WATER USE LICENCE APPLICATION SUMMARY REPORT

NAME OF APPLICANT:

ACME Capital (Pty) Ltd

Compiled by

Sonia Jordaan & James Dabrowski

(Confluent Environmental)

Signature:

Date : August 2022

Hi Pierre

I've also been on the phone with the BGCMA this morning to discuss your application and they have confirmed that a site visit will not be necessary for your application. This means we can now progress further along with the application process which is good news.

Louise - for your information - the application number for the WULA is **WU22733.**

Regards

James Dabrowski
Confluent Consulting

Establishment of Vineyard on Portions 43, 104 and RE/7 of Farm 444, Plettenberg Bay, Western Cape.

Aquatic Assessment Report

For:

Cape EAPrac

By:

Confluent Environmental

December 2021

confluent
aquatic consulting & research

Declaration of Specialist Independence

- I consider myself bound to the rules and ethics of the South African Council for Natural Scientific Professions (SACNASP);
- At the time of conducting the study and compiling this report I did not have any interest, hidden or otherwise, in the proposed development that this study has reference to, except for financial compensation for work done in a professional capacity;
- Work performed for this study was done in an objective manner. Even if this study results in views and findings that are not favourable to the client/applicant, I will not be affected in any manner by the outcome of any environmental process of which this report may form a part, other than being members of the general public;
- I declare that there are no circumstances that may compromise my objectivity in performing this specialist investigation. I do not necessarily object to or endorse any proposed developments, but aim to present facts, findings and recommendations based on relevant professional experience and scientific data;
- I do not have any influence over decisions made by the governing authorities;
- I undertake to disclose all material information in my possession that reasonably has or may have the potential of influencing any decision to be taken with respect to the application by a competent authority to such a relevant authority and the applicant;
- I have the necessary qualifications and guidance from professional experts in conducting specialist reports relevant to this application, including knowledge of the relevant Act, regulations and any guidelines that have relevance to the proposed activity;
- This document and all information contained herein is and will remain the intellectual property of Confluent Environmental. This document, in its entirety or any portion thereof, may not be altered in any manner or form, for any purpose without the specific and written consent of the specialist investigators.
- All the particulars furnished by me in this document are true and correct.

Dr. James Dabrowski (Ph.D., Pr.Sci.Nat. Water Resources; SACNASP Reg. No: 114084)

December 2021

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1. INTRODUCTION

ACME Capital (PTY) Ltd, a subsidiary of Dormell Properties 139 (PTY) Ltd, have recently purchased three properties located just north of Plettenberg Bay, with 10 ha available for the establishment of vineyards under the brand of Telluric Farm. The proposed vineyard will be located on a steeply sloped hill located just to the north of the Diep River, facing predominantly south-east. Annual production will begin at 2 730 cases (6 x 750 mL) in year one and increase to 6 860 cases by year four. The farm will produce the following two vinifera varietals: Pinot Noir and Chardonnay. The majority of the wine will be sold directly from the on-site tourism facility that will be developed as part of the project. The proposed project aims to augment the current land with compatible use which is not only sustainable, but generates a positive socio-economic return.

The establishment of the vineyards and related infrastructure occurs within close proximity to important wetland and estuarine habitats associated with the Bitou and Keurbooms rivers, prompting the need to conduct an aquatic specialist assessment that meets the requirements of the National Environmental Management Act, 1998 (Act 107 of 1998) (NEMA) and the National Water Act (Act 36 of 1998) (NWA).

1.1 Key Legislative Requirements

1.1.1 National Environmental Management Act (NEMA, 1998)

According to the protocols specified in GN 1540 (Procedures for the Assessment and Minimum Criteria for Reporting on Identified Environmental Themes in Terms of Sections 24(5)(A) and (H) and 44 of the National Environmental Management Act, 1998, when Applying for Environmental Authorisation), assessment and reporting requirements for aquatic biodiversity are associated with a level of environmental sensitivity identified by the national web-based environmental screening tool (screening tool). An applicant intending to undertake an activity identified in the scope of this protocol on a site identified by the screening tool as being of:

- **Very High** sensitivity for aquatic biodiversity, must submit an Aquatic Biodiversity Specialist Assessment; or
- **Low** sensitivity for aquatic biodiversity, must submit an Aquatic Biodiversity Compliance Statement.

According to the protocol, prior to commencing with a specialist assessment a site sensitivity verification must be undertaken to confirm the sensitivity of the site as indicated by the screening tool:

- Where the information gathered from the site sensitivity verification differs from the screening tool designation of **Very High** aquatic biodiversity sensitivity, and it is found to be of a **Low** sensitivity, an Aquatic Biodiversity Compliance Statement must be submitted.
- Similarly, where the information gathered from the site sensitivity verification differs from the screening tool designation of **Low** aquatic biodiversity sensitivity, and it is found to be of a **Very High** sensitivity, an Aquatic Biodiversity Specialist Assessment must be submitted.

The screening tool identified the site as being of **Very High** aquatic biodiversity based on the fact that the development occurs in a Freshwater Ecosystem Priority Area (FEPA) and will take place in close proximity to wetland and estuarine habitat associated with the Bitou and Diep Rivers.

1.1.2 National Water Act (NWA, 1998)

The Department of Water & Sanitation (DWS) is the custodian of South Africa's water resources and therefore assumes public trusteeship of water resources, which includes watercourses, surface water, estuaries, or aquifers. The National Water Act (NWA) (Act No. 36 of 1998) aims to protect water resources, through:

- The maintenance of the quality of the water resource to the extent that the water resources may be used in an ecologically sustainable way;
- The prevention of the degradation of the water resource; and
- The rehabilitation of the water resource.

A watercourse means:

- A river or spring;
- A natural channel in which water flows regularly or intermittently;
- A wetland, lake or dam into which, or from which, water flows; and
- Any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse, and a reference to a watercourse includes, where relevant, its bed and banks.

No activity may take place within a watercourse unless it is authorised by the Department of Water and Sanitation (DWS). According to Section 21 (c) and (i) of the NWA, an authorization (Water Use License or General Authorisation) is required for any activities that impede or divert the flow of water in a watercourse or alter the bed, banks, course or characteristics of a watercourse. The regulated area of a watercourse for section 21(c) or (i) of the Act water uses means:

a) The outer edge of the 1 in 100-year flood line and/or delineated riparian habitat, whichever is the greatest distance, measured from the middle of the watercourse of a river, spring, natural channel, lake or dam;
b) In the absence of a determined 1 in 100-year flood line or riparian area the area within 100m from the edge of a watercourse where the edge of the watercourse is the first identifiable annual bank fill flood bench (subject to compliance to section 144 of the Act); or
c) A 500 m radius from the delineated boundary (extent) of any wetland or pan.

1.2 Scope of Work

Based on the key legislative requirements listed above the scope of work for this report includes the following:

- Undertake a desktop study of relevant freshwater information for the site;
- Undertake a site visit to the study area;

- Identify and delineate the freshwater ecosystems affected by the development activities;
- Determine the present ecological state, functional importance and conservation value of the freshwater ecosystems that are potentially affected by the proposed development;
- Describe and assess the significance of the potential impacts of the activities on freshwater ecosystems; and
- Provide a summary of the findings in the form of a Freshwater Ecology Impact Assessment Report.

2. METHODS

2.1 Desktop Assessment

A desktop assessment was conducted to contextualize any affected watercourses or estuaries in terms their local and regional setting, and conservation planning. An understanding of the biophysical attributes and conservation and water resource management plans of the area assists in the assessment of the importance and sensitivity of the watercourses, the setting of management objectives and the assessment of the significance of anticipated impacts. The following data sources and GIS spatial information were consulted to inform the desktop assessment:

- DWS spatial layers;
- National Freshwater Ecosystem Priority Areas (NFEPA) spatial layers (Nel et al., 2011);
- National Wetland Map 5 and Confidence Map (CSIR, 2018); and
- Western Cape Biodiversity and Spatial Plan (WCBSP) for Bitou (CapeNature, 2017).

2.2 Baseline Assessment

A site visit was conducted on the 30th of September 2021, with the objective of identifying and classifying watercourses potentially affected by the development, determining their Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS), and assessing the impacts of the development on watercourses.

2.2.1 Watercourse Classification

Classification of watercourses is important as this determines the PES and EIS assessment methodologies that can be applied. Furthermore, classification of the watercourse provides a fundamental understanding of the hydrological and geomorphic drivers that characterise the watercourse and therefore assists in the interpretation of impacts to the watercourse. Watercourses were categorised into discrete hydrogeomorphic units (HGMs) based on their geomorphic characteristics, source of water and pattern of water flow through the watercourse. These HGMs were then classified according to Ollis et al. (2013).

2.3 Impact Assessment

Development activities typically impact on the following important drivers of aquatic ecosystems:

- *Hydrology:* Impacts on hydrological functioning at a landscape level and across the site which can arise from changes to flood regimes and base flows and modifications to general flow characteristics, including change in the hydrological regime or hydroperiod of the aquatic ecosystem (e.g. seasonal to temporary or permanent; impact of over-abstraction or instream or off-stream impoundment of a wetland or river etc.);
- *Geomorphology:* This refers to the alteration of hydrological and geomorphological processes and drivers, and associated impacts to aquatic habitat and ecosystem goods and services primarily driven by changes to the sediment regime of the aquatic ecosystem and its broader catchment;
- *Modification of water quality:* This refers to the alteration or deterioration in the physical, chemical and biological characteristics of water within streams, rivers and wetlands, and associated impacts to aquatic habitat and ecosystem goods and services (e.g. due to increased sediment load, contamination by chemical and/or organic effluent, and/or eutrophication etc.);
- *Fragmentation:* Loss of lateral and/or longitudinal ecological connectivity due to structures crossing or bordering watercourses (e.g. road or pipeline crossing a wetland);
- *Modification of aquatic habitat:* This refers to the physical disturbance of in-stream and riparian aquatic habitat and associated ecosystem goods and services including the loss or degradation of all or part of any unique or important features associated with or within the aquatic ecosystem (e.g. waterfalls, springs, oxbow lakes, meandering or braided channels, peat soils, etc.)*;* and
- *Aquatic biodiversity:* Impacts on community composition (numbers and density of species) and integrity (condition, viability, predator prey ratios, dispersal rates, etc.) of the faunal and vegetation communities inhabiting the site.

Modifications to these drivers ultimately influence the PES and EIS of a watercourse. Accordingly, impacts to the watercourse were described and assessed based on their potential to modify each of the above-mentioned drivers of aquatic ecosystem health, using the PES and EIS of the watercourse as a baseline against which to assess impacts. The impact assessment methodology is described in the appendix to this report (Appendix 3).

