gap Analysis Report** Deliverable 2.2: Inventory of Water Resource Models
Phase 3	**Reserve Determination**		
Task 3.1	Step 1	Initiate Groundwater Reserve Study	Recorded in Deliverable 2.1 and Deliverable 2.2
Task 3.2	Step 2	Water RU Delineation	Deliverable 3.1: Delineation of Water RUs
Task 3.3	Step 3	Ecological Status and Reference Conditions per RU	Deliverable 3.2: Ecological Reference Conditions
Task 3.4	Step 4	Determine BHN and EWR	Deliverable 3.3: BHN and EWR Requirement Report
Task 3.5	Step 5	Operational Scenarios & Socio-economic	Deliverable 3.4: Operational Scenarios & socio-economic and ecological consequences
Task 3.6	Step 6	Evaluate scenarios with Stakeholders	Deliverable 3.5: Stakeholder engagement of operation scenarios
Task 3.7	Step 7	Monitoring Programme	Deliverables 3.6: Monitoring Programme Report
Task 3.8	Step 8	Gazette & implement Reserve	Deliverable 3.7: Groundwater Reserve Determination Report Deliverable 3.8: Database Deliverable 3.9: Gazette Template

1.4. Report outline and structure

The Gap Analysis Report consists of the collection, collation and review of the existing data and reports from DWS (2019: 121), DWS groundwater databases and additional studies/reports available for the study area (see **Section 2**). These datasets are framed in context of their applications and use for this study's scope, a **high confidence groundwater reserve determination**. Recommendations on how to overcome identified gaps are detailed according to the steps outlined in WRC (2013) (**Section 4**).

2. REVIEW OF AVAILABLE WATER RESOURCE INFORMATION

2.1. Necessary information to support groundwater Reserve determination

To adequately assess the groundwater Reserve for the Berg catchment it is necessary to understand the current status of the groundwater (and surface water) resources. As explained above, this study will utilise the eight-step process for determining the groundwater Reserve as outlined in GRDM (WRC, 2013) and the associated data requirements for each step is detailed in **Table 2-1**. This high confidence study aims to compliment the gazetted Water Classes and RQOs (DWS, 2019: 121), and therefore the gap analysis will be a continuation and supplementation to the informing study (DWS, 2016) of the gazette (DWS, 2019: 121), and the resultant compilation of reports (DWS, 2016a-e, 2017a-d, 2018a-e, 2019). As DWS (2016c) outlines, there has been a considerable amount of previous work undertaken in the Berg catchment which will support this study. As the study progresses, if additional data or information sources are found to be useful, they will be incorporated.

Table 2-1 Summary of data requirements for the eight-step procedure for determining the groundwater Reserve as outlined Groundwater Resource Directed Measures manual (WRC, 2013).

Step	Main objectives	Data / Information categories required

Step 1:
Initiate the BHN and EWR assessment
	• Identify and assess the scope and nature of the project.
	• Collect, collate, and review all available literature, data, information, and water resource models from existing and parallel studies.
	• Evaluate the collated data and water resource models to:
	  ○ Identify any data / information gaps
	  ○ Determine the integrity, reliability and representativity for a high confidence determination
	• Develop GIS dataset.
		• Background information of the Berg catchment.
		• List of stakeholders.
		• All available water resource models.
		• Classification of water resources within the Berg catchment, including IUAs and TECs to be achieved and maintained.
		• RQO's for the Berg catchment, associated EWRs, and surface water and groundwater quality determinations.
		• Collection and collation of all data listed in subsequent steps.

Step 2: **Delineate resource units, and select study sites**	• Produce detailed maps that delineate aquifer specific GRUs. • General review of the current status of the water resource to inform delineation. • Review of surface water EWR sites from a groundwater perspective to confirm or update the present status and delineate new nodes (if required).	• Geology to inform aquifer type, spatial extent and boundaries. • Aquifer information (hydraulic parameters, classification, vulnerability, susceptibility and stress status). • Groundwater levels. • Flow data (quaternary-scale naturalized monthly and daily flow data). • Land use (National land cover, point and diffuse contamination sources). • Ecology (aquatic ecosystem data, ecoregions, vegetation bioregion, and protected areas).

Step	Main objectives	Data / Information categories required
Step 3: **Determine the reference conditions, present ecological status and the ecological importance and sensitivity of each of the selected study sites.**	• Determine reference conditions for delineated GRUs: ○ PS (present status) for water quality and volume (aquifer stress: recharge and use) • Estimate recharge. • Determine the allocated groundwater component. • Assess groundwater quality per GRU. • Estimate discharge – first order estimate of groundwater contribution to baseflow. • Determine the current status of the water resource in terms of the water resource system, ecological characteristics, socio-economic conditions and community well-being.	• Groundwater abstraction and allocation data (spatial and temporal; as inputs to saturated volume fluctuation [SVF] and cumulative rainfall departure [CRD] methods for recharge estimation). • Available water infrastructure data (infrastructure network for groundwater, and supply to outside of catchment) • Ecological conditions and reference status from surface water Classes and RQO study (DWS, 2016). • Classification of rivers (input from surface water study; DWS, 2016). • Water quality [Chloride concentrations of precipitation and groundwater (as inputs to chloride mass balance [CMB] method for recharge estimation) and quality for stress indicators]. • Monthly rainfall (Mean Annual Precipitation [MAP]) data (for CRD method). • Monthly and seasonal groundwater level data (for SVF and CRD methods). • Inflow, outflow and abstraction data (as inputs to the SVF method for recharge estimation). • Specific yield data (for SVF method).
Step 4: **Determine BHN and EWR for each of the selected study sites.**	• Determine groundwater dependent population and the associated BHN for all GRUs. • Determine the EWR component dependent on groundwater discharge for all GRUs (groundwater dependent ecosystems). • Determine groundwater interaction with rivers (baseflow). • Determine the allocable groundwater volume. • Determine groundwater quality in comparison to EWR requirements.	• Groundwater significance (allocation, use, and supply). • Aquifer vulnerability and susceptibility. • Surface and groundwater quality. • Augmentation and reconciliation strategies. • Current and planned groundwater allocation data. • River hydrograph data (flow data). • Seasonal surface water and groundwater use, and soil tracer data (isotopes). • Daily precipitation data. • Socio-economic data (economic sectors, socio-economic zones, population statistics, spatial distribution, gross geographical product, and other census data). • All RQO for EWR sites (DWS, 2019: 121). • Existing Water Resource Models. • Groundwater dependent ecosystem inputs (National maps, remote sensing data, Critical Biodiversity Area [CBA] and Ecological Support Areas [ESAs] extents).

Step	Main objectives	Data / Information categories required
Step 5: **Determine operational scenarios and its socio-economic and ecological consequences**	• Determine operational scenarios and its socio-economical & ecological impacts. • Updating scenario impacts based on a reassessment of current and future water use operations on the aquifer, groundwater component of BHN/EWRs and water quality.	• Existing monitoring networks and operational procedures. • Planned groundwater allocation and abstraction data. • Augmentation and reconciliation strategies. • Existing Water Resource Models. • Stakeholder database. • Point and diffuse contamination sources.
Step 6: **Evaluate scenarios with stakeholders**	• Evaluate operational scenarios and consequences, as well as the groundwater component of BHN/EWR (using the Water Resource Classification as a guide) with relevant stakeholders.	• Existing monitoring networks and operational procedures. • Planned groundwater allocation and abstraction data. • Augmentation and reconciliation strategies. • Existing Water Resource Models. • Stakeholder database.
Step 7: **Design an appropriate monitoring programme**	• Update existing monitoring programmes or design new monitoring programmes for GRUs if required. • Outline additional cost associated with updates to monitoring programme if applicable).	• Existing monitoring networks and operational procedures.
Step 8: **Gazette and implement the Reserve**	• Drafting of gazette template. • Database collation.	

Considering there is no parallel study for the surface water component of the Reserve determination, the surface water data review and understanding will be summarised from the *"Determination of Water Resource Classes and Resource Quality Objectives in the Berg catchment"* study, hereafter referred to as the "Berg Water Resource Classification and RQO study" (DWS, 2016). This study determines Water Classes for IUAs and RQOs for RUs for all significant water resources within the Berg catchment area as part of the Berg and Olifants Water Management Area (WMA). The main reports, in terms of a data review and gap analysis include, but are not limited to, the Water Resource Information Gap Analysis and Models (DWS, 2016c), Report on Resource Units and IUA Delineation (DWS, 2016d), Status Quo (DWS, 2017a), Linking the Value and Condition of the Water Resource (DWS, 2016e), Quantification of the EWR and changes in EGSAs (Ecosystems goods, services and attributes) (DWS, 2017b), Resource Unit Prioritization (DWS, 2018a), Evaluation of Resource Units (DWS, 2018b), and Outline of Resource Quality Objectives (DWS, 2018c) reports. A list and brief description of additional relevant information sources and databases are summarised in **Section 2.3** and **APPENDIX** A.

Section 2.2 discusses the existing surface water and groundwater inputs, and how these can be used in context of the groundwater Reserve determination.

2.2. Water Resource Classification and RQOs (DWS, 2019)

2.2.1. Surface water

The scope of this project does not require a re-evaluation of the surface water resource units (DWS, 2022a). The results from the previous Reserve Determination Study and more updated datasets will be used as inputs into the groundwater component. The various components that were considered during the surface water study (DWS, 2016) are discussed in **Sections 2.2** in context of their relevance to this groundwater Reserve determination study. Previous Water Resource Classifications are discussed to assess whether additional refinement is required to achieve the high confidence level of this project. **Table 2-2** presents a summary of the priority RUs in the Berg catchment.

2.2.1.1. Rivers and Dams

The Berg River catchment is the largest catchment within the study area, along with smaller catchments such as the Diep, Kuils, Eerste, Sir Lowry's, Steenbras and numerous small catchments on the Cape Peninsula and West Coast (see **Figure 2-1**). The resource unit's delineation (see **Table 2-2**) considered river systems, recharge and discharge zones, groundwater use and management, and surface water divides on a quaternary and secondary level scale (DWS, 2016d). Each of the RUs identified in various sub-catchments were grouped together per quaternary catchment, where some quaternary catchments were then combined so that the integration of both surface water and groundwater systems could be achieved.

2.2.1.2. Wetlands

Several significant wetlands are of importance in the Berg catchment, namely the Edith Stevens Wetland Park, Zeekoevlei, Rondevlei, Zoarvlei and Rietvlei (see **Figure 2-2**).

The current understanding and data inputs for the surface water classes of wetlands is from the National Freshwater Ecosystems Priority Areas (NFEPA) wetlands map (Nel et al., 2011), and the CAPE Nature Fine-Scale Biodiversity Planning Project wetland maps (DWS, 2016d and references within). The NFEPA approach (after South African National Biodiversity Institute [SANBI], Ollis et al., 2013), the priority wetlands identified by the CoCT, and the geology (DWS, 2016d) were factors that were consulted in determining the wetland resource units (see **Figure 2-2** and **Table 2-3**) and resulted in the recognition of the following wetland types in the area (after DWS, 2016d):

- Floodplain wetlands - occur on mostly flat areas adjacent to and formed by an alluvial river channel.
- Valley-bottom wetlands - occur mostly on flat areas located along the valley floor and can be either channelled or un-channelled.
- Depressions - defined as a wetland or aquatic ecosystem with closed (or near closed) elevation contours within which water accumulates and may be flat-bottomed (often described as pans), or extend over large areas termed "wetland flats" or "floodplain flats".
- Seeps - a wetland area located on gentle to steeply sloping land, dominated by colluvial, uni-directional movement of water and material down-slope.

2.2.1.3. Estuaries

There are 22 estuaries in the Berg catchment including the Berg River and Langebaan Lagoon which receive contributions from groundwater. A number of these estuaries have Gazetted RQOs and ecological nodes (DWS, 2019: 121; **Figure 2-1**, **Table 2-4**) and a number have been assessed for desktop to comprehensive level health assessments (DWS, 2016d).