3. ASSUMPTIONS & LIMITATIONS

- With ecology being dynamic and complex, there is the likelihood that some aspects (some of which may be important) may have been overlooked;
- This assessment is based on the findings of a visual assessment of the site combined with available desktop resources. This study was not informed by detailed hydraulic, hydrological, faunal or floral assessments;
- The PES and EIS assessments undertaken are largely qualitative assessment tools and thus the results are open to professional opinion and interpretation. An effort has been made to substantiate all claims where applicable and necessary.
- The assessment of impacts relies on an understanding of the conditions prior to the commencement of the unlawful activities. As the activities have already occurred, this assessment relied on a combination of desktop analysis of historical imagery and observed on-site verifications of current conditions.

4. STUDY SITE

The properties are located in quaternary catchment K60F in the Kromme River Primary Catchment (Figure 1). The main river draining this catchment is the Bitou River which, together with the Keurbooms River, forms Keurbooms Estuary located in between Plettenberg Bay and Keurboomstrand. The catchment area falls within the Southern Folded Mountains ecoregion (Ecoregion Level 2: 25.01). The terrain morphology consists predominantly of closed hills and mountains of moderate to high relief with altitude ranging from 100 – 1300 m.a.m.s.l. Rainfall is low (MAP of 0 – 400 mm) and occurs predominantly winter but does occur all year round. Summers are hot (mean daily maximum temperature of 28 to 32 ºC) and winters are mild to cold (mean daily maximum temperature of 12 to 20 ºC).

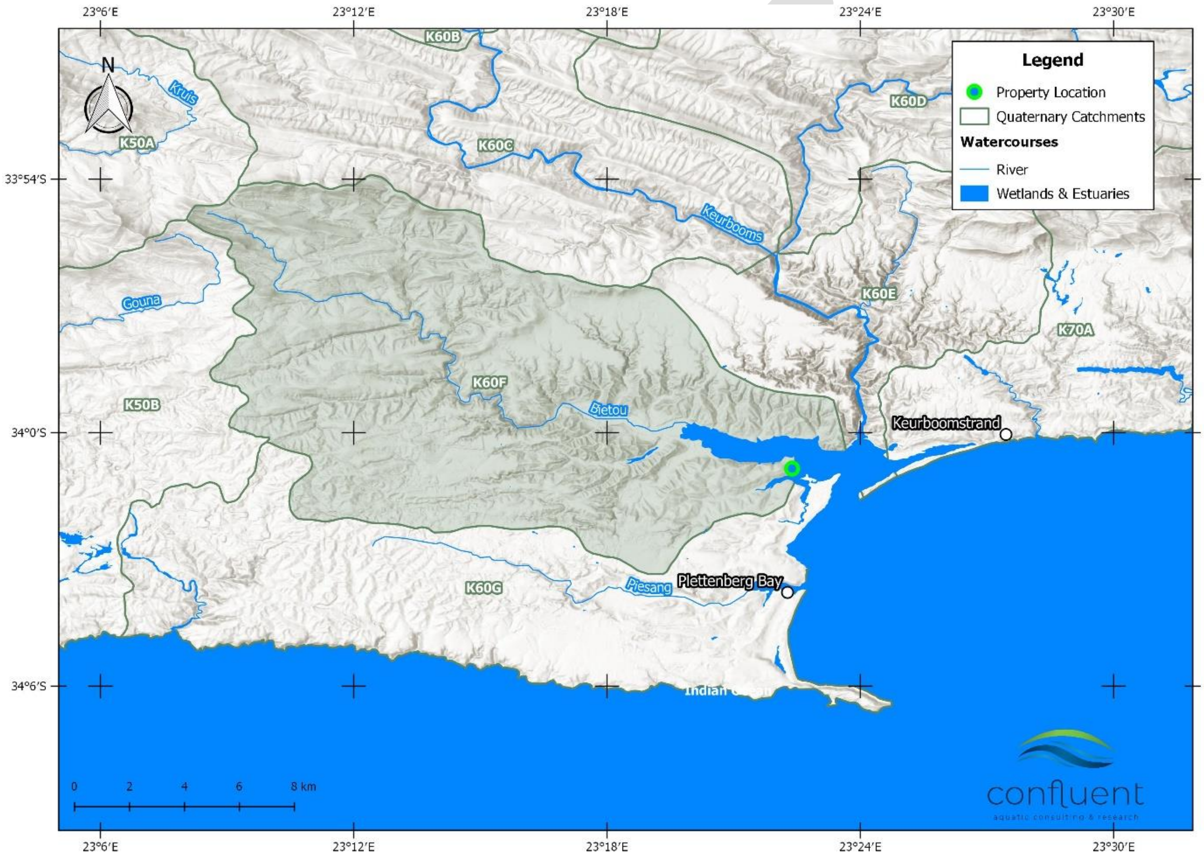

Figure 1: Location of the properties in quaternary catchment K60F.

4.1 National Freshwater Ecosystem Priority Areas (NFEPA)

The properties are located in sub-quaternary catchment (SQC) 9092 (Figure 2). According to the National Freshwater Ecosystem Priority Atlas, this SQC has been classified as a Freshwater Ecosystem Priority Area (FEPA; Nel *et al.,* 2011). A FEPA is an area prioritised for conserving freshwater ecosystems and associated biodiversity. The selection of FEPAs is determined through a process of systematic biodiversity planning using data on freshwater ecosystem types, species and ecological processes. FEPAs should be maintained in a good condition to manage and conserve freshwater ecosystems and to protect water resources for human users. The main river in this SQC is the Bitou River, which joins the Keurbooms River to form the Keurbooms Estuary. The Keurbooms Estuary is classified as an estuary FEPA. The recommended condition for all river FEPAs (i.e. the Bitou River) is an A or B ecological category (Nel et al., 2011). The recommended ecological category for the Keurbooms Estuary is an A (Van Niekerk and Turpie, 2012).

It is therefore important that the catchment area and broader hydrological network must therefore be managed in a way that maintains the good ecological condition of the river reach and estuarine area.

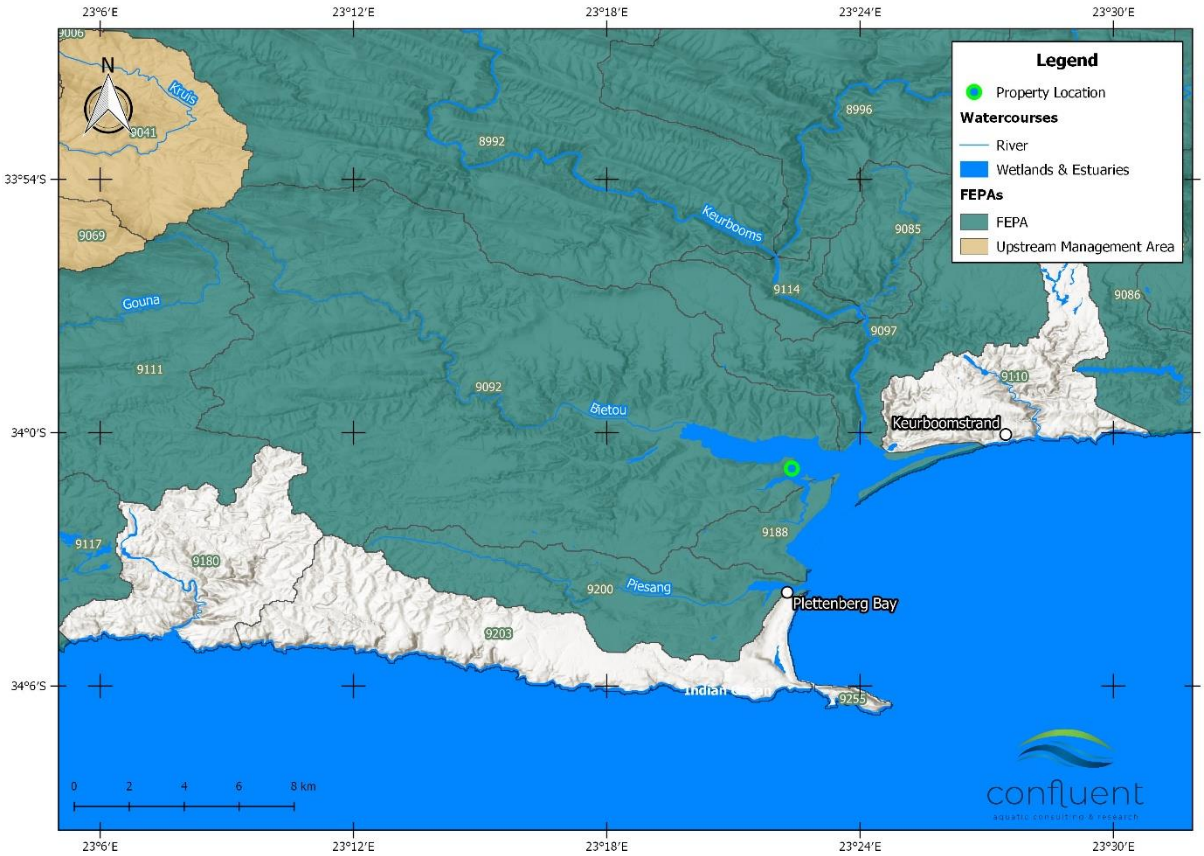

Figure 2: Map of the properties in relation to FEPAs.

4.2 Western Cape Biodiversity Spatial Plan (WCBSP)

According to the WCBSP for Bitou, only the far eastern most corner of RE/7/444 is categorized as an aquatic CBA (Figure 3). No other aquatic CBAs or ESAs are indicated to occur on the remainder of RE/7/444 or either of the other two properties. The designated CBA area on RE/7/444 forms part of the larger Keurbooms estuary and is located upstream of Rietvlei Road. Management objectives for aquatic CBAs are provided in Table 1 and are in general alignment with the FEPA management objectives described in Section 4.1. No activities are planned to be undertaken within any aquatic CBA.