Table 2-2 Summary of results of the prioritization process for the Berg catchment (DWS, 2018a)

IUA	Prioritised Resource Units (RUs)				
	River	Estuary	Dam	Wetland	Groundwater
D8 Upper Berg	Bviii1, Bvii13, Biii3		Berg River Dam and Wemmershoek Dam	SWSA* SEEP	G10A, G10B
D9 Middle Berg	Bvii5, Bviii11, Bvii3			West Coast Shale Renosterveld FLOODPLAIN (Berg)	
C5 Berg Tributaries	Biii4, Bi1			SWSA* SEEP	G10E
B4 Lower Berg	Bvii12, Bvii6		Voëlvlei Dam and Misverstand Dam	West Coast Shale Renosterveld FLOODPLAIN (Berg) Northwest Sandstone Fynbos SEEP and FLOODPLAIN (Boesmans River) Kiekoesvlei DEPRESSION Koekiespan DEPRESSION	G10J
A1 Berg Estuary		Berg (Groot)		Southwestern Shale Fynbos UNCHANNELED VALLEY BOTTOM (Berg)	G10M
A2 Langebaan		Langebaan		Salt marsh SEEP (Geelbek)	G10M
A3 West Coast				Southwest Sand Fynbos DEPRESSION (Yzerfontein)	G21B
D10 Diep	Bv1, Biv6	Rietvlei/ Diep		Rietvlei Southwest Sand Fynbos FLOODPLAIN and Dune Strandveld FLOODPLAIN (seasonal) Riverlands DEPRESSION and SEEP	G21D
E11 Peninsula	Bviii6, Bvii20	Wildevöelvlei		Sand Fynbos DEPRESSION (Pick n Pay Reedbeds) Sand Fynbos DEPRESSION (Wildvöelvlei) Sand Fynbos DEPRESSION (seasonal) SWSA* UNCHANNELLED VALLEY-BOTTOM	
E12 Cape Flats	Bvii7	Zandvlei		Zeekoeivlei DEPRESSION (open water and seasonal) Rondevlei DEPRESSION (open water and seasonal) Nooiensfontein FLOODPLAIN Blouvlei DEPRESSION Princessvlei DEPRESSION SEEP (Philippi seasonal wetlands)	G22C G22D G22E
D6 Eerste	Biii6, Biv8	Eerste		SWSA* SEEP	
D7 Sir Lowry's	Bvii22, Bvii21, Bviii9	Lourens	Steenbras Reservoir and Steenbras Upper Dam	SWSA* SEEP	
TOTAL	**20**	**7**	**6**	**24**	**11**

* SWSA – Strategic Water Source Area

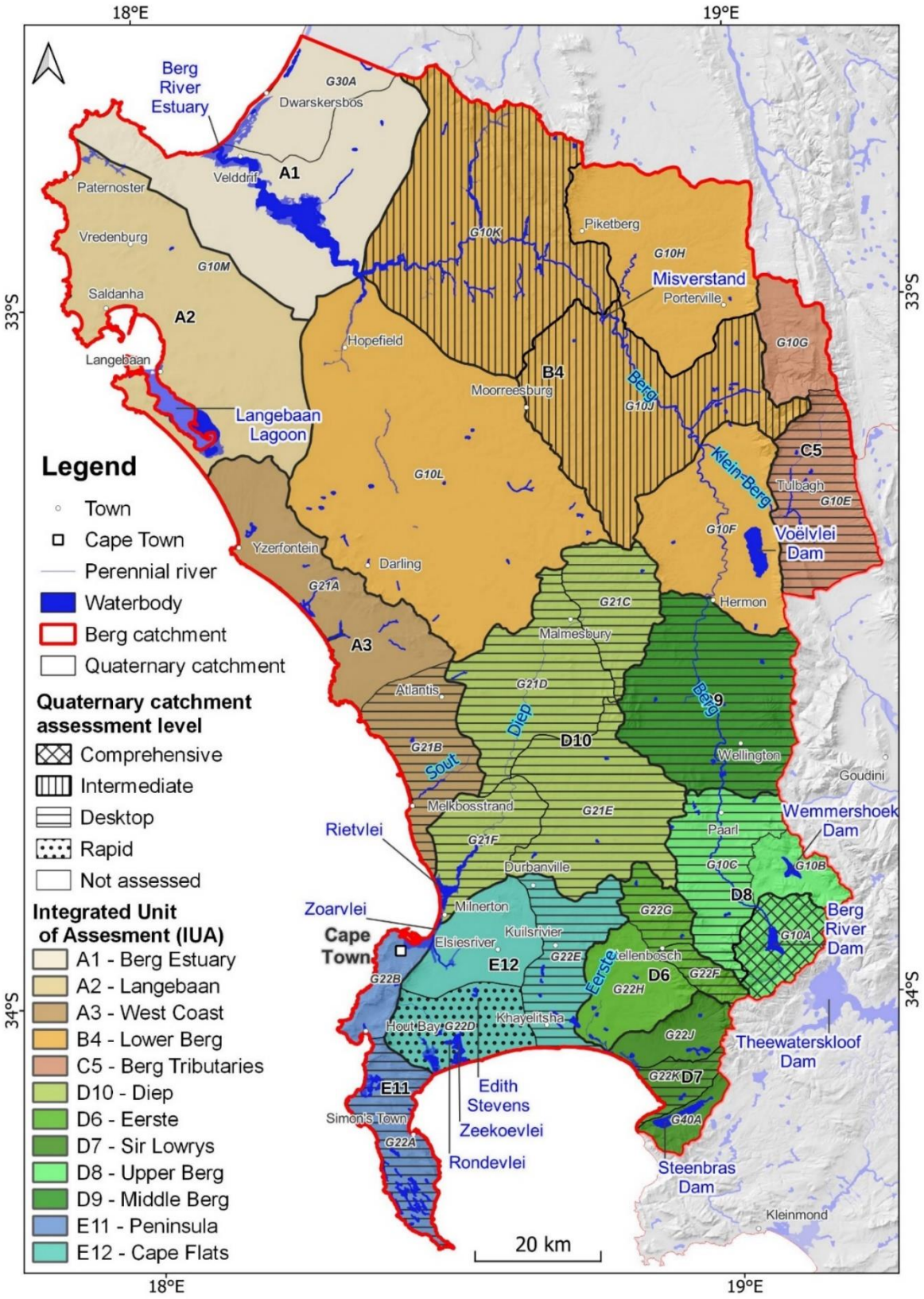

Figure 2-1 **Quaternary catchments and level of existing surface water Reserve determinations in the Berg catchment (DWS, 2017b).**

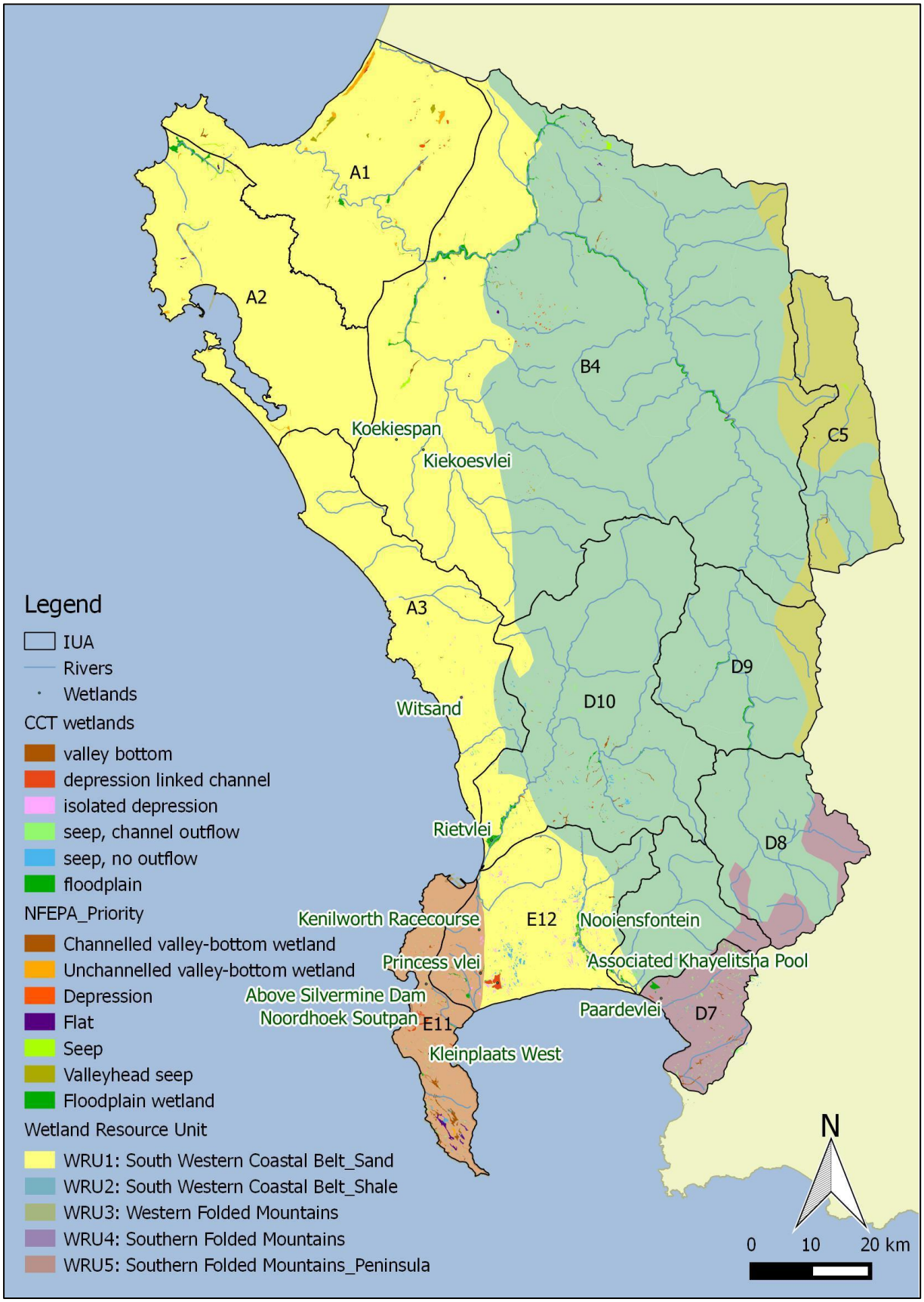

Figure 2-2 **Wetland Resource Units (DWS, 2016d), NFEPA and CoCT priority wetland extents. Note the limited number of wetlands delineated in the Cape Fold belt area (purple).**

Table 2-3 Wetland WRUs from DWS (2016d).

WRU name	Typical wetlands	HGM types	Wetland names
WRU1: Southwestern Coastal Belt (Sand)			Witsand
			Yzerfontein Soutpan
			Zeekoevlei
			Wetlands associated with Khayelitsha Pool
			Nooiensfontein
			Koekiespan
			Kiekoesvlei
			Rietvlei
WRU2: Southwestern Coastal Belt (Shale)			
WRU3: Western Folded Mountains	Small valley bottom and seep wetlands.	Seep; Valley bottom	
WRU4: Southern Folded Mountains			
WRU5: Southern Folded Mountains (Peninsula)	Range from mountain seeps, riverine systems and isolated depressions	Depression; Seep; Valley bottom	Kenilworth Racecourse
			Princess Vlei
			Kleinplaats West

Table 2-4 Priority nodes for estuaries from DWS (2017b). A = Unmodified / Natural, B = Largely Natural, C = Moderately Modified, D = Largely Modified, E = Seriously Modified, F = Critically / Extremely Modified; VH = Very High; H = High; M = Moderate; U = Undefined.