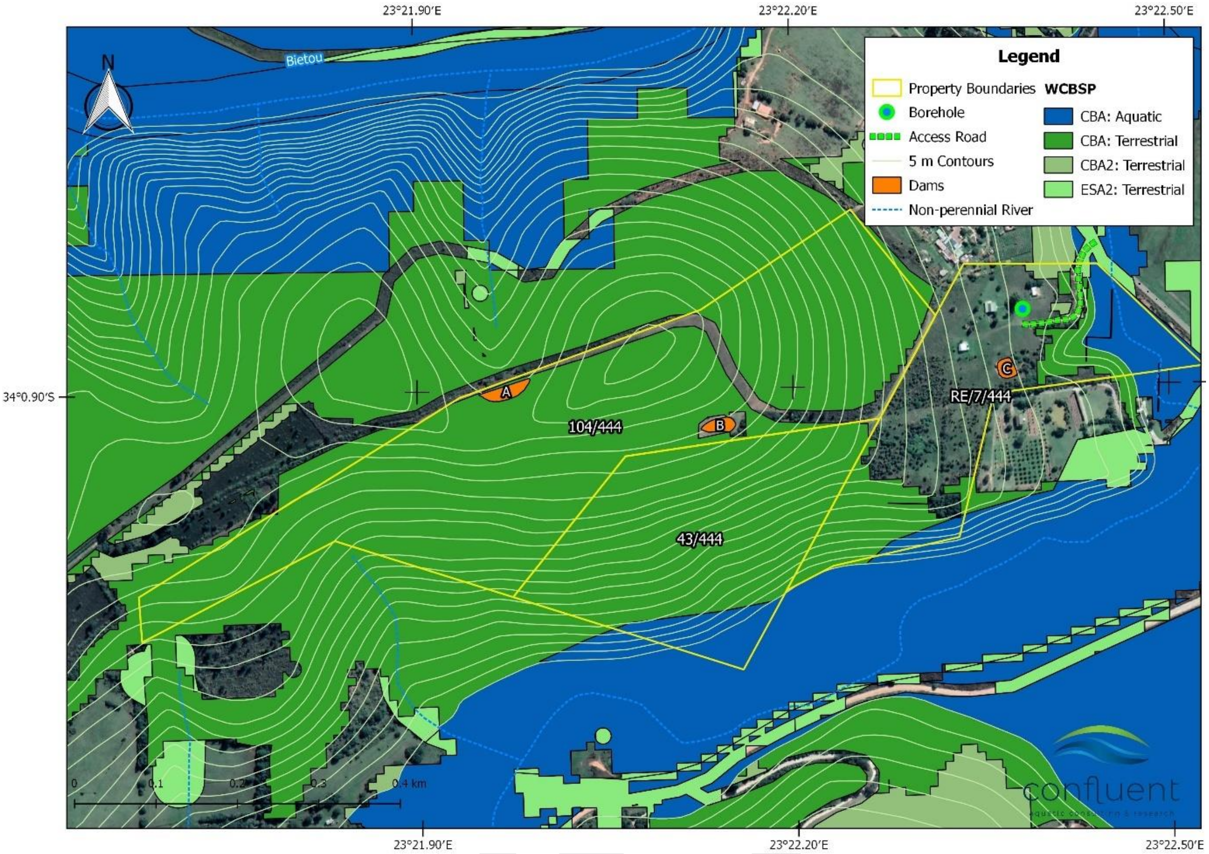

Figure 3: Map of the dams and road crossings in relation to the Western Cape Biodiversity Spatial Plan (WCBSP).

Table 1: Definitions and management objectives of the Western Cape Biodiversity Spatial Plan.

Category	Definition	Management Objective
CBA1	Areas in a natural condition that are required to meet biodiversity targets, for species, ecosystems or ecological processes and infrastructure	Maintain in a natural or near-natural state, with no further loss of natural habitat. Degraded areas should be rehabilitated. Only low-impact, biodiversity-sensitive land uses are appropriate

4.3 Resource Quality Objectives

The classification of water resources and development of Resource Quality Objectives (RQOs) for the Breede-Gouritz Catchment Management Area was finalised in 2018. Quaternary catchment K60F, falls within the G15 Coastal Integrated Unit of Analysis (IUA). The Water Resource Class for this IUA is II, indicating moderate protection and moderate utilisation. The Target Ecological Category (TEC) for the Keurbooms Estuary has been set as an A (Natural), which indicates that the estuary must be managed to achieve a pristine state. Specific RQOs have been produced for the estuary in alignment with the TEC. These include specific limits at which indicators of water quantity and quality, habitat and biota must be maintained. Water quality RQOs that could potentially be influenced by nonpoint source pollution derived from the vineyards are listed in (Table 2). As no part of the development will take place within the estuary, RQOs related to water quantity, habitat and biota are not expected to be affected.

Table 2: Numeric RQOs relevant to potential impacts associated with the development/

Indicator	Numeric RQO
Dissolved Inorganic Nitrogen (DIN)	DIN not >100 µg/L once-off.
Dissolved Inorganic Phosphorus (DIP)	DIP not >20 µg/L once-off
Turbidity	>10 NTU in low flow

5. SITE ASSESSMENT

5.1 Watercourse Classification

The properties are located along a ridge which falls away steeply to the north (in the direction of the Bitou River) and to the south (in the direction of the Diep River) (Figure 4). The estuarine functional zone (EFZ) of the Keurbooms Estuary extends into the eastern most extent of RE/7/444 and the southern extent of 43/444. Otherwise, no watercourses are located within the extent of any of the properties. Two dams are located on 104/444 and one on RE/7/444, all of which are off-stream dams. The northern most dam on 104/444 is located within an area of natural drainage but is not located within a watercourse. A non-perennial drainage line does eventually form further down the slope from this dam, which drains into the Bitou River. The southern-most dam on 104/444 is fed by furrows that run along the contour of the hill. The furrow intercepts runoff from the most elevated portion of the property and directs it into the dam.

The portion of the estuary falling within RE/7/444 is upstream of Rietvlei Road. The road crosses a portion of the estuary that is fed by the Diep River. The road forms a barrier across the estuary and tidal exchange is limited to a series of pipe culverts underneath the road. Consequently, vegetation immediately downstream of the road is more representative of supratidal saltmarsh habitat and is dominated by *Juncus kraussii* (Figure 6). There is a distinct contrast upstream of the road and the area is dominated by species that are more indicative of freshwater conditions which include *Typha capensis* (dominant) and *Phragmites australis* (less abundant).

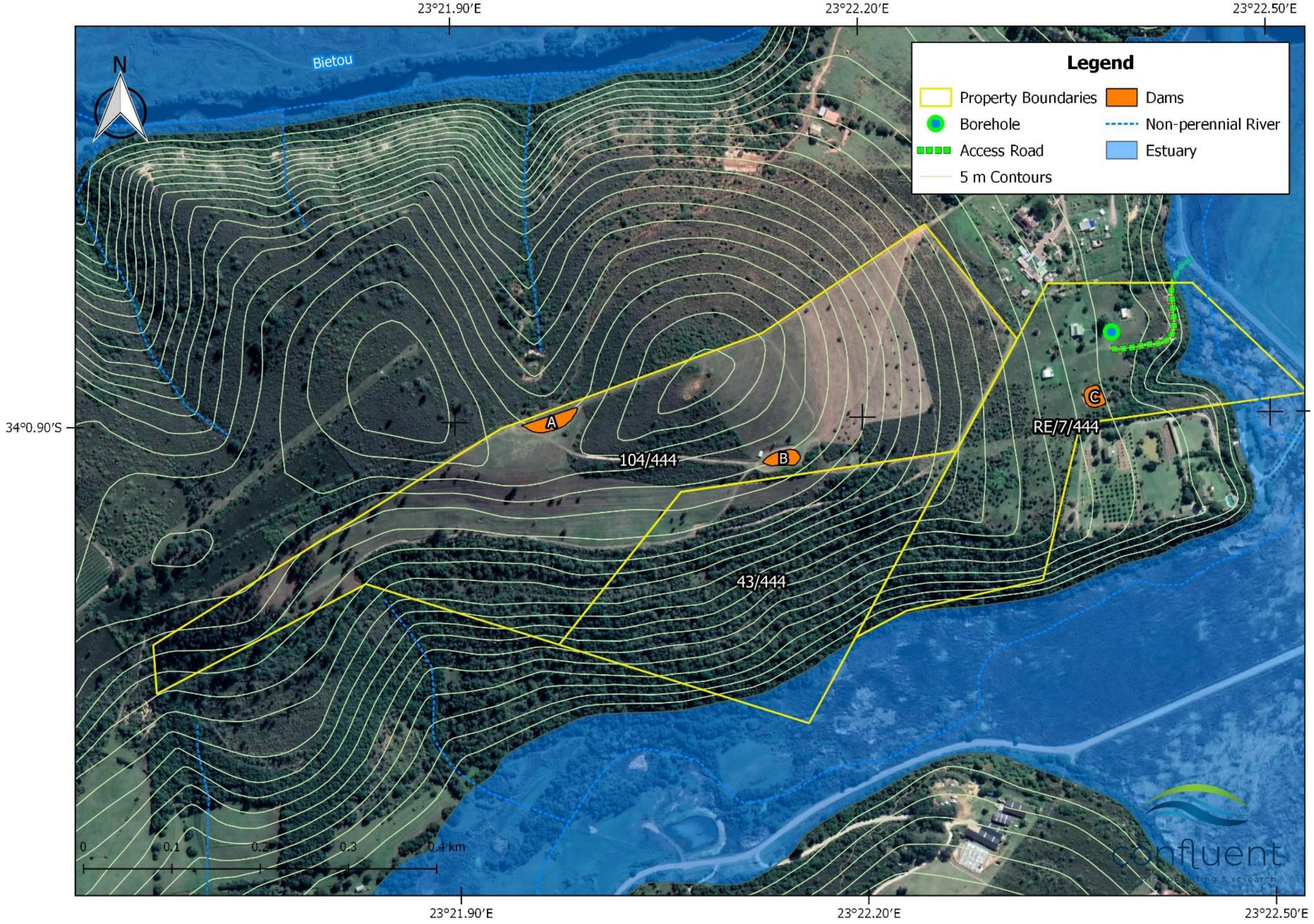

Figure 4: Location of activities in relation to watercourses.

Figure 5: Photographs of three offstream dams located on 104/444 and RE/7/444.

Figure 6: Dense stands of *Juncus kraussii* (left) and *Typha capensis* (right) downstream and upstream of Rietvlei Road, respectively.

5.2 Present Ecological State (PES)

In order to assist with the interpretation of the impact assessment the PES of the Keurbooms Estuary. According to the desktop eco-classification (Van Niekerk *et al.* 2015) the PES of the Keurbooms Estuary is B (Table 3), indicating that there has been a small change from the natural state. Most of the abiotic indices used to derive the overall PES are in fact in a natural condition (A). Modifications to fish assemblages and bird populations are the most important drivers of change from the natural state. The ecological importance is therefore regarded as being high and Turpie (2004) ranked the Keurbooms estuary as the 18th most important system in South Africa in terms of conservation importance. According to the National Wetland Map Version 5 (CSIR, 2018) the ecosystem threat status of the Keurbooms Estuary is Vulnerable, and the protection status is Poorly Protected.

Table 3: Summary of the Present Ecological Status (PES) and Ecological Importance of the Keurbooms Estuary (Van Niekerk *et al*., 2015).

Index	Category
Hydrology	*A*
Hydro-dynamics	*A*
Physical Habitat	*A*
Salinity	*A*
Water Quality	*A/B*
Microalgae	*A*
Macrophytes	*A/B*
Invertebrates	*A*
Fish	*B/C*
Birds	*B*
Overall PES	**B**
Ecological Importance	**High**

6. SUMMARY OF PROPOSED ACTIVITIES

The proposed layout of the vineyard is illustrated in Figure 7. Specific activities are discussed in more detail in the sections below.

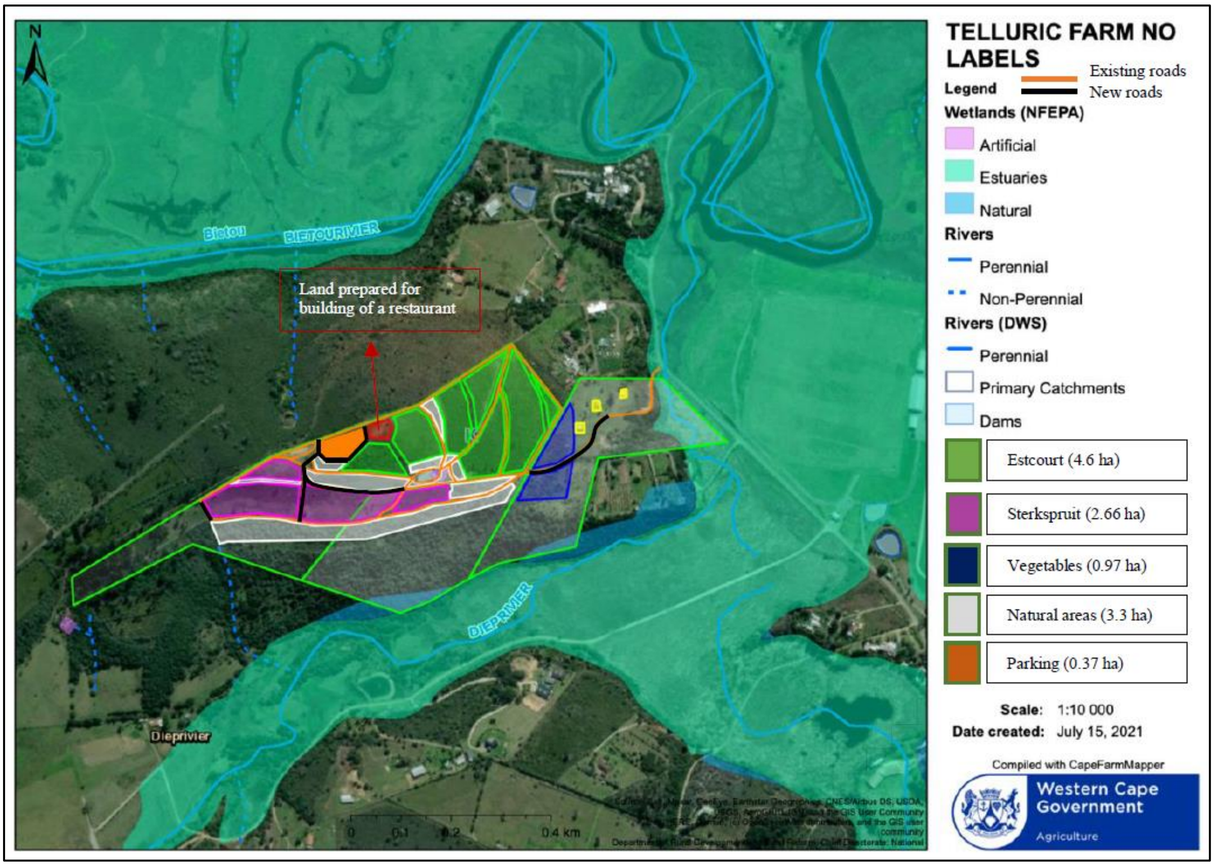

Figure 7: Proposed layout of vineyards and associated infrastructure (obtained from the Agricultural Agro-Ecosystem Specialist Assessment and Management Plan for Future-Centric Farm: Telluric).

6.1 Establishment of Borehole

A borehole has been sunk to provide water for supplementary irrigation of the vines. The borehole is located within 500 m of the estuary (Figure 4). Abstraction of water from a borehole within 500 m of a wetland or estuary requires a Water Use License Application (WULA) as per Section 21 (a) of the NWA.

6.2 Upgrade of Access Road

An existing dirt access road will be formalised as an entrance into the vineyard. This will involve widening the existing road and tarring it. The road runs up a steep slope that runs up from Rietvlei Road, into the property (Figure 4). The start of the road at the junction with Rietvlei Road occurs within EFZ and any areas outside of the footprint of this stretch of existing road should be regarded as sensitive (particularly south and east of the existing road) (Figure 8). The embankment to the east of road falls away steeply down towards the EFZ below.

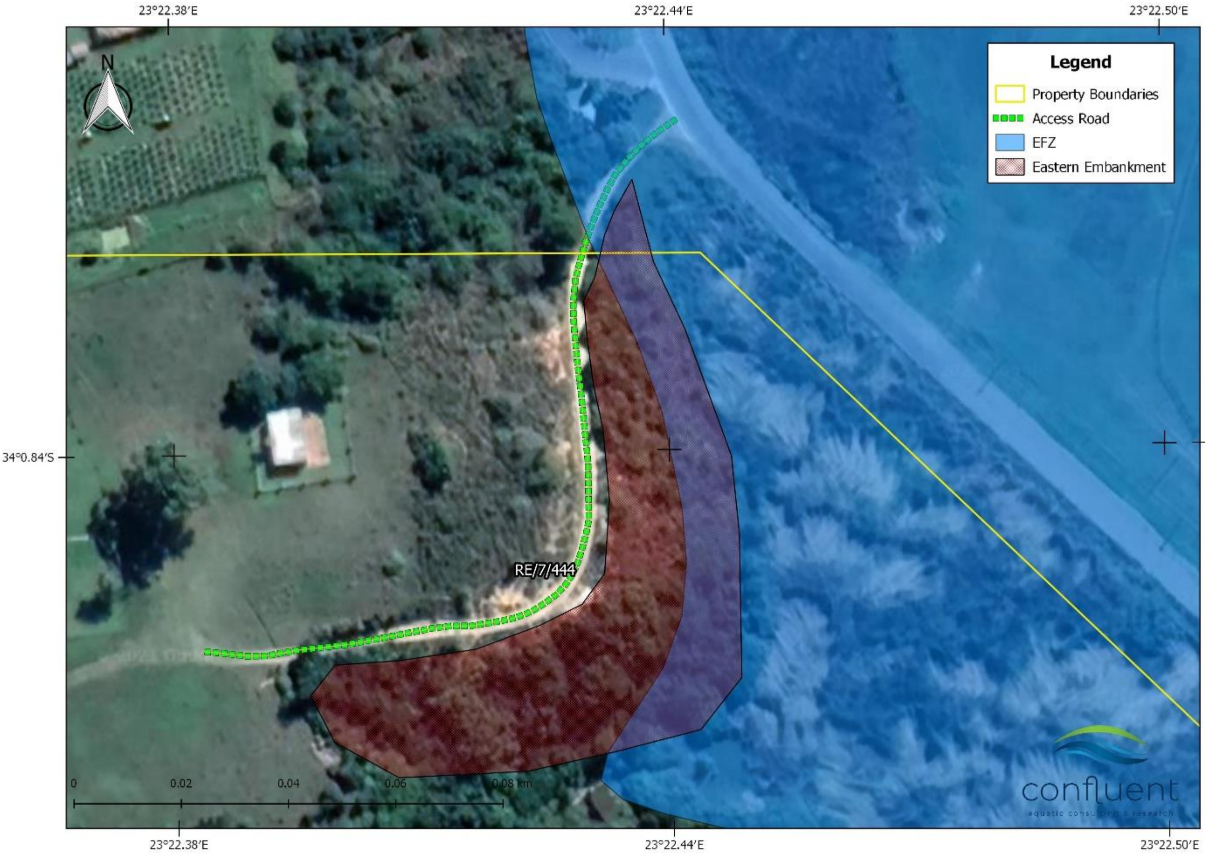

Figure 8: Map indicating the existing access road, the EFZ and the steep embankment to the east of the road.

6.3 Formalisation of Dams

Three farm dams are situated on two of the properties (Figure 4). Two are situated on Portion 104 of 444 and one on Portion RE/7/444. While these dams are located within areas of natural drainage, none of these dams are located within a watercourse. A contoured furrow intercepts surface runoff and supplies water to Dam B, while Dam A and C receive surface runoff from the hillslopes.

In order to ensure the dams store water efficiently, Dams A and B will undergo a restoration and upgrading process. These processes will include the clearing, grading and proper sealing of the dams via a sodium bentonite clay application. The dams will be emptied by pumping the water into a holding tank or sleeve. The existing dam substrate will be loosened to a depth of 200 – 300 mm and all slopes in the dams will be graded to approximately 18 - 20 degrees. All organic matter, plants and foreign matter/materials (stones, rocks, roots, etc.) will be removed and the soil will be prepared to wet for optimal conditions (this refers to adding water to the area needing to be sealed until the water content is over the optimal so that optimal compaction can occur). Bentonite clay will be spread over the wet area via raking and mixed into the soil by hand in order to achieve a homogeneous mixture. A plate compactor will then be used i to seal and smooth the area. The final sealed thickness will be approximately 100-150mm.

Dam C will be enlarged to a volume of approximately 4 700 m^3. This storage volume will exceed the volume of storage which can be generally authorised (2 000 m^3 per property) as per the NWA. The enlargement of the Dam C will therefore require a WULA as per Section 21 (b) of the NWA.

Table 4: Estimated dimenstions and storgae capacity of dams.

Dam	Surface Area (m^2)	Average Depth (m)	Volume (m^3)
Dam A	650	1.5	975
Dam B	650	1.5	975
Dam C	300	2	600

6.4 Establishment of Vineyards

The establishment of vineyards will largely be restricted to the slopes of Portions 43 and 104 of Farm 444 of and will not encroach into any watercourses. The vineyards will be established on existing pastures and will not encroach into the broad band of indigenous vegetation that runs along the southern slopes of all three properties, which will serve as an effective buffer.

6.5 Construction of Infrastructure

Additional infrastructure will include the development of a restaurant and cellar and associated parking on top of the hill on Portion 104 of 444. Various other smaller buildings will be constructed on RE7 of 444.

6.6 Determination of Section 21 (c) & (i) Water Uses

According to the NWA estuaries are not defined as watercourses and activities in proximity to estuaries are therefore not considered as Section 21 (c) & (i) water uses. Activities within 500 m of wetlands are however considered as Section 21 (c) & (i) water uses. Estuaries are by their nature transitional zones where marine water and freshwater mix and where constantly changing tidal influences create a dynamic environment. It can therefore be complex to determine where freshwater areas (i.e. wetlands and rivers) end and where estuaries begin. The most recent delineation of the Keurbooms Estuary is displayed in Figure 9. The boundaries of the estuary were confirmed and used for the for reserve determination studies for selected estuaries in the Breede-Gouritz Water Management Area (DWS, 2015). This delineation is therefore considered to be the most recent and accurate estimation of the boundaries of the estuary. The map illustrates that all planned activities within the Telluric Farm will occur within 500 m of the estuary. No Section 21 c & i water uses are therefore applicable from the perspective of water use authorisation for the project.