Node	IUA	Quaternary Catchment	Name	PES	REC	EIS
Bxi1	A1	G10M	Berg River Estuary	D	C	H
Bxi3	A2	G10M	Langebaan Estuary	B	A	VH
Bxi12	A3	G21A	Modder Estuary	C	C	M
Bxi7	D10	G21F	Rietvlei/Diep Estuary	D	C	H
Bxi9	E12	G22K	Zandvlei Estuary	D	C	H
Bxi20	E12	G22D	Zeekoe Estuary	E	D	U
Bxi10	E11	G22B	Hout Bay Estuary	E	D	U
Bxi11	E11	G22A	Silvermine Estuary	D	D	U
Bxi19	E11	G22A	Elsies Estuary	E	D	U
Bxi18	E11	G22A	Buffels Wes Estuary	F	D	U
Bxi17	E11	G22A	Krom Estuary	A	A	U
Bxi16	E11	G22A	Schuster Estuary	A	A	U
Bxi15	E11	G22A	Bokramspruit Estuary	C	C	U
Bxi14	E11	G22A	Wildvoelvlei Estuary	D	D	M
Bxi3	D6	G22H	Eerste Estuary	E	D	M
Bxi4	D7	G22J	Lourens Estuary	D	D	U
Bxi6	D7	G22K	Sir Lowry's Pass Estuary	E	D	U
Bxi6	D7	G40A	Steenbras Estuary	B	B	U

2.2.2. Groundwater

The GRU delineations (DWS, 2016d) highlight that the Berg WAAS project formed the basis for most of the groundwater understanding in the DWS (2016) study, in terms of aquifer types/delineation, aquifer characteristics, conceptual understanding and regional groundwater flow, recharge, and water quality. In addition to this, the data used for the study (DWS, 2016) was acquired from DWS databases (listed in **Section 2.3.1**) during the projects gap analysis phase in 2016. This will be updated based on additional data from 2016 to the most current datasets.

The GRU delineation approach involves delineating the physical aquifer geometry (which is predominantly controlled by geology), assessing recharge areas, a conceptual understanding of the aquifer boundary conditions (i.e., where water enters, namely recharge, flows through, and exits the systems, such as springs, rivers, lakes and dams) and groundwater-surface water interactions. The geology of the Berg catchment is the dominating control on the topography, recharge (in terms drainage and the orogenic control over precipitation) and water chemistry. Based on the complexity and varying geological characteristics of the different aquifers in the study area (i.e., the Sandveld Group, the TMG and the basement aquifers), including the strong compartmentalization of TMG due to major faults or fault zones, most aquifers in the region cross quaternary catchment boundaries and therefore do not correlate with surface water units of analysis. Although DWS (2016d) considered geological controls, GRUs were primarily delineated according to surface water catchments with varying aquifer types grouped (see **Table 2-5** and **Figure 2 3)**. Additionally, important aquifers such as the TMGA in Steenbras that the CCT is currently developing were not included in any GRUs. Based on this the GRUs will be re-evaluated in the following deliverable (D3.1; DWS, 2022a) to ensure that groundwater resources are fully encompassed and are aquifer specific.

Recharge and water level data will provide further insight into the GRU delineation. Recharge methods for the various aquifer types are discussed in the Berg WAAS project (DWAF, 2007) that yielded similar but nuanced results. This is particularly true when examining the orographic TMG Aquifer (TMGA) and Sandveld coastal recharge regions, as varying models either over estimated or were more conservative with recharge estimations.

Table 2-5 Delineated GRUs for the Berg catchment (after 2016d).

Sub- Region	GRU	Quaternary
Greater Cape Town	1-Peninsula	G22A and G22B
	2-Cape Flats	G22C, G22D and G22E
	3-Helderberg	G22G; G22H; G22K and G22J
Upper Berg	4-Paarl- Upper Berg	G10A; G10B; G10C and G10D
	5-Tulbagh Valley	G10E and G10F
	6-24 Rivers	G10G; G10H and G10J
Lower Berg	7-Piketberg	G30A and G30D
	8-West Coast	G10K; G10M; G10L and G21A
	9-Atlantis	G21B
	10-Malmesbury	G21C; G21D and G21E

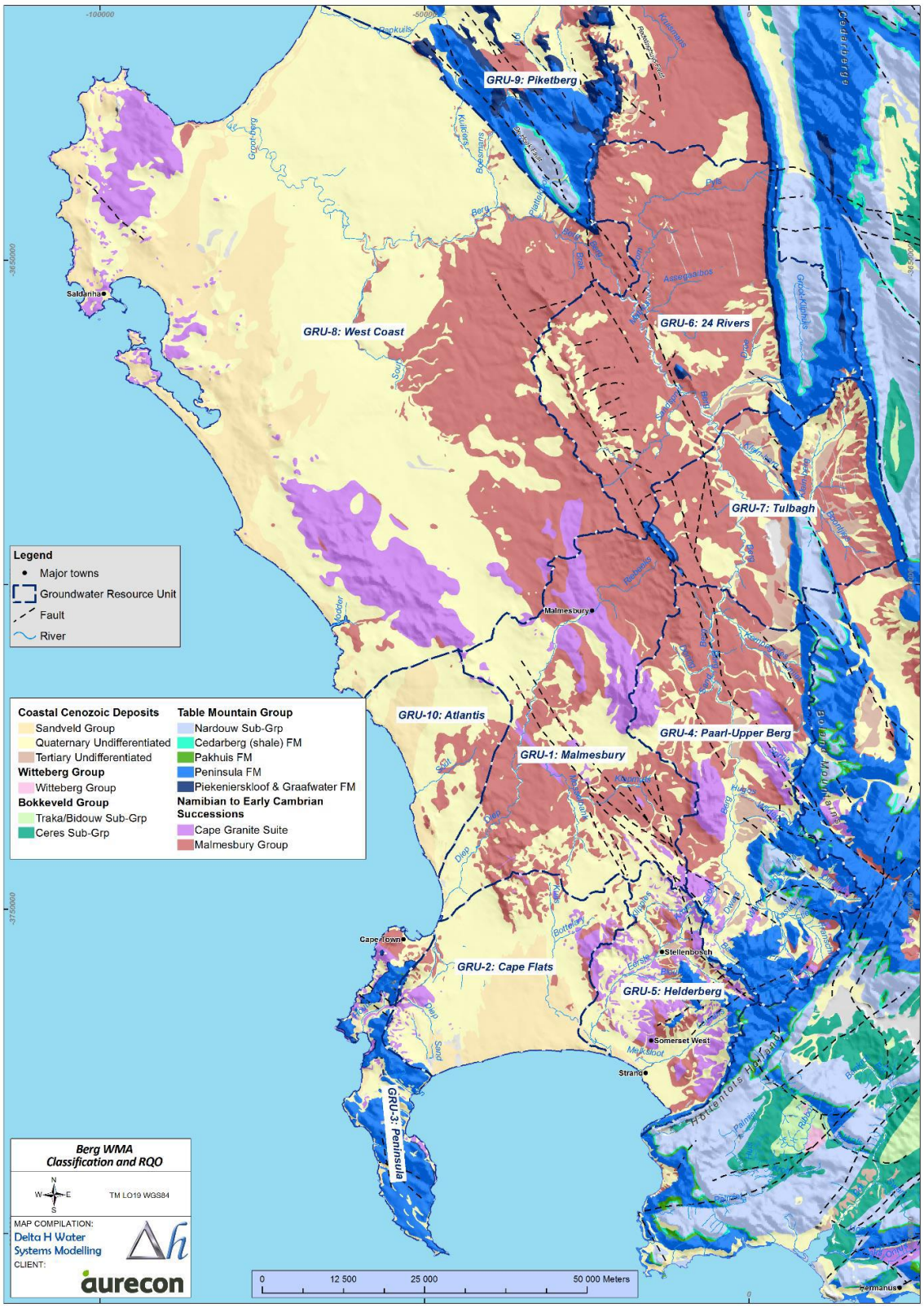

Figure 2-3 Spatial extent of GRUs outlined in Table 2-5 (after DWS, 2016d).

2.3. Available groundwater data and previous studies

Various DWS national groundwater datasets and previous studies have been collected, collated and standardised for a high confidence groundwater Reserve determination in this report and the Inventory of Water Resource Models Report (DWS, 2022b).

2.3.1. DWS groundwater databases

The DWS groundwater databases (see **Table 2-6**) include water level (**Figure 2-4**), groundwater quality (**Figure 2-5**), and groundwater use data (**Figure 2-6**) from numerous DWS-owned, municipal-owned and privately-owned boreholes. Daily, monthly and quarterly water level and water quality monitoring datasets have been standardised to remove or "flag" duplicated data points and grossly misleading or extreme values.

Significant efforts have been made to clean unique site-identifiers across all datasets, particularly for the NGA, Hydstra, WMS and WARMS databases, where point co-ordinates had to be verified using registered addresses and Surveyor-General Cadastral Codes (i.e., ERF number). It was noted in DWS (2016c) that almost one third of the WARMS co-ordinates had to be corrected in this way, adding significant time and budget considerations for data standardisation and quality control. Other quality control considerations are further described in **Section 3.2.**

Table 2-6 List of available groundwater databases and studies. National Groundwater Databases indicated in grey.

Study	Description
The Berg Catchment Water Availability Assessment Study (Berg WAAS (DWAF, 2007)	Provides quantifications of allocable water, as a prerequisite for compulsory licensing, by defining comprehensive conceptual models, a GIS water balance model, and excel-based water balance model for the whole study area.
Pre-Feasibility and Feasibility Studies for the Augmentation of the Western Cape Water Supply System (WCWSS) by means of further surface water developments (DWS, 2012)	Feasibility investigations of six surface water development options in the Breede, Palmiet and Berg catchments, as well as a comprehensive EWR determination for the Berg River Estuary.
Reconciliation Strategies for All Towns in the Southern Planning Region (2016)	Planning strategies to meet future demands and municipal usage of groundwater and whether groundwater development has been implemented (as of Reconciliation Strategy for All Towns reports, 2016).
Water Reconciliation Strategy for the WCWSS (2016)	Reconciliation of predicted future water requirements with supply available from the Western Cape Water Supply System (WCWSS) for a 25-year planning horizon. The strategy includes recommendations on various interventions that should be implemented to meet the future water requirements.
Water Resources of South Africa Study (WR2012)	The WR2012 (completed in 2016) builds on the WR2005 study (completed in 2010) and provides integrated water resource analysis and information covering South Africa, Lesotho and Swaziland. The rainfall-runoff WRSM/Pitman model was a significant component of this project and has since undergone further enhancements (5 Nov 2015).
Groundwater projects associated with City of Cape Town's New Water Programme (CoCT NWP)	Provides numerical groundwater models, including all relevant ancillary data used to develop the models, for the Atlantis Water Resource Management Scheme, the Cape Flats Aquifer (CFA) Management Scheme and the Table Mountain Group wellfield development for the Steenbras and Eikenhof-Nuweberg Wellfields.
Groundwater Resources Assessment Study: Phase II (GRAII; DWAF, 2006)	The GRAII includes a general methodology for GRD and estimates groundwater potential on a national scale. The dataset includes water balance data per quaternary catchment focusing on spatially disaggregated recharge, groundwater use and baseflow.

Study	Description
Berg River Baseline Monitoring Programme (Parsons & Associates, 2007)	The Berg River Baseline Monitoring Programme provides an important overview of the use of the water resources in the Berg catchment and includes the proposed interventions intended to improve the water quality of the Berg River system.
DWS: Water Use Authorization & Registration Management System (WARMS)	The WARMS dataset provides data on registered water use volumes, the intended use, date of registration and property associated with the use, and supports the implementation of section 137(2)(c) of the NWA, 1998. Data downloaded 16/06/2022.
DWS: National Groundwater Archive (NGA)	A national groundwater database that includes, but is not necessarily available for every data point, localised borehole information (spatial distribution through coordinates, field measurements [EC, pH], borehole depth and construction, lithology, water levels, etc), test pumping data, and groundwater level monitoring data pre ~2004. Data downloaded 03/03/2022.
DWS: Hydstra	A national groundwater database that stores continual groundwater level measurements (i.e., data loggers recording water level at daily and hourly time intervals). Data from NGA (pre ~2004) for sites that were still being monitored post 2004 were migrated to Hydstra such that complete records are now available in Hydstra. Data downloaded 08/06/2022.
DWS: Water Management System (WMS)	A national groundwater database that stores groundwater quality data including EC, pH, major ions, and a variety of trace element constituents. Data from the National Groundwater Quality Monitoring Programme (NGwQMP) have also been incorporated into this dataset. Data downloaded 26/04/2022.
DWS: Resource Quality Information Services (RQIS)	A national database that stores surface water quality results with data summaries of archived data and “cleaned” organic chemistry for rivers, dams, and lakes. Data downloaded 08/06/2022.

2.3.2. Other studies

The Berg WAAS study was the predominant informing study for the GRU determination and groundwater understanding in the DWS (2016) study. It provided insight into the recharge areas, aquifer types, a conceptual understanding of regional groundwater flow and a desktop level estimate of groundwater availability for the main aquifers. Since then, additional studies have been undertaken (see **Table 2-6**) of local aquifers, such as the CoCT NWP work on the Atlantis Aquifer, Cape Flats Aquifer and Steenbras-Nuweberg Table Mountain Group Aquifers (TMGA), and studies of the West Coast Aquifers by various private consultants and academia. The findings of these studies and data will be incorporated into an updated understanding of the project and support the delineation of GRUs. As such groundwater level and quality monitoring data gathered by the CoCT at various sites across the CFA, Atlantis aquifer and TMGA; as well as by the West Coast District Municipality for the Langebaan Road wellfield has been sourced to augment the monitoring data from NGA, WMS and Hydstra.

Additional datasets requested from the DWS are indicated in red in **APPENDIX A**.

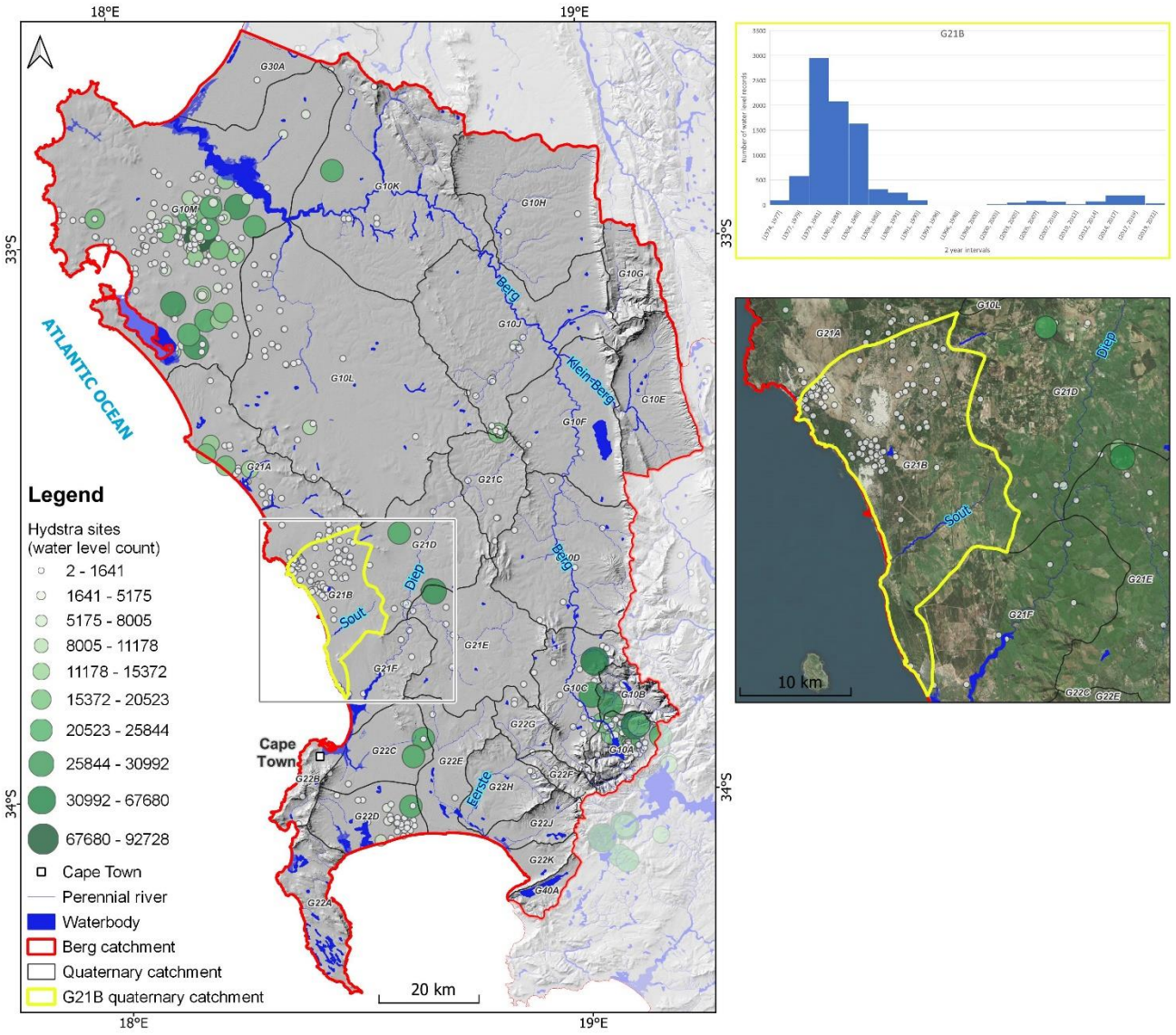

Figure 2-4 **Spatial distribution of Hydstra site locations and associated number of groundwater level records per site. Inset bar chart illustrates a selection example of temporal range of groundwater levels.**

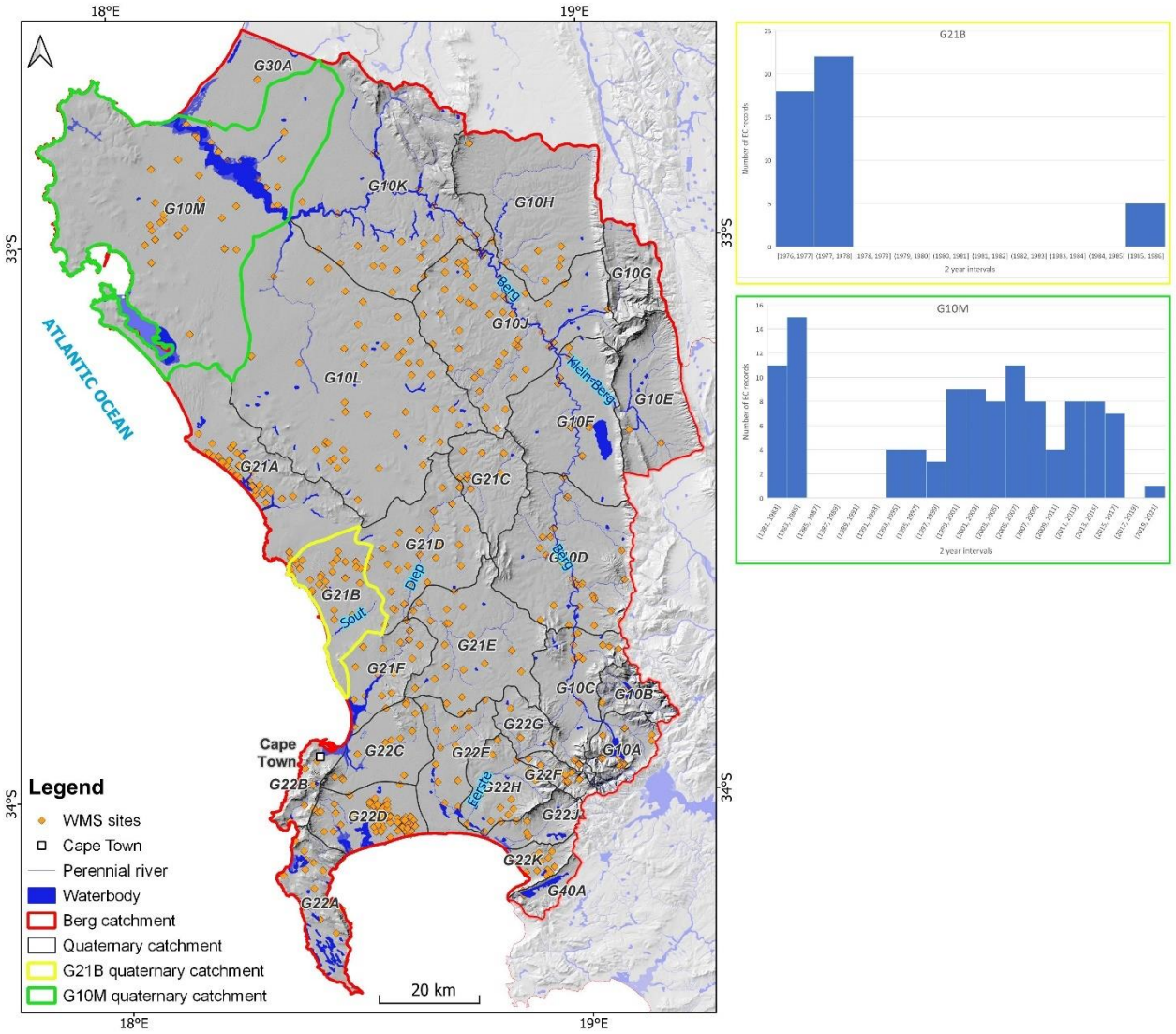

Figure 2-5 **Spatial distribution of WMS site locations. Inset bar charts illustrate selection examples of the temporal range of EC records**

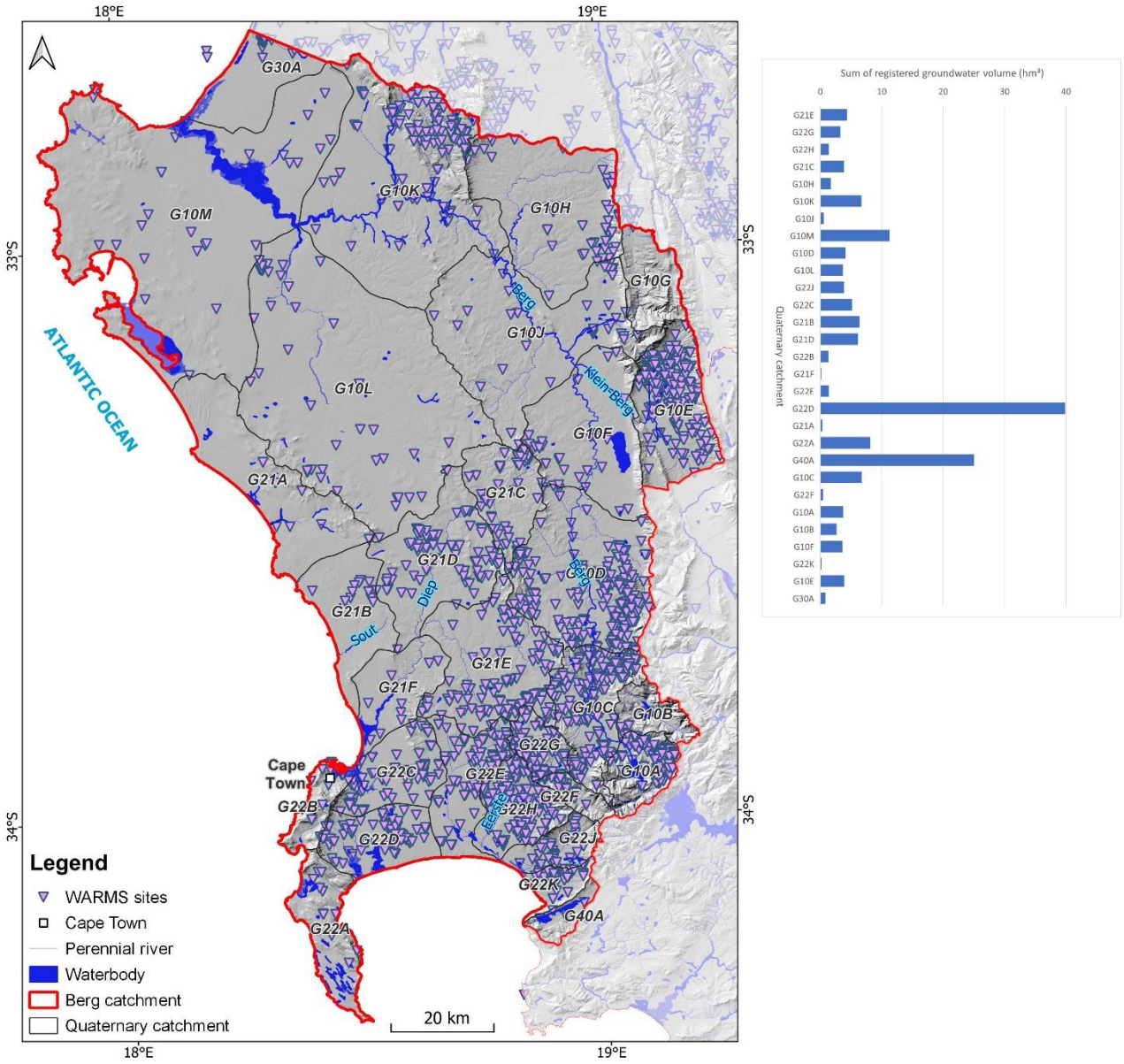

Figure 2-6 **Spatial distribution of WARMS site locations. Inset bar chart illustrates registered water use (hm³) per quaternary catchment.**

3. INFORMATION GAPS

3.1. Surface water

The surface hydrology models were comprehensively assessed in the DWS (2016) study and routine monitoring data from DWS and CoCT was incorporated into the assessment of the reserve and RQOs. DWS (2016) did not recognise any data gaps or barriers for the surface water, other than collecting additional data for the biophysical nodes.