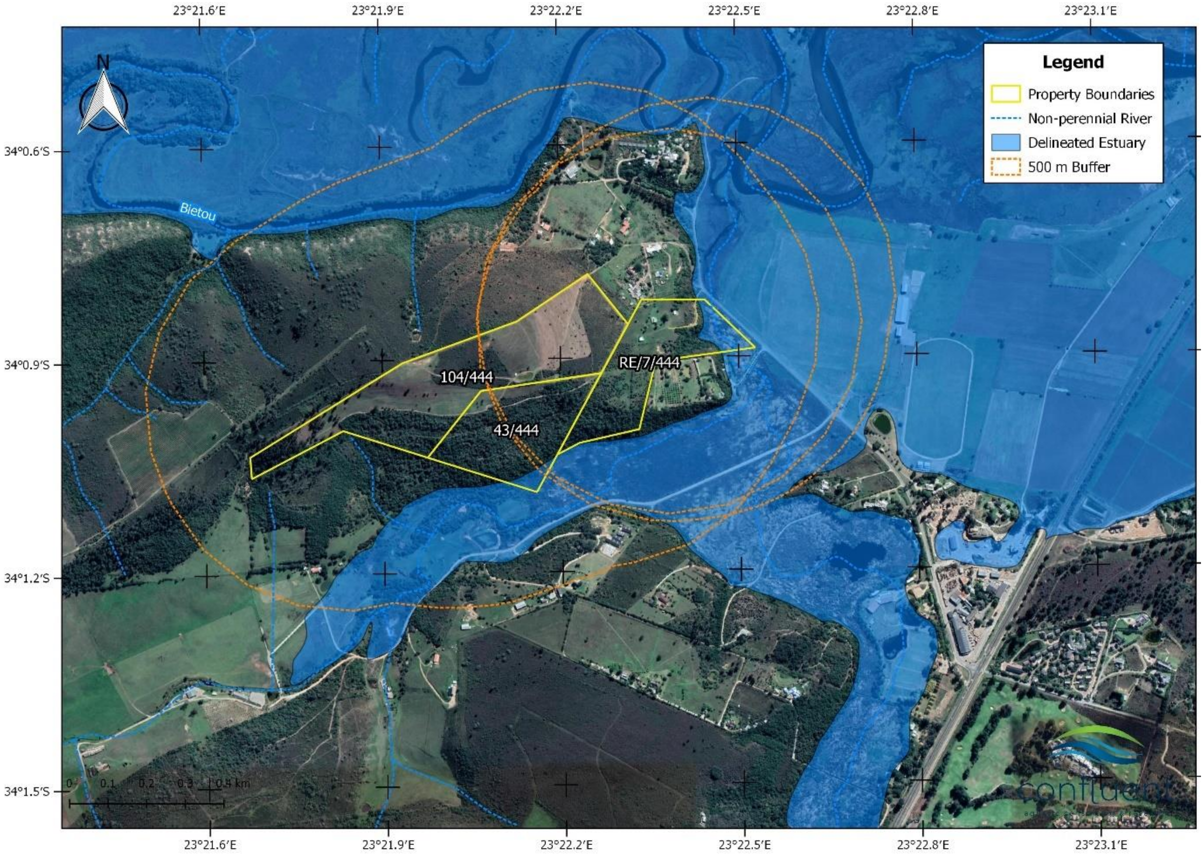

Figure 9: Map indicating 500 m buffers around planned activities on Telluric Farm in relation to mapped freshwater and estuarine features.

7. IMPACT ASSESSMENT

Much of the development will occur on relatively steep slopes that drain towards the Diep River arm of the estuary. Therefore, while no construction or operational activities will occur within the delineated area of a watercourse or within the estuary, it is important that the site is carefully managed so as to avoid erosion and runoff of sediments, nutrients and other pollutants (i.e. pesticides) into sensitive water resources. In this respect the proximity of the vineyards and the wide, well vegetated buffer in between the vineyards and the Diep River arm of the estuary will provided significant protection and will minimise impacts to the estuary. The upgrade of the access road will take place in closer proximity to the estuary and represents the most significant potential impact to the estuary.

7.1 Construction Phase Impacts

Impact 1: Disturbance of wetland habitat caused during the upgrade of the access road.

The access road is in close proximity to the estuary and the presence and operation of construction vehicles and storage of construction materials could potentially encroach into estuarine habitat causing disturbance to estuarine fauna and flora. While the road does occur within the EFZ, widening of the road will not encroach into any estuarine habitat.

	Without Mitigation	With Mitigation
Intensity	Low	Very low
Duration	Short term	Brief
Extent	Limited	Limited
Probability	Likely	Unlikely
Significance	**-40: Minor (-)**	**-18: Negligible (-)**
Reversibility	High	High
Irreplaceability	Low	Low
Confidence	High	High

Mitigation:

- The alignment of the widened road must be clearly demarcated to avoid any unnecessary disturbance of estuarine habitat outside of the demarcated area; and
- No construction materials or equipment (including vehicles) must be stockpiled/parked/stored outside of the demarcated area of the widened access road in the EFZ (see Figure 8).

Impact 2: Input of suspended sediment into the estuary caused by erosion during upgrading the access road.

Preparation of the road surface and widening of the road along its steep gradient is likely to expose a large area of bare soil that could be vulnerable to erosion. The proximity of the road to the estuary could lead to high loads of sediment being transported into the estuary during rainfall events.

	Without Mitigation	With Mitigation
Intensity	Moderate	Low
Duration	Short term	Brief
Extent	Local	Limited
Probability	Almost certain	Probably
Significance	**-60: Minor (-)**	**-28: Negligible (-)**
Reversibility	High	High
Irreplaceability	Low	Low
Confidence	High	High

Mitigation:

- Upgrade of the road surface must be planned to coincide with the dry season;
- Silt fencing must be placed along the eastern edge of the road to minimise sediment runoff down the steep embankment of the road into the estuary. This fencing must extend along the length of the road up to the junction with Rietvlei Road;
- Surface runoff from the road must be prevented from washing over the side of the eastern embankment of the road and into the estuary below. If necessary, surface runoff can be channelled along the length of the road (e.g. using packed sand bags) down towards the

junction with Rietvlei Road, where it must be attenuated by a temporary check dam (e.g. constructed from hay bales), before draining towards the estuary;

- There are currently existing narrow pipe culverts beneath the road that drain water from the western to the eastern side of the road and down the side of the steep eastern embankment towards the estuary. If these are to remain within the new road design, they must be blocked during the construction phase to prevent sediment laden water from discharging onto the eastern embankment; and
- Any exposed sections of embankments to the side of the road must be re-vegetated post construction to stabilise soil and minimise erosion.

Impact 3: Pollution of estuary caused by spillage and leaks of hydrocarbons used in construction vehicles and machinery

The use, parking, refuelling and servicing of construction vehicles (and machinery) could potentially result in leaks or spills of hydrocarbons (i.e. fuel, oil, grease etc.) which could contaminate the estuarine habitat via surface runoff.

	Without Mitigation	With Mitigation
Intensity	Moderate	Very low
Duration	Short term	Brief
Extent	Local	Limited
Probability	Likely	Unlikely
Significance	**-50: Minor (-)**	**-18: Negligible (-)**
Reversibility	High	High
Irreplaceability	Low	Low
Confidence	High	High

Mitigation:

- All potentially hazardous substances (e.g. diesel, oil etc.) must be stored in appropriately bunded area that fall outside of the direction of preferential flow paths and outside of the EFZ;
- No refuelling or maintenance of vehicles within the EFZ;
- Vehicles and equipment must be regularly serviced and maintained; and
- Excavators and all other machinery and vehicles must be checked for oil and fuel leaks daily. No machinery or vehicles with leaks are permitted to work within the EFZ.

7.2 Operational Phase Impacts

Impact 4: Pollution of estuarine habitat caused by runoff of sediments, pesticides and nutrients from vineyards

Vineyards will be established on steep slopes which could mobilise sediments, nutrients and pesticides via surface runoff into estuarine habitat. The vineyards are however well-buffered from the estuary, and together with the implementation of additional mitigation measures, this impact is expected to be negligible.

	Without Mitigation	With Mitigation
Intensity	Very low	Negligible
Duration	Ongoing	Ongoing
Extent	Local	Limited
Probability	Probably	Unlikely
Significance	**-44: Minor (-)**	**-27: Negligible (-)**

Reversibility	High	High
Irreplaceability	Low	Low
Confidence	High	High

Mitigation:

- Vineyard rows must be planted along the contours as opposed to perpendicular to the contours;
- Cultivation of indigenous permanent cover crop on the vine row (underneath the vines) and in work rows (rows between the vines) will improve water retention and soil structure and control unwanted weeds and also minimise transport of soil, nutrients and pesticides in surface runoff;
- Representative soil samples will be taken and analysed to ensure that only nutrients removed from the soil during the growth season will be replaced by fertilisation. This minimises over-application of fertilisers;
- The farm will rely heavily on integrated pest management in such a way that chemical control will be eliminated as far as possible. Biological chemicals will be applied if intervention is at all necessary; and
- The estuary is well buffered from the vines due to the large distance between vineyards and the estuary (approximately 200 m) and the presence of a broad band of indigenous vegetation that runs along the northern bank of the Diep River. The large distance between the vineyards and the estuary will significantly minimise impacts of surface runoff from the vineyards to the estuary

Impact 5: Erosion of the bed and banks of the estuary caused by stormwater discharge from the access road and other hardened surfaces.

Significant stormwater volumes could be generated from the steep slopes of the property. The access road in particular can become a significant conduit that directs stormwater along the road and directly into estuarine habitat. This could lead to scour and erosion of the bed and banks of the estuary.

	Without Mitigation	**With Mitigation**
Intensity	Moderate	Low
Duration	Ongoing	Ongoing
Extent	Limited	Limited
Probability	Likely	Unlikely
Significance	**-60: Minor (-)**	**-33: Negligible (-)**
Reversibility	High	High
Irreplaceability	Low	Low
Confidence	High	High

Mitigation:

- Landscaping at higher elevations within the properties must aim to direct surface runoff away from road surfaces towards natural or artificial detention areas (e.g. Dam C, swales etc.); and
- Stormwater discharge from hardened surfaces (e.g. access road, parking areas etc.) must be directed through retention and/or energy dissipation structures prior to discharging into any estuarine or terrestrial habitat.

8. CONCLUSION

The majority of activities will occur well outside of the Keurbooms Estuary and the broader hydrological network and no degradation of aquatic habitat is anticipated. The most significant impacts are associated with the upgrade of the access road. These impacts can however be mitigated to result in negligible impacts on the estuary. In general, all activities and associated impacts are aligned to provincial and national conservation and water resource management objectives (**Error! Reference source not found.**) and it is highly unlikely that this d evelopment will compromise the PES (B) or TEC (A) of the estuary or result in impacts that will not meet the RQOs established for the Keurbooms Estuary.

Overall, the nature of the development and associated construction and operational phase impacts are considered to be acceptable from an aquatic ecosystem perspective and it is recommended that authorisation should be granted for the project.