However, there are some gaps regarding the delineation of EWR sites with respect to establishing groundwater contribution. EWR sites and nodes were established based on surface water considerations. From a groundwater perspective some additional nodes might be useful to facilitate the determination of the groundwater contribution to the Reserve.

Although larger wetlands have been identified and assessed previously, it appears that the smaller, but ecological sensitive and relevant wetlands that are mainly associated with the TMGA have not been included in the WRC and RQOs. Furthermore, the hydrogeological controls on wetlands, such as lithological and structurally controlled wetlands, and the groundwater dependency of these ecosystems have not been established. This is especially important in the TMG lithologies as there are significant wetlands that are fed by seepage from the TMGA. Existing datasets (i.e., NFEPA, Nel et al., 2011; Ollis et al., 2013) do not adequately assess these, and as a result, this constitutes a gap in the determining a high confidence groundwater reserve. The groundwater dependency can be approximated through remote sensing mapping, such as using moisture stress index values (MSI) as a proxy for possible wetland locations and groundwater dependency (see **Figure 3-1**).

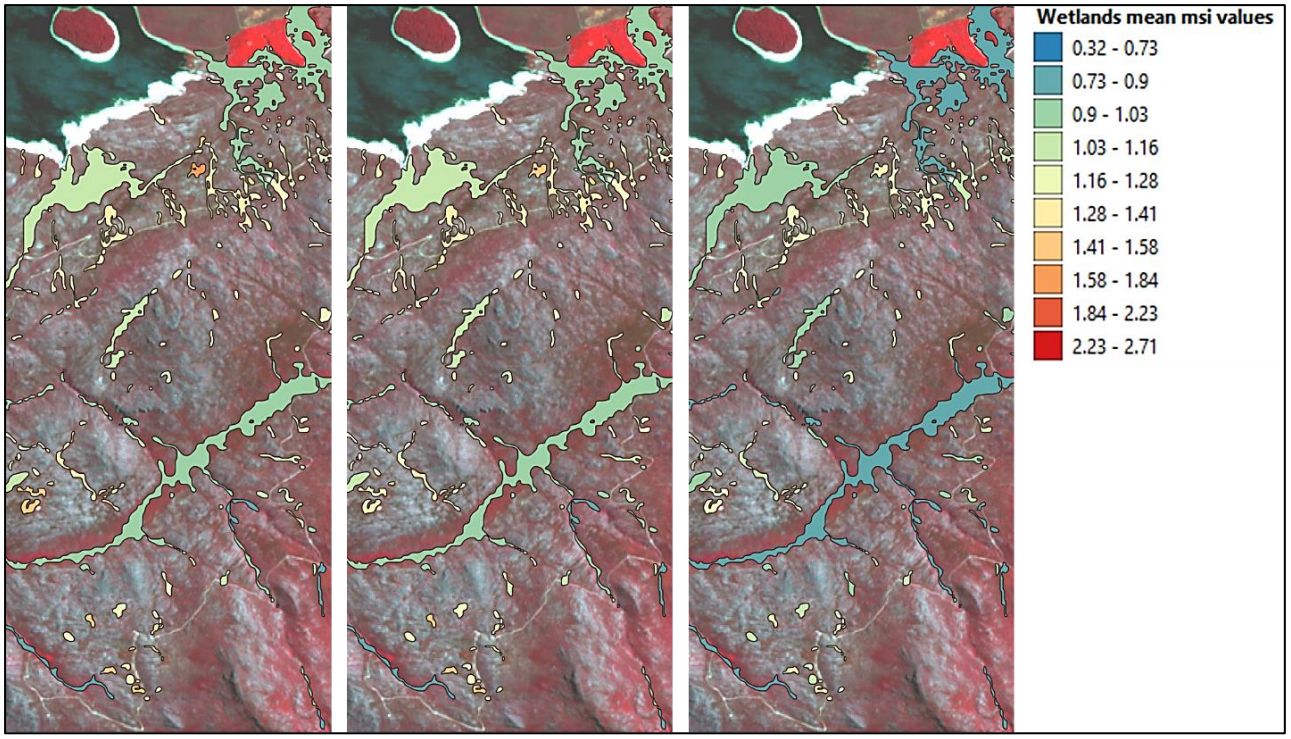

Figure 3-1 **Dry season MSI maps of possible wetland locations in the southern Steenbras region that have hydrogeological (lithological and structural) controls. Panels: left – 2017, centre - 2018, right - 2019 (CoCT, 2021a).**

3.2. Groundwater

The DWS groundwater databases and CoCT monitoring baselines provide a wealth of point data sources for this study. However, various limitations of the DWS groundwater datasets, in terms of point data availability, are outlined for the NGA, WMS, WARMS and Hydstra databases below:

- **Water level data often not provided with lithological information (Hydstra):** Water levels can be used to determine potentiometric surfaces which allow for an understanding of groundwater flow paths, internal boundary conditions, and could be an important component of GRU delineation. However, the borehole locations are often not associated with downhole geological information making it time consuming and difficult to delineate the target aquifer. If this is the case, only the development of regional groundwater flow path/potentiometric surface can be developed.
- **Spatial distribution:** Given the spatial distribution and timeseries of the DWS groundwater databases, DWS monitoring networks, and extensive baseline monitoring undertaken in the CoCT NWP, there will likely be sufficient spatial distribution of data across the GRUs. However, significant lateral data standardisation and quality control is required. The most notable is the standardization and verification of unique site IDs across datasets. Owing to the NGA becoming an “archive” for groundwater levels post-2004, and the migration of groundwater level data from NGA to Hydstra for only the “currently active” sites, there is now a significant overlap of daily and hourly groundwater levels records in the Hydstra database due to inconsistent site IDs. This may have significant implications on project time related to data processing.
- **Site coordinate verification (WARMS):** Site locations require verification using ERF numbers and other ownership details (i.e., Surveyor-General cadastral records). Historic sites were recorded with Cape (Modified Clarke) datum positions and have not been transformed to Haartebeesthoek (World Geodetic System [WGS] 84) positions. It is noted that this transformation only occurs with amendments to registered use. This implies that site positions may not be in the correct spatial locations (possible 100 to 300 m offsets) and will require correction. One way to do this would be to use a common point (i.e. trig beacons) in both Cape (Modified Clarke) datum and Haartebeesthoek (WGS84) positions to define transformation parameters for a selection of sites (e.g. per topographic sheet).
- **Registrations of water use (WARMS):** The dataset does not include all details on small-scale water use (i.e., only limited data on Schedule 1 users). Additionally, only a single water use volume is recorded per site, therefore (although a legal requirement) the volume can only be used as an indication of the maximum use, rather than an actual use case, since an individual may either exceed or not fully use their allocated legal volume. However, despite the lack of Schedule 1 user information, it is recommended that the census data be used to supplement whether there is a reliance on municipal supply or not.
- **Timeseries data spread:** There are sufficient long-term time-series monitoring records in the NGA, WMS and Hydstra datasets. The frequency of measurements, length of record and spatial distribution of these databases varies dramatically between them and across the study area. Incorporating other datasets (outlined in and **Section 2.2.2**) may have significant implications on project time related to data processing and quality control.
- **Limited metadata (NGA, WMS and Hydstra):** DWS (2016c) notes the unreliability of downhole NGA data due to a lack of detailed lithological descriptions and incomplete metadata. Similarly, the WMS water quality results lack specific details of quality control measures, particularly for the identification of outliers and charge balance errors within the dataset. Likewise, in the Hydstra dataset, there is no indication of the water level status metadata (i.e. static or dynamic). Since there is no way of tracking down missing metadata, these datasets will be supplemented with other regional studies (e.g., Berg Water Availability and Assessment [WAAS] study, DWAF, 2007) and additional studies that have been undertaken for local aquifers.

4. CONCLUSION AND RECOMMENDATIONS

As summary of the identified gaps and recommendations for addressing these are provided below with respect to the 8 steps of Reserve determination.

4.1. Step 1: Initiate the BHN and EWR assessment

In the data compilation phase, it is noted that there are significant digital (spreadsheets) and spatial datasets (GIS database, shapefiles, etc.) that were developed as part of the DWS (2016) study. As the initial study forms the foundation, especially for the ecological and surface water components, to this study, it is requested that the digital and GIS database be provided. Manual extraction of spreadsheets from PDFs and digitising spatial data from geo-rectified images introduces human error and inaccuracies into the data, as well as significantly increasing the time that is required to process the data into a workable format.

The PSP have received a number of reports associated to DWS (2016) but still require the following reports and GIS datasets:

- **DWS (2016) - Complete GIS and digital datasets**
- DWS (2017b) - Appendix A - K of the Quantification of EWR and changes in EGSA's Report: RDM/WMA9/00/CON/CLA/0217
- DWS (2017c) - The Ecological Base Configuration Scenarios Report: RDM/WMA9/00/CON/CLA/0317
- DWS (2018d) - The Monitoring Programme to Support RQO implementation: RDM/WMA9/00/CON/CLA/0318
- DWS (2018e) - The Confidence Assessment for RQOs Report: RDM/WMA9/00/CON/CLA/0417

4.2. Step 2: Delineate resource units and select study sites

Given the strong geological control on delineating the aquifers, the 1:250 000 and the recently updated 1:50 000 scale geological maps from the Council for Geoscience (CGS) will be a key data input required for this step. The shapefiles for the Cape Town 3318, Worcester 3319 and Clanwilliam 3218, 1:250 000 sheets cover the Berg study area, however, the PSP only has all of the 1:50 000 pdfs and not all of the corresponding shapefiles. This is a disadvantage to the regional delineation of the GRUs, as the 1:250 000 geological maps are at a coarser scale and less representative than the more refined 1:50 000 maps which reproduce the mapping of the area more accurately.

As the 1:50 000 maps are not readily available on the CGS online data portal the PSP, with the support of DWS, will liaise with CGS to provide additional 1:50k series that may be available as it is understood that government entities assist each other in that regard. Alternatively, the 1:250k series will be used and selectively updated to represent that most accurate delineation of the GRUs, such as the aquifer extent delineating during the CoCT's NWP of the Cape Flats, Atlantis and selected TMG aquifers.

4.3. Step 3: Determine the reference conditions

The outcomes of the status quo assessment done for Berg Water Resource Classification and RQO study (DWS, 2017a) define the reference condition of the water resources with respect to water system characteristics, socio-economic conditions and ecological qualities. These results, however, need to be confirmed or updated based on the most current datasets, including those for groundwater use, groundwater quality, recharge, and discharge on a GRU scale.