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APPENDIX 1: IMPACT ASSESSMENT METHODOLOGY

Individual impacts for the construction and operational phase were identified and rated according to criteria which include their intensity, duration and extent. The ratings were then used to calculate the consequence of the impact which can be either negative or positive as follows:

Consequence *= type x (intensity + duration + extent)*

Where type is either negative (i.e. -1) or positive (i.e. 1). The significance of the impact was then calculated by applying the probability of occurrence to the consequence as follows:

Significance *= consequence x probability*

The criteria and their associated ratings are shown in Table 5.

Table 5: Categorical descriptions for impacts and their associated ratings

Rating	Intensity	Duration	Extent	Probability
1	Negligible	Immediate	Very limited	Highly unlikely
2	Very low	Brief	Limited	Rare
3	Low	Short term	Local	Unlikely
4	Moderate	Medium term	Municipal area	Probably
5	High	Long term	Regional	Likely
6	Very high	Ongoing	National	Almost certain
7	Extremely high	Permanent	International	Certain

Categories assigned to the calculated significance ratings are presented in Table 6.

Table 6: Value ranges for significance ratings, where (-) indicates a negative impact and (+) indicates a positive impact

Significance Rating	Range	
Major (-)	-147	-109
Moderate (-)	-108	-73
Minor (-)	-72	-36
Negligible (-)	-35	-1
Neutral	0	0
Negligible (+)	1	35
Minor (+)	36	72
Moderate (+)	73	108
Major (+)	109	147

Each impact was considered from the perspective of whether losses or gains would be irreversible or result in the irreplaceable loss of biodiversity of ecosystem services. The level of confidence was also determined and rated as low, medium or high (Table 7).

Table 7: Definition of reversibility, irreplaceability and confidence ratings.

Rating	Reversibility	Irreplaceability	Confidence
Low	Permanent modification, no recovery possible.	No irreparable damage and the resource isn't scarce.	Judgement based on intuition.
Medium	Recovery possible with significant intervention.	Irreparable damage but is represented elsewhere.	Based on common sense and general knowledge
High	Recovery likely.	Irreparable damage and is not represented elsewhere.	Substantial data supports the assessment

Groundwater Complete

TELLURIC: REPORT ON GEOHYDROLOGICAL INVESTIGATION AS PART OF THE WATER USE LICENSE APPLICATION

JANUARY 2022

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LIST OF ABBREVIATIONS

ABBREVIATION		MEANING
mbs	-	**Meters below surface**
mamsl	-	**Meters above mean sea level**
m^2/s	-	**Meter squared per second**
l/s	-	**Liters per second**
km	-	**Kilometer**
ha	-	**Hectare**
DWS	-	**Department of water & sanitation**
I&APs	-	**Interested & affected persons**
MAP	-	**Mean annual precipitation**
WULA	-	**Water Use License Application**
mm/a	-	**millimeters per year**
GQM	-	**Groundwater Quality Management**

TELLURIC FARM: REPORT ON GEOHYDROLOGICAL INVESTIGATION AS PART OF THE WATER USE LICENSE APPLICATION: JANUARY 2022

EXECUTIVE SUMMARY:

Groundwater Complete was contracted by Beauconstantia to conduct a geohydrological study and report on findings as specialist input to the Water Use License Application (WULA) for the farm Ganse Vallei 444 portion RE/7 (hereinafter referred to only as Telluric).

The proposed water use is located on Remainder 7 of the farm Ganse Vallei 444, which is situated approximately 4 kilometres north-east of Plettenberg Bay Town in the Western Cape Province. The proposed site is situated 1.3km off the N2, bordering the estuary of the Bitou River.

The geohydrological environment can be summarised as follows:

- The geology in the Telluric area created a highly varying secondary, fractured rock aquifer system with various unconnected or poorly connected aquifers.
- The area is underlain by Cape Supergroup sedimentary rocks.
- The Cape Supergroup is known for deformation and creating the cape fold belt mountain ranges. The deformation can also form high-yielding fractured aquifers.
- The borehole was drilled to a depth of 195 m and casing was inserted to 150m and sealed off.
- The upper part of the borehole was sealed of due to the poor water quality in the upper aquifers.
- The static groundwater level depth varies greatly due to the poorly connected aquifers and ranges between 18 and 20 mbs.
- The aquifer at Telluric receives on average approximately 7 % recharge of the MAP, which is estimated to be a conservative value.
- There are no other groundwater users nearby who will be influenced by the water use applied for in this application.

The aquifer test program revealed the following:

- The transmissivity for the Telluric borehole is approximately 4.5 m^2/d.
- The sustainable yield for the borehole was calculated to be 8 280 l/h, respectively for a 24-hour per day pumping cycle.
- The total daily sustainable yield is 198 000 l/d, which translates to 72 500 m^3/a.

The baseline assessment, geology and aquifer test results led to the following conceptual model:

- Telluric is located on a large deposit of **Kirkwood** conglomerate, siltstone and mudstone.
- The Kirkwood formation is underlain by the Baviaanskloof and Skurweberg formations, which is likely where the groundwater from the borehole is sourced from.

- The shale, siltstone and mudstone layers act as aquicludes or groundwater barriers, that do not allow movement between upper and lower layers.
- Due to the dipping/sloping nature of the geology the groundwater recharge to the deeper aquifers does not take place around the borehole but to the west and north of the borehole where the aquifer outcrops.

Conclusions and recommendations from the impact assessment are provided below:
If the recommended sustainable yields per borehole are not exceeded, the proposed groundwater abstraction is not expected to neither have significant immediate effects on groundwater availability of nearby groundwater users not would it have lasting adverse impacts on the groundwater system.

The pumping tests have shown that after extensive pumping:

- During the pumping test, the borehole responded well to pumping and used very little of the available drawdown.
- After pumping was ceased, the borehole recovered quickly and completely, further indicating the strength of the borehole.
- The estimated sustainable yield of 2,3 l/s is a safe and conservative rate for the borehole to be used at.
- The estimated sustainable yield is more than sufficient to provide the volume of 1.7 l/s applied for in the WUL application.
- There is low risk of saltwater intrusion due to the piezometric pressure of the sandstone aquifer and the integrity of the Kirkwood formation.
- Monitoring of the quality and groundwater level will be conducted to ensure that the borehole does not impact the groundwater quantity or quality.

1 INTRODUCTION

Groundwater Complete was contracted by Beauconstantia to conduct a geohydrological study and report on findings as specialist input to the Water Use License Application (WULA) for the farm Ganse Vallei 444 portion RE/7 (hereinafter referred to only as Telluric).

The proposed water use is located on Remainder 7 of the farm Ganse Vallei 444, which is situated approximately 4 kilometres north-east of Plettenberg Bay Town in the Western Cape Province. The proposed site is situated 1.3km off the N2, bordering the estuary of the Bitou River. A map showing the location of the property and borehole is provided in **Figure 1**.

The intent of the WULA is to pump water from a borehole to use in the cultivation of a vineyard, orchards and potential restaurant-type venue.

Notes:

- *The main aim of this study was to determine the potential impact of the proposed water use on both the groundwater quality and quantity.*

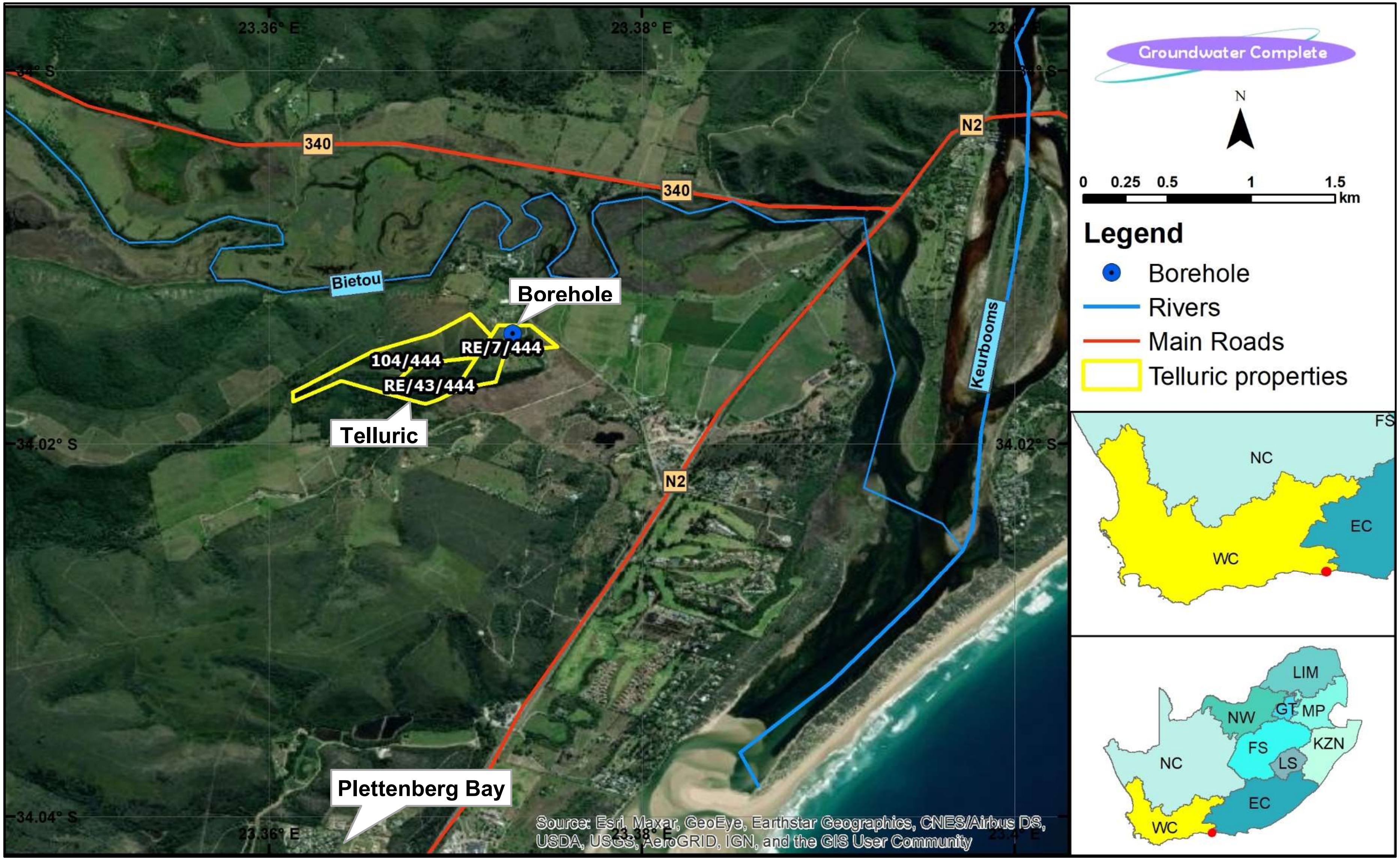

Figure 1: Locality map showing the project area around Telluric.

2 GEOGRAPHICAL SETTING

2.1 SURFACE TOPOGRAPHY AND WATER COURSES

The study area is situated in the fynbos biome region of Western Cape, South Africa. The highest surface elevations in and around the project outline are hills in and around the project area, at around 200 mamsl. The lowest elevations are river valleys at sea level (0 mamsl) to the south. The Telluric borehole itself, is situated at around 25 mamsl.

The watercourses in the vicinity of the project area drain predominantly to the south. The Bitou River is situated north and east of Telluric while the Diep River flows past the southern portion of the site. The part of the Bitou River located near the borehole is classified as an estuary, rising and falling with the tides and the water is therefore of significantly higher salinity.

Notes:

- *The water courses in the project area are all in their lower reaches (due to proximity to the ocean) and would rather be classified as estuaries than rivers. Their levels and qualities (especially the Bitou River) are greatly influenced by the ebbing and flowing tides.*

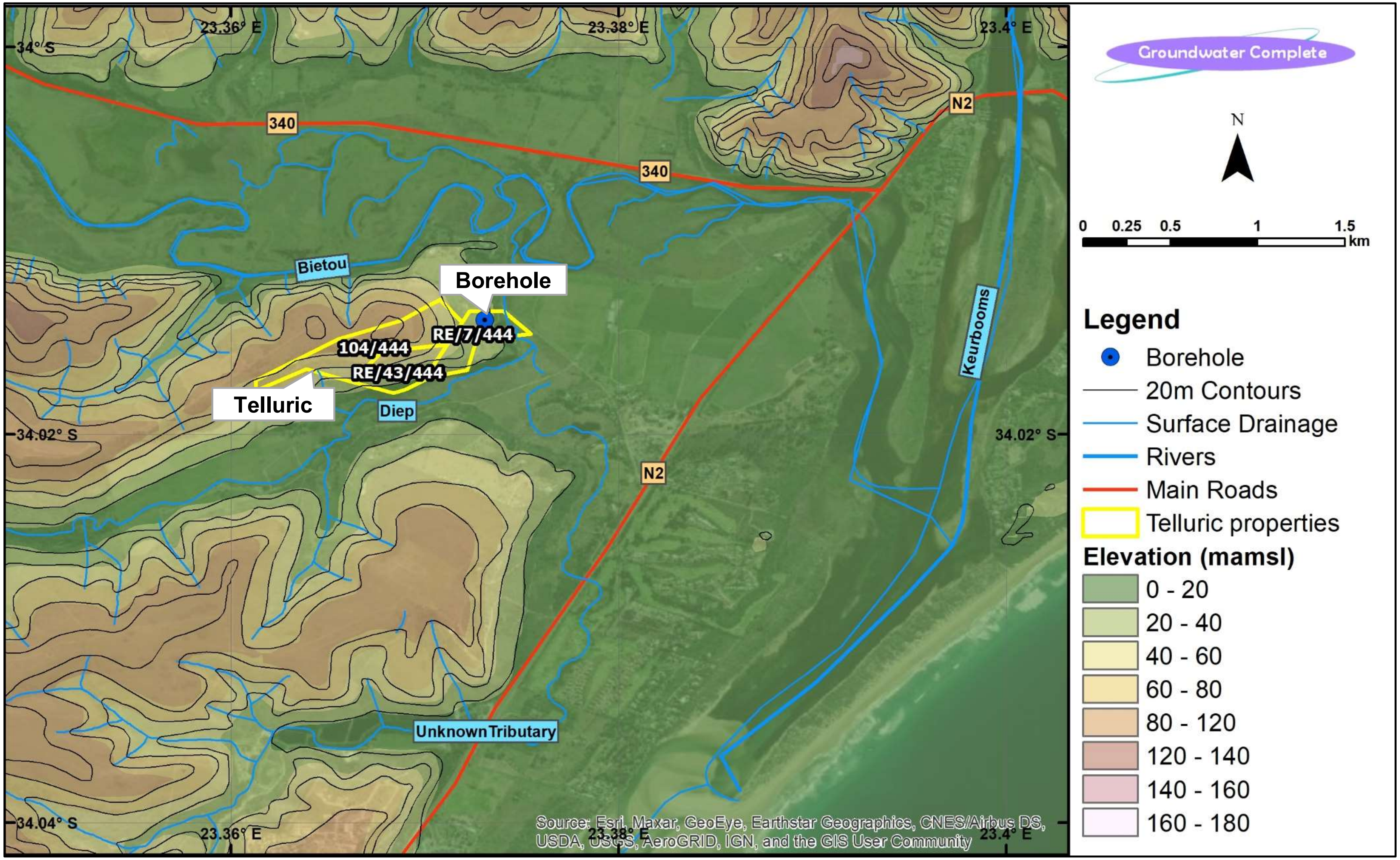

Figure 2: Surface elevations and water courses

2.2 CLIMATIC CONDITIONS

The project area is located within a region that receives its annual rainfall more or less equally distributed throughout the year **(Figure 3)**. Unfortunately, the nearest available rainfall station containing any useful long-term data is located 60 km to the west of Telluric near the town of Wilderness. In spite of the distance, the MAP at the Telluric should be closely enough represented by the DWA rainfall station (K3E003) for the purposes of this study. Thus, the MAP at Telluric is estimated at approximately 650 mm/a.

Average daily temperatures vary from approximately 24 ^{0}C in the summer to ± 17 ^{0}C in the winter. Average night temperatures vary from approximately 17 ^{0}C in the summer to ± 10 ^{0}C in the winter **(Figure 4).**

Evapotranspiration is relatively low (about 1 000 mm/a), but still results in an environmental moisture deficit for 9 months of the year **(Figure 3)**.

Notes:

- *The project area has a mild climate with approximately 650 mm of rainfall distributed relatively evenly through the year.*
- *Evapotranspiration is relatively low but still results in an environmental moisture deficit for 9 months of the year.*

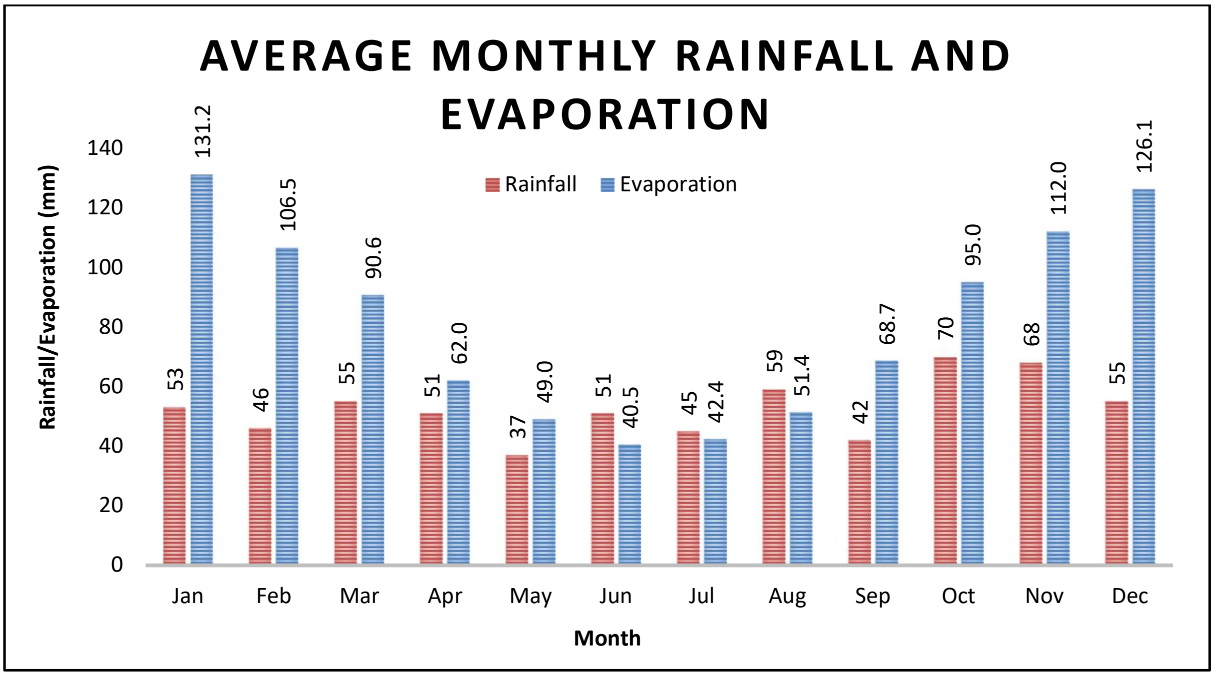

Figure 3: Average monthly rainfall and evaporation for the Wilderness area (DWA, 2015)

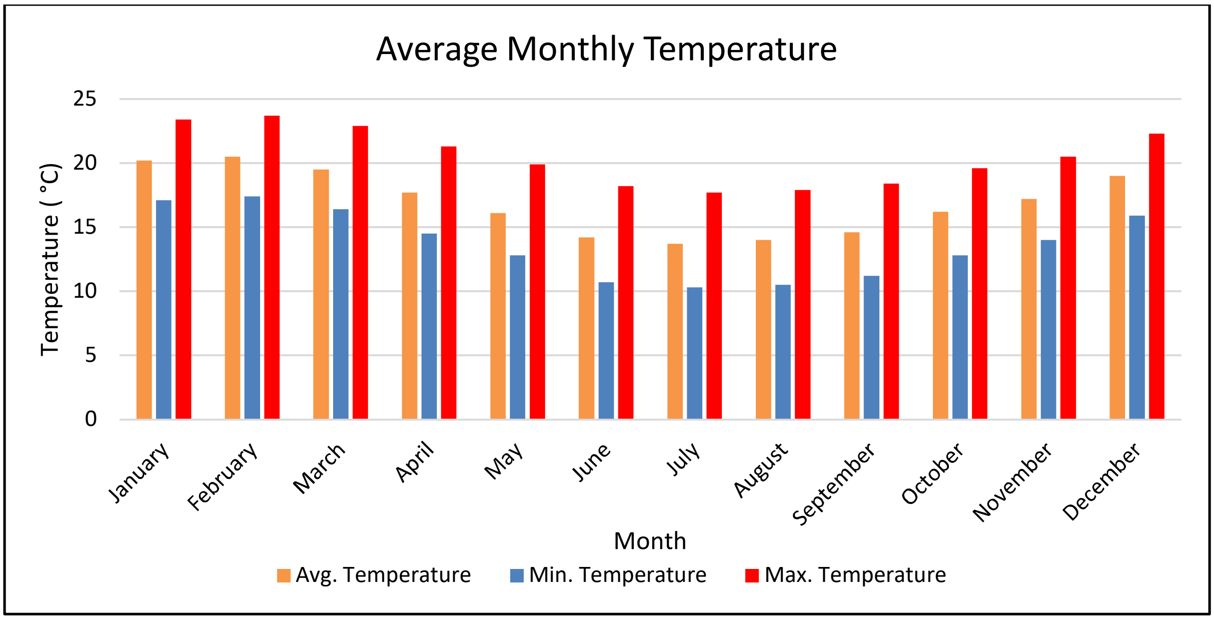

Figure 4: Average monthly temperatures for the Plettenberg Bay area *(en.climate-data.org, 2021)*

3 METHODOLOGY

3.1 DESK STUDY

No previous groundwater studies could be found in the immediate vicinity of Telluric as there are virtually no other groundwater users in the area. The only reports in the wider area are internal project reports conducted during various studies (including artificial recharge, exploration for, drilling and testing of boreholes for bulk water supply) to the Plettenberg Bay municipality. Three such studies are referenced in Section 10 and are abbreviated as

- *Groundwater Africa, 2007 – Artificial recharge assessment*
- *Groundwater Africa, 2018 – Groundwater supply – Plettenberg Bay*
- *Groundwater Africa, 2021 – Groundwater Supply – Kurland.*

Other reports on the characteristics of the Table Mountain Group aquifers were consulted – most notably "Characterisation Of The Deep Aquifers Of South Africa – The Karoo Supergroup And Table Mountain Group (*Makiwane, 2019*)" for this report. Existing 1:250 000 geological and 1:500 000 hydrogeological maps were used during the assessment **(Figure 9)**.