Updated water quality (WMS) and water use (WARMS) datasets from the DWS request will be incorporated to update those respective components of the status quo assessment. The CoCT New Water Programme (NWP) monitoring campaigns can provide more recent records to supplement this study. Aside from the data quality and standardisation procedures associated with DWS datasets, outlined in **Section 3.2**, the groundwater quality data in the status quo assessment (DWS,2017a) was based on average means of water quality parameters which can be considered an over estimate as the mean values could potentially be skewed by outliers. Significant data processing may be required to remove duplicates, non-detects, and outliers. Additionally, the water use component of the status quo assessed "fitness of water use" per user sector, which excluded sectors of mining, power generation, water supply, as well as schedule 1 users both listed and those not listed in the WARMS database.

Recharge datasets remain a limitation from the DWS (2016) study, as they are largely regional datasets and not aquifer specific. Reliability of the GRAII recharge dataset has been questioned based on insufficient coverage of chloride measurements, the interpolation method used, and the application of the data to a 1 km grid (DWS, 2016c). DWAF (2008) compared several recharge estimation methods in their water balance model and a combination of the different methods may be used and possibly updated to include recent rainfall and evapotranspiration inputs (updates from Hydsta and SAWS). For the GRU delineation the regional and previous study's recharge estimates will be useful, but in Step 3, more localised methods will be required to be compared with regional recharge datasets.

4.4. Step 4: Determine BHN and EWR for each of the selected study sites

The surface water EWR assessment and quantification was relatively thorough for the surface water reserve, however, the data used to quantify the EWR component from DWS (2016) is approximately 5 years old and therefore this data will need to be updated. River health, flow monitoring, water quality, water level and ecological data are regularly collected during DWS, Breede-Gouritz Catchment Management Agency (BGCMA) and CoCT NWP monitoring campaigns, which can be used as more recent records to supplement this study.

BHN requirements are limited to the Reconciliation Strategy for All Towns, Water Reconciliation Strategy for the WCWSS and the SA Census data. All of which may be outdated, and require updating via the current Reconciliation Strategy for All Towns that is underway, if data is available, or communication with municipalities to determine if their use of groundwater has changed and if so, what their usage currently is. This is important as if municipal records indicate that there is a reliance on groundwater, then the 25 ℓ/day per person assumption (WRC, 2013) will not be applied to a particular catchment/GRU and thus, allow for more realistic approach and avoid over-estimation of groundwater reliance to particular GRUs. It is recommended that DWS assist the PSP in retrieving the latest and comprehensive version of the planning and allocation data to increase the accuracy of the BHN assessment.

4.5. Step 5: Determine operational scenarios and its socio-economic and ecological consequences

Updated current and future scenarios of water use will be considered when assessing the impact of these operational scenarios on the aquifer, the groundwater component of the BHN/EWR and the water quality. Outputs from these assessments, in terms of water use and allocation, and the updates on whether planned municipal groundwater schemes have been implemented (outlined in **Section 4.4**), will also be considered (DWS, 2022a). These can then be modelled in appropriate models as detailed in Inventory of Water Resource Models Report (DWS, 2022b); however, this data has not yet been supplied for this high confidence groundwater Reserve determination.

4.6. Step 6: Evaluate scenarios with stakeholders

No data and information gap has been identified.

4.7. Step 7: Design an appropriate monitoring programme

The Berg River monitoring programme (Parsons and Associates, 2007) and the monitoring programme in support of the gazetted RQO implementation (DWS, 2018d) provided an important overview of the water resources in the Berg catchment. The proposed interventions outlined in the DWS (2018d) are critical input for designing an appropriate monitoring programme for the delineated GRUs. As this initial reserve determination study forms the foundation, especially for the ecological and surface water components, it is requested that the following reports and GIS datasets be provided:

- DWS (2018d) - The Monitoring Programme to Support RQO implementation: RDM/WMA9/00/CON/CLA/0318
- DWS (2018e) - The Confidence Assessment for RQOs Report: RDM/WMA9/00/CON/CLA/0417

Manual extraction of spreadsheets from PDFs and digitising spatial data from geo-rectified images introduces human error and inaccuracies into the data, as well as significantly increasing the time that is required to process the data into a workable format.

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APPENDIX A – AVAILABLE DATA

Table A- 1 Summary of available reports and data, related to various data categories to support the groundwater Reserve determination for the Berg catchment. Datasets highlighted in red are still outstanding.

Data category	Source	Description and relevance to study	Data	Status
Socio-economic				
Population statistics	Stats SA: Census (2011), Community Survey (2016), Pilot Census (2018), Census (2022)	Includes data that will be used, in combination with other socio-economic factors, to assess the degree of dependence on water resources within the study area and determine the groundwater Reserve requirements to satisfy BHN and maintain EWRs.	Data regarding access and quality of basic services, demographics, enumeration areas, total population, population density, education, living conditions, income, etc.	Available
	CSIR: StepSA (2015)			Available
Allocation data	Reconciliation Strategies for All Towns (2016)	All planning strategies for both surface water use, groundwater use will be considered when assessing the degree of dependence on the water resources in the study area. This will include information on current water allocation as well as water allocation forecasting for each local municipality.	Current and future development and implementation statuses, targeted aquifer, allocation details, surface water use, groundwater use, etc.	Available
	Water Reconciliation Strategy for the WCWSS (2016)			Available
	Water use Authorization & Registration Management System (WARMS)			Available
Administrative and demarcation boundaries	CD: Cadastral Spatial Information	Comprises of various spatial boundaries that are used for a variety of spatial analysis during the GRD.	Spatial boundaries of regions, towns, provinces, district municipalities, local municipalities, wards, public places, farm portions, erf, street parcels, etc..	Available
	CD: National Geo-spatial Information (2017/18)			Available
	Municipal Demarcation Board (2018)			Available
Stakeholders	Berg Water Resource Classification and RQO study (DWS, 2016b)	Identifies stakeholders to be considered in terms of resource planning and addressing concerns related to operational scenarios put forward during the GRD.	Stakeholder name, entity, contact details, etc.	Available
Macro-economic data	Berg Water Resource Classification and RQO study (DWS, 2016d, 2016e, 2017a, 2017b)	Provides sectoral economic outputs that will be used, in combination with other socio-economic factors, to assess the degree of dependence on water resources in the study area and determine the groundwater Reserve requirements to satisfy BHN and maintain or update EWRs.	Includes provincial and district level information such as land-use, economic sectors, spatial distribution, and gross geographical product. DWS (2016b and 2017a) also provides information regarding marginal value and cost of water.	Available

Data category	Source	Description and relevance to study	Data	Status
Land-use				
National Landcover	CSIR/ARC (2000)	Provides information about land use change and its influences on groundwater. Other applications of land use data for GRD include environmental planning and protection, assessments of possible areas of contamination, socio-economic impacts, compliance monitoring, and strategic decision making.	Land cover (urban, agricultural, forestry, mining, industry, informal settlements, etc.) as well as point-source spatial and attribute data such as landfill sites (open/closed/historical), WWTW, cemeteries, etc.	Available
	Department of Environmental Affairs, SANLC (73 class: 2020 and 2018; 9 class: 2018 and 2020; 72 class 2013/2014)			
	CD: NGI (2017/18)			
Landcover supplements	City of Cape Town's NWP	Depending on scale and level of detail required (considerations made during Phase 3 of this study, i.e., Delineation of Water Resource Units), this data will supplement the national landcover data to identify land use change and its influences on groundwater, possible areas of contamination, and wetland classes.	Sentinel 2 imagery (10m) landcover used as input for Moisture Stress Index (MSI) and Normalised Difference Vegetation Index (NDVI) processing and analysis. Outputs are used as indicators of groundwater dependent ecosystems.	Available
	Water Resources of South Africa, 2012 Study (WR2012)		Land use information (quaternary catchment scale), containing abstraction and return flows at points other than dams, irrigation information, alien vegetation, and afforestation.	Available
Existing IUAs	**Berg Water Resource Classification and RQO Study (DWS, 2016d, 2016e, 2017a, 2017b)**	Integrated Units of Analysis (IUAs) are broader-scale units for assessing the socio-economic implications of different operational scenarios and ecological conditions to be maintained at a sub-catchment scale. IUAs and related RUs are reviewed for input to Phase 3 of this study, i.e., Delineation of groundwater Water Resource Units.	Spatial units of land classes rooted in socio-economic, ecological, hydrogeological etc., assessments provide inputs onto which this study builds. 12 IUAs are identified for the Berg catchment which cover 5 socio-economic zones.	Reports Received, **GIS Dataset Required**
Hydroclimatology				
Rainfall	Water Resources of South Africa, 2012 Study (WR2012)	Provides is a key component used to estimate recharge (local and regional scale) to different GRU's during modelling. Data will be used as support parameter for recharge estimation and water use calculation using CRD and SVF methods.	Station details, daily/monthly/ annual rainfall data, as well as long-term median monthly rainfall (1950 – 2022). It is important to note the ~10 year data gap between the Water Resources of South Africa, 2012 Study (WR2012) and this study.	Available
	Groundwater Resources Assessment Study, Phase II (GRAII)			Available
	SA Atlas of Climatology and Agrohydrology (Schulze, 2009)			Available
	Hydstra			Available

Data category	Source	Description and relevance to study	Data	Status
	South African Weather Services (SAWS)			Pending
	City of Cape Town's NWP			Available
Evaporation	Water Resources of South Africa, 2012 Study (WR2012)	Provides a key component used to estimate recharge (local and regional scale) to different GRU's during modelling (i.e., Water Balance Modelling). Although evaporation is not a direct input for the recharge estimation and water use calculation using CRD and SVF methods, evaporation will be considered and used as support parameter during the recharge estimation.	Station details, daily/monthly/ annual evaporation data, as well as long-term median monthly are available on a national scale. It is important to note the ~10 year data gap between the Water Resources of South Africa, 2012 Study (WR2012) and this study.	Available
	Groundwater Resources Assessment Study, Phase II (GRAII)			Available
	SA Atlas of Climatology and Agrohydrology (Schulze, 2009)			Available
	Hydstra			Available
	City of Cape Town's NWP			Available
Temperature	SA Atlas of Climatology and Agrohydrology (Schulze, 2009)	Provides a key component used to estimate recharge (local and regional scale) to different GRU's during modelling (i.e., Water Balance Modelling). Although temperature is not a direct input for the recharge estimation and water use calculation using CRD and SVF methods, temperature will be considered and used as support parameter during the recharge estimation.	Station details, long-term annual mean temperatures, long-term monthly means of daily maximum, minimum and average temperatures, and monthly means of diurnal temperature range (Daily Tmax – Daily Tmin). It is important to note the ~10 year data gap between the Water Resources of South Africa, 2012 Study (WR2012) and this study.	Available
	Groundwater Resources Assessment Study, Phase II (GRAII)			Available
	Water Resources of South Africa, 2012 Study (WR2012)			Available
Ecology, Conservation and EWR				
Protected Areas	Western Cape Biodiversity Spatial Plan 2017: Protected Areas; and The Western Cape Biodiversity Spatial Plan (WCBSP)	Identifies areas that require safeguarding to ensure the continued existence and functioning of ecosystems across terrestrial and freshwater domains. The datasets include formally protected areas, those with less formal protection, and private conservation areas (such as contract nature reserves and WWF-SA land) for which CapeNature is the managing authority.	Spatial and attribute data for protected areas, conservation areas and biosphere reserves including Critical Biodiversity Areas (CBAs), Ecological Support Areas (ESAs), and Ecosystem Threat Status.	Available
	The South African Protected Areas Database (SAPAD)			Available
	CapeNature Reserves (2021)			Available
National Freshwater Ecosystem Priority Areas (NFEPA)	SANBI (2011) National Freshwater Ecosystem Priority Areas (NFEPA) Project Update	Identifies priority areas to meet national biodiversity goals which include various measures to protect them.	Spatial and attribute data for Freshwater Ecosystem Priority Areas (FEPA's) which includes protection protocols for both FEPA's and free-flowing rivers.	Available

Data category	Source	Description and relevance to study	Data	Status
National Vegetation Map (NVM) types and classification	SANBI (2018) NVM and Database	Used to assess impact on run-off efficiency and considered a relevant input when determining recharge to different GRU's during modelling.	Spatial and attribute data for natural vegetation	Available
PES/EIS and ES	Desktop PESEIS assessment (DWS, 2014)	Used during the prioritisation of aquifer specific GRUs which (prioritised according to ecological sensitivity of the receiving water resources, high usage/'water dependence, and BHN requirements)	Spatial and attribute data for the Present Ecological State (PES), the Ecological Importance (EI) and the Ecological Sensitivity (ES) for the Berg, Breede and Olifants-Doorn primary draining regions and per sub-quaternary reaches for secondary catchments. The REMP provides data related to monitoring of the ecological conditions in River ecosystems (instream and riparian).	Available
	River Eco-status Monitoring Programme (REMP). A component of the National Aquatic Ecosystem Health Monitoring Programme (NAEHMP).			Available
	National Wetland Monitoring Programme (NWMP)			Available
	National Estuarine Monitoring Programme (NEsMP)			Available
IUAs and RUs	**Berg Water Resource Classification and RQO study (DWS, 2016d)**	Spatial units that represent significant water resources in the study area and are used to assess socio-economic implications and ecological conditions at a sub-catchment level.	Spatial and attribute data of the 12 IUAs and the 10 GRUs identified in the study. Includes information relating to socio-economic zones, biophysical and allocation nodes, ecoregions, geomorphic zones, PES and vegetation bioregions.	**Reports and GIS Dataset Required**
Sub-Quaternary Catchments Prioritised for Wetland Rehabilitation	Working for Wetlands Programme within the South African Department of Environmental Affairs (DEA)	Provides information for sub-quaternary catchments which are assessed for wetland rehabilitation using factors including biodiversity, rehabilitation potential, ecosystem service value, and livelihoods.	Spatial and attribute data	Available
EWR	Comprehensive Reserve Determination Study for the Berg River (1999)	EWR estimates for two EWR river sites in the upper parts of the Berg catchment. Used in DWS (2016) study.	Report	Available
	Operating rules for the Berg River Dam (SW 2003, 2008)	Refined and operations management of the preliminary Reserve releases from the Berg River Dam.		Available
	Western Cape Water Supply Scheme (WCWSS) project	Included Rapid III-level Reserve determinations for the Krom and Steenbras rivers (DWA 2012c).		Available

Data category	Source	Description and relevance to study	Data	Status
		An Intermediate-level Reserve determination for the Berg River Estuary (DWA 2010).		Available
		Extrapolated EWR data to 23 nodes throughout the Berg Basin (DWA 2012b) in accordance with the provisions of the WRCS (Dollar et al. 2006).		Available
Hydrology				
Catchment boundaries	Water Research Commission (WRC)	Boundaries of areas from which any rainfall will drain into the watercourses through surface water flow and will be used for a variety of spatial GIS and groundwater-related modelling assessments.	Spatial delineations of primary, secondary, tertiary, and quaternary catchments boundaries.	Available
Water Management Areas (WMAs)	Water Management Area (WMA) boundary dataset (2004 & 2021)	Areas whereby regional- or catchment-level management will be undertaken in accordance with the National Water Resource Strategy (NWRS). The data provides a framework for protection, use, development, conservation, management, and control of water resources for the country.	Spatial boundaries	Available
Strategic Water Source Areas SWSA for surface water (SWSAsw)	Water Research Commission (WRC 2018) project (K5/2431)	SWASsw are defined as areas that supply a relatively large quantity of mean annual surface water runoff in relation to their size.	Spatial data for Water Source Areas (WSAs) at a national and sub-national scale are included to provide a complete coverage.	Available
Ecological Water Requirements (EWRs)	**Berg Water Resource Classification and RQO study (DWS, 2017b and 2017c)**	Provides a set of criteria for all biophysical nodes identified in the study area which are considered when describing the approach to evaluating ecosystems goods, services, and attributes (EGSA's). The data will be used to re-evaluate, from a groundwater perspective, the classification scenarios used to inform the current recommendations for Water Resource Classes and RQOs.	Information regarding water requirements for each biophysical node as well as the estimations of groundwater contribution to baseflow.	Reports (2017b) Received, **Report (2017c) and GIS Dataset Required**
	Pre-feasibility and feasibility study for augmentation of WCWSS: EWR assessment. Volume No. 1: Main Report (DWS 2012a)			Available
	Pre-feasibility and feasibility study for augmentation of WCWSS: EWR assessment. Volume No. 1: Appendix 3 (DWS 2012b)			**Dataset Required**

Data category	Source	Description and relevance to study	Data	Status
	Pre-feasibility and feasibility study for augmentation of WCWSS: EWR assessment. Volume No. 1: Appendix 4 (DWS 2012c)			Available
	Pre-feasibility and feasibility study for augmentation of WCWSS: EWR assessment. Volume No. 1 Berg estuary environmental requirements: (DWS 2012d)			Available
Resource Quality Objectives (RQOs)	**Berg Water Resource Classification and RQO study (DWS, 2018b & 2018c)**	ROQs are broad quantitative descriptions of the water resource and provide numerical limits that can be monitored and assessed for compliance. These include the Target Ecological Category (TEC) to be achieved or maintained.	Spatial and attribute data of RQOs for river, estuary, wetland, dam, and groundwater resources in the Berg catchment (includes numerical limits for quantity, quality, habitat and biota).	**GIS Dataset Required**
Surface Water Information	NGIS: CD National Geo-spatial Information (DRDLR)	This study requires hydrogeological results to be presented on a quaternary catchment scale. The Berg River catchment is the largest catchment within the study area, along with other smaller catchments such as the Diep, Kuils, Eerste, Sir Lowry's Steenbras and numerous small catchments on the Cape Peninsula and West Coast. There are 22 estuaries in the Berg catchment including the Berg River and Langebaan Lagoon estuary which both receive contributions from groundwater. Several significant wetlands are of particular importance in the Berg catchment, namely the Edith Stevens Wetland Park, Zeekoevlei, Rondevlaie, Zoarvlei and Rietvlei.	Spatial and attribute data for all surface water sites including dams, rivers, springs, wetlands, vleis, estuaries, flood plains, seeps etc.	Available
	DWS (Rivers of the Western Cape)			Available
	National Freshwater Ecosystem Priority Areas (NFEPA) - Wetlands			Available
Surface Water Quality	Water Resources of South Africa, 2012 Study (WR2012)	Although surface water quality in not a direct input for estimating the recharge of each GRU using the CMB or SVF methods, it is considered an important support parameter. Macro, trace, and isotope data can be used to distinguish between water from different aquifer systems as well as between surface water and groundwater (including flow paths and recharge area).	Station information and water quality results of physical, chemical, and microbial constituents. The NCMP and NMMP also provide surface water quality with data summaries of archived data and "cleaned" organic chemistry for rivers, dams, and lakes. Water quality models including Salinity model SALMOD and WRSM2000/Pitman are available and have been updated for WR2012.	Available
	The Water Management System (WMS): National Chemical Monitoring Programme (NCMP)			Available
	The Water Management System (WMS): National Microbial Monitoring Programme (NMMP)			Available

Data category	Source	Description and relevance to study	Data	Status
	City of Cape Town's NWP	Updated water quality will be compared to the EWR for each biophysical node and the impacts related to changes in water quality will be assessed.		Available
	Berg River Baseline Monitoring Programme (Parsons and Associates, 2007)			Available
Flow	Hydstra	Flow rates are an important parameter for estimating the groundwater component of the study. Flow data normally comprise of both the overland flow, termed run-off, and the groundwater discharge into rivers or stream. Inflow and outflow data inputs will be used for estimating recharge (using the SVF method) and groundwater model calibrations.	Includes gauging station information, simulated and measured flow, surface water flow direction (calculated from the 20m SUDEM), and time-series discharge data (monthly and daily mean) for the region covered by the Berg, Olifants Doorn, and Breede WMAs. The WR2012 study includes present-day streamflow (with all land use set to the 2009 hydrological year), patched observed streamflow (patched with the DWS observed streamflow data) in rivers, and naturalised flow (monthly flows in million cubic metres per month).	Available
	Water Resources of South Africa, 2012 Study (WR2012)			Available
	Western Cape Department of Agriculture			Available
	City of Cape Town's NWP			Available
Water Levels	Water Resources of South Africa, 2012 Study (WR2012)	Seasonal changes in surface water levels are important inputs when quantifying surface water – groundwater interactions. The flow direction and gradient are determined by the difference in hydraulic head between surface water and groundwater and is an essential parameter for any groundwater flow or mass balance model update.	Station details, model results from surface water models, and reservoir and dam balances (2014) are provided.	Available
	City of Cape Town's NWP			Available
Run-off	Water Resources of South Africa, 2012 Study (WR2012)	WR2012 is most used national dataset for water resources planning and management (only available as mean annual values per quaternary catchment). The Berg WAAS includes groundwater potential calculated per aquifer type and per quaternary catchment. Quaternary scale data was spatially disaggregated based on the outcrop area (a function of altitude, slope, and rainfall).	The Berg WAAS used mean annual run off per catchment from the Water Resources of South Africa, 1990 Study (WR90) and presents a GIS model of the spatial distribution of overland flow. The WR2012/WRSM2000/Pitman model presents simulated mean annual runoff at both daily and monthly time-steps.	Available
	The Berg Water Availability Assessment Study (WAAS)			Available

Data category	Source	Description and relevance to study	Data	Status
Baseflow & baseflow indices	Groundwater Resources Assessment Study, Phase II (GRAII)	Baseflow is the sustained low flow in a river during dry or fair weather conditions. Not all baseflow is necessarily contributed to by groundwater (it includes contributions from groundwater discharge and surface water interflow). The ratio of annual baseflow to the total annual run-off is known as the baseflow index. To accurately assess the groundwater Reserve (i.e., the volume of water required to sustain surface water resources, EWR and BHN), the volume of water that can be abstracted without affecting groundwaters contribution to surface water flow has to be considered. This will be done by estimating recharge to a particular GRU, assessing its contribution to baseflow (or a surface water resource), and calculating the BHN to be met from groundwater.	GRAII was used as first-order estimates for groundwater contribution to baseflow in the Berg WASS and includes disaggregated baseflow values within each catchment. Disaggregation was based on outcrop area, location of springs, aquifer-specific recharge distribution, geological reasoning, and surface and groundwater modelling.	Available
	The Berg Water Availability Assessment Study (WAAS)			Available
Water Use	Water Resources of South Africa, 2012 Study (WR2012)	Surface water resources in the study area is dominated by the Western Cape Water Supply System (WCWSS), mainly from the Berg River catchment, with significant contributions from Palmiet, Steenbras and Riviersonderend Rivers, and lesser contributions from the Diep and Eerste River, along with various dams on streams in the Cape Peninsula Mountains.	Includes spatial locations and water use information for every quaternary catchment including domestic, RDP, industrial, agricultural, and mining water use. Other datasets including major and minor dam levels, abstraction and return flows at points other than dams, and irrigation.	Available
	Water use Authorization & Registration Management System (WARMS)			Available
	Berg Water Resource Classification and RQO study (DWS,2017a)			**GIS Dataset Required**
	Pre-feasibility and feasibility study for augmentation of WCWSS: EWR assessment. Volume No. 1: Main Report (DWS 2012a)			Available
	City of Cape Town's NWP			Available
Hydrogeology				
Aquifer Type	National Maps 2012 (DWS)	Indication of the aquifer type and borehole yield class.	Spatial and attribute data including yield (median l/s, excluding dry boreholes).	Available
Aquifer Classification	National Maps 2012 (DWS)	Identification of major, minor and poor aquifers (based on yield) and associated water quality indicators (i.e., good, variable, moderate and poor).	Spatial and attribute data	Available

Data category	Source	Description and relevance to study	Data	Status
Groundwater Quality	Water Resources of South Africa, 2012 Study (WR2012)	A key support parameter for estimating the recharge of each GRU using the CRB method. Macro, trace, and isotope data can be used to distinguish between water from different aquifer systems as well as between surface and groundwater (including flow paths and recharge area). Updated water quality will be compared to the EWRs for each biophysical node (the impacts related to changes in groundwater quality) and may be used as an indicator for determining the amount of potable water.	Water quality models including Salinity model SALMOD and WRSM2000/Pitman are available and have been updated for WR2012. The GRAII and WMS datasets were used as input data in the Berg WAAS and provides station information and groundwater quality data (macro, trace, radioactive and isotope element parameter analysis), including data from the National Groundwater Quality Monitoring Programme (NGwQMP), and chloride concentration raster's (1km x 1km scale). Updated groundwater quality from the City of Cape Town's New Water Programme and the WMS will be integrated during the GRD.	Available
	Groundwater Resources Assessment Study, Phase II (GRAII)			Available
	The Water Management System (WMS)			Available
	National Maps 2012 (DWS)			Available
	The Berg Water Availability Assessment Study (WAAS)			Available
	City of Cape Town's NWP			Available
Strategic Water Source Areas (SWSA) for groundwater	Water Research Commission (WRC 2018) project (K5/2431)	SWSAgw are spatial delineations of areas with high groundwater availability as well as where this groundwater forms a nationally important resource.	Spatial data for Water Source Areas (WSAs) at a national and sub-national scale are included to provide a complete coverage.	Available
Aquifer Vulnerability	National Maps 2013 (DWS)	Estimation of the likelihood for contamination to reach a specified position in the groundwater system after introduction at some location above the uppermost aquifer.	Spatial and attribute data	Available
Aquifer Susceptibility	National Maps 2013 (DWS)	A qualitative measure of the relative ease with which a groundwater body could potentially be contaminated by anthropogenic activities.	Spatial and attribute data	Available
Hydraulic characteristics	National Groundwater Archive (NGA)	A measure of the ease of fluid flow through porous material. Hydraulic conductivity (K) is the rate of flow through a cross-section of one square metre under a unit hydraulic gradient at right angles to the direction. of flow (m/d).	Available model outputs and datasets	Available
	City of Cape Town's NWP			Available
Groundwater Harvest Potential	Department of Water and Sanitation Directorate: Hydrological Services	Provides quantitative information on sustainable rates of groundwater abstraction in South Africa. Local scale environmental and socio-economic factors could considerably reduce the maximum rate of abstraction. Groundwater harvest potential will only be used as an overview for this study.	Abstraction rates (m^3/km^2)	Available

Data category	Source	Description and relevance to study	Data	Status
Groundwater Abstraction & Use	Water use Authorization & Registration Management System (WARMS)	The WARMS dataset provides usage data on registered use above Schedule 1. It is important to note that the data, in its current format, is not aquifer specific and does not indicate seasonal fluctuations of groundwater use or from which aquifer the water is being abstracted. Data from the City of Cape Town's New Water Programme will be used to bolster these datasets in terms of spatial distribution, aquifer depths, seasonal fluctuations (including irrigation requirements) and general changes in usage based on localised census data. NGA data can be a useful crosscheck.	Includes spatial locations and water use information for every quaternary catchment including domestic, RDP, industrial, agricultural, mining water use.	Available
	National Groundwater Archive (NGA)			Available
	City of Cape Town's NWP			Available
Allocation data	Reconciliation Strategies for All Towns (2016)	Planning strategies (for both surface and groundwater use) and water allocation data will be used to assess degree of dependence on water resources.	Current and future development and implementation status, aquifer targeted, supply source, allocation details, surface and groundwater use, etc.	Available
	Water Reconciliation Strategy for the WCWSS (2016)			Available
Groundwater levels	Hydstra	Groundwater levels will be used to determine groundwater flow directions and hydraulic gradient. It is a key support parameter for estimating the recharge of each GRU using the CRD or SVF methods. The CRD method is a water balance approach and is based on the premise that fluctuations in groundwater levels are caused by rainfall events. The SVF method is a lumped parameters approach which considers water levels, abstraction from the aquifer, and natural flow. A good spatial distribution of boreholes within each GRU is a prerequisite for the successful application of both the CRD and SVF methods for recharge estimations.	Includes spatial information and time series groundwater level data as well as field measurements at more local scales. The GRAII dataset provides a regional-scale spatial distribution of groundwater levels modelled as a 1 km x1 km raster.	Available
	National Groundwater Archive (NGA)			Available
	City of Cape Town's NWP			Available
	National Maps 2005 (DWS)			Available
	Groundwater Resources Assessment Study, Phase II (GRAII)			Available
	Berg River Baseline Monitoring Programme (Parsons and Associates, 2007)			**All Reports and GIS Dataset Required**
	Table Mountain Group Aquifer Feasibility Study, hydrocensus data (City of Cape Town, 2004b, 2005b, 2006)			Available
	The Berg Water Availability Assessment Study (WAAS)			Available

Data category	Source	Description and relevance to study	Data	Status
Groundwater Recharge	Groundwater Resources Assessment Study, Phase II (GRAII)	Several attempts at estimating recharge on a national scale have been undertaken, most of which are based on single recharge calculation methods, e.g., baseflow separation, CMB, CRD, SVF, or GIS modelling. The Berg Water Availability Assessment Study (WAAS) calculated groundwater potential (per major aquifer, per quaternary catchment) as recharge minus registered use (derived from the WARMS database) minus baseflow (derived from GRAII datasets). In doing so recharge estimates with various GIS-based methods was conducted per GRU and provides a significant baseline for this study.	Time series data for aquifer-specific monthly recharge values (based on monthly rainfall data and applying seasonal changes to spatial distribution from map-centric simulations).	Available
	The Berg Water Availability Assessment Study (WAAS)			Available
	Other Models i.e. (City of Cape Town's NWP)			Available
IUAs and GRUs	**Berg Water Resource Classification and RQO study (DWS, 2016d)**	IUAs are spatial units that represent significant water resources in the study area and are used to assess socio-economic implications and ecological conditions at a sub-catchment level.	Spatial and attribute data of the 12 IUAs and the 10 GRUs identified in the study. Includes information relating to socio-economic zones, biophysical and allocation nodes, ecoregions, geomorphic zones, PES and vegetation bioregions.	**GIS Dataset Required**
Resource Quality Objectives (RQOs)	**Berg Water Resource Classification and RQO study (DWS, 2018c)**	ROQs are broad quantitative descriptions of the water resource and provide numerical limits that can be monitored and assessed for compliance. These include the Target Ecological Category (TEC) to be achieved or maintained.	Spatial and attribute data of RQOs for priority groundwater resources in the Berg catchment including numerical limits for quantity (abstraction, low flow and discharge) and quality (nutrients, salts, pathogens, and key system variables/constituents)	**GIS Dataset Required**
Ecological Water Requirements (EWRs)	**Berg Water Resource Classification and RQO study (DWS, 2017b)**	Provides a set of criteria for all biophysical nodes identified in the study area which are considered when describing the approach to evaluating ecosystems goods, services, and attributes (EGSA's). Data will be used to re-evaluate, from a groundwater perspective, the classification scenarios used to inform the current recommendations for Water Resource Classes and RQOs.	Information regarding water requirements for each biophysical node as well as the estimated groundwater contribution to baseflow.	**GIS Dataset Required**
	Pre-feasibility and feasibility study for augmentation of WCWSS: EWR assessment. Volume No. 1: Main Report (DWS 2012a)			Available
	Pre-feasibility and feasibility study for augmentation of WCWSS: EWR assessment. Volume No. 1: Appendix 3 (DWS 2012b)			**Dataset Required**

Data category	Source	Description and relevance to study	Data	Status
	Pre-feasibility and feasibility study for augmentation of WCWSS: EWR assessment. Volume No. 1: Appendix 4 (DWS 2012c)			Available
	Pre-feasibility and feasibility study for augmentation of WCWSS: EWR assessment. Volume No. 1 Berg estuary environmental requirements: (DWS 2012d)			Available
Maps (1:250k)	Council for Geoscience (CGS)	Various geological maps, particularly at 1:250 000 and 1:50 000 scales, will be used to assess the spatial distribution of key geological features in the study area. Structural features and formations in several stratigraphic sequences will be used to update both the vertical dimensions and aerial extent of GRUs. This data, along with other datasets outlined in this report (i.e.., borehole data, surface water, precipitation, etc), will be used to update GRUs and define areas of recharge, storage, and discharge during modelling.	Includes spatial and attribute data of lithostratigraphic boundaries, major faults (including thrusts and shear zones), dominant lithologies, stratigraphic units, etc.	Available
	Umvoto Africa (after CGS)			Available
Maps (1:50k)	**Council for Geoscience (CGS)**			**Required**
	Umvoto Africa (after CGS)			Available
Lithology	Council for Geoscience (CGS)			Available
	Umvoto Africa (after CGS)			Available
Stratigraphy	Council for Geoscience (CGS)			Available
	Umvoto Africa (after CGS)			Available
Structural	Council for Geoscience (CGS)			Available
	Umvoto Africa (after CGS)			Available
BH Data (drilling targets, depth, yield, construction)	National Groundwater Archive (NGA)	Wellfield and borehole test data for the study area and will be used as geological and hydrogeological model inputs. Borehole data (such as groundwater levels, groundwater chemistry, borehole construction information, geological logs, etc) will be used as model inputs to provide a realistic representation of the groundwater flow regime, simulate contaminant transport, and delineate aquifer zones, as well as provided realistic basis for parameter testing and evaluation of model sensitivity.	Localised aquifer specific site information (including spatial distribution) and basic groundwater related information such as field measurements, drilling depths, casing, screens, annular fill, lithology, water levels, water strikes, etc.	Available
	City of Cape Town's NWP			Available

Data category	Source	Description and relevance to study	Data	Status
Strategies and Planning				
Allocation data	Reconciliation Strategies for All Towns, and Water (2016)	Planning strategies for surface water use, groundwater use and water allocation, amongst other factors, will be used to assess the degree of dependence on water resources. These include the current water allocations as well as allocation forecasting information for all local municipality.	Current and future development and implementation status, water allocation details, aquifer targeted, surface water use, groundwater use, etc.	Available
	Reconciliation Strategy for the WCWSS (2016)			Available
Existing monitoring programmes	**Berg Water Resource Classification and RQO study (DWS, 2018d, 2018e)**	The Berg River Baseline Monitoring Programme provides and important overview of the use of the water resources in the Berg catchment and includes the proposed interventions intended to improve the water quality of the Berg River system. Monitoring protocols, including those from the Berg Water Resource Classification and RQO study, and the Pre-feasibility and feasibility study for augmentation of WCWSS, and the City of Cape Town's New Water Programme will be used to design or update programmes to include all GRUs delineated in the next phase of this study.	Monitoring strategies and various biophysical datasets (water quality data for both long- and short-term resource targets) for the Berg catchment.	**Reports and GIS Dataset Required**
	BGCMA Monitoring data			To Request (DWS)
	Berg River Baseline Monitoring Programme (Parsons and Associates, 2007)			To Request (DWS)
	Berg River Improvement Plan (2012)			To Request (DWS)
	Pre-feasibility and feasibility study for augmentation of WCWSS: EWR assessment. Volume No. 1: Main Report (DWS 2012a)			Available
	City of Cape Town's NWP			Available
Water Use	Water Resources of South Africa, 2012 Study (WR2012)	Surface water resources in the study area is dominated by the Western Cape Water Supply System (WCWSS), mainly from the Berg River catchment, with significant contributions from Palmiet, Steenbras and Riviersonderend Rivers, including lesser contributions from the Diep and Eerste River, along with various dams on streams in the Cape Peninsula Mountains.	Includes spatial locations and water use information for every quaternary catchment (domestic, RDP, industrial, agricultural, and mining water use). Other datasets including major and minor dam levels, abstraction and return flows at points other than dams, and irrigation.	Available
	Water use Authorization & Registration Management System (WARMS)			Available
	Berg Water Resource Classification and RQO study (DWS,2017a)			To Request (DWS)
	City of Cape Town's NWP			Available