3.2 RESULTS OF HYDROCENSUS/USER SURVEY

A hydrocensus/groundwater user survey was conducted within the project area by Groundwater Complete in January 2022. The main objectives of a hydrocensus field survey can be summarised as follow:

- To locate all interested and affected persons (I&APs) with respect to groundwater and surface water – most notably water users,
- To collect all relevant information from the I&APs (i.e. name, telephone number, address, etc.),
- Accurately record/log boreholes on the I&APs properties, and
- To collect all available information regarding the logged boreholes (i.e. yield, age, depth, water level etc.) but especially the use of groundwater from boreholes in the area.

A total of 18 landowners/neighbours were contacted during the user survey and only 3 reported any form of groundwater use at all. Only one of the abovementioned (Mr. M. Mouat, portion 7/306) has a borehole which is likely to be affected by the groundwater use on Telluric. No specific information is available at the time of this report due to the fact that borehole in question was only drilled in December 2021 – **after development of the Telluric borehole**. The borehole on the property of 7/306 is reportedly in the process of being tested but the results were not available at the time of this report. The positions of the nearby landowners are indicated in **Figure 5**. The recorded hydrocensus/user information is summarized in **Table 1**.

The positions of municipal water supply boreholes in the greater Plettenberg Bay area were obtained from Groundwater Africa reports to the municipality but no specific information such as actual abstraction rates and pump equipment in each borehole could be obtained. The boreholes are drilled into the Peninsula Aquifer while our interpretation of the geology intersected Telluric borehole led to the conclusion that the Telluric borehole intersected fresh water in the Baviaanskloof Aquifer directly below the Kirkwood Formation. The nearest municipal borehole is located more than 4.7km away from the Telluric borehole.

A map indicating the positions of the municipal boreholes is provided in **Figure 6** and the borehole information is provided in **Table 2**.

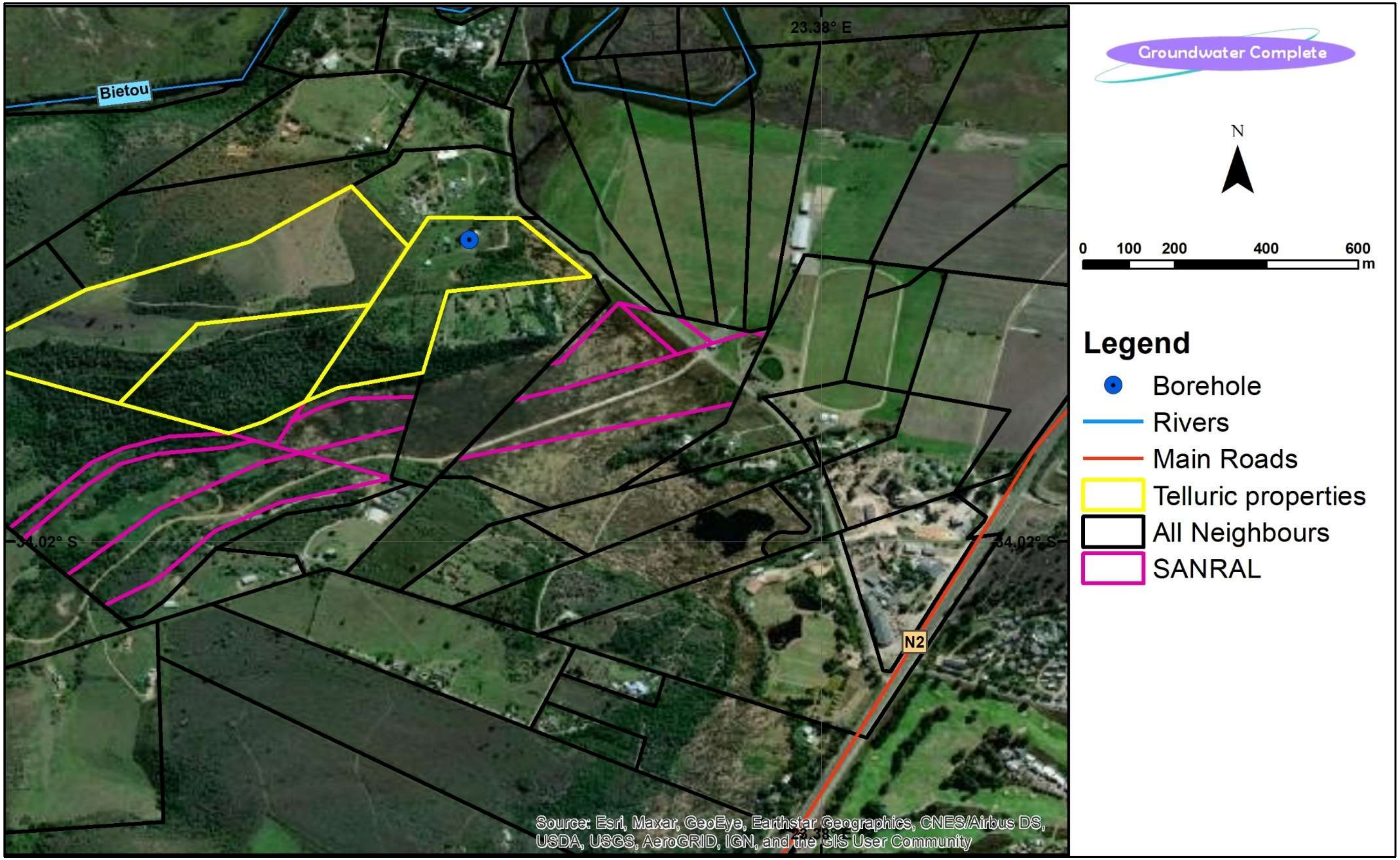

Figure 5: Positions of the neighbouring properties found during the hydrocensus/user survey.

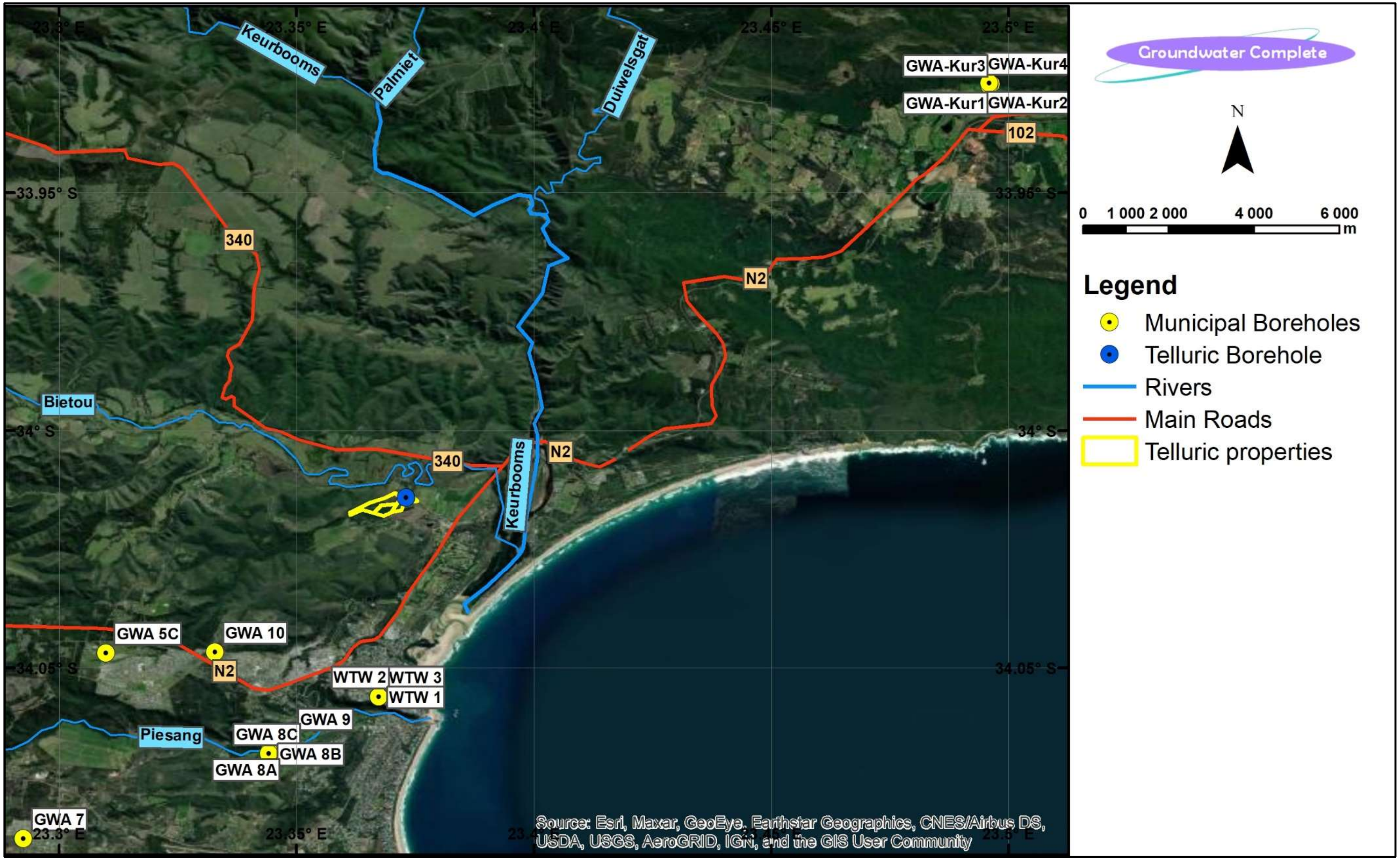

Figure 6: Positions of the municipal water supply boreholes

Table 1: Summarized results of hydrocensus/user survey

Farm Portion	Owner name	Contact number	Email adress	method of contact	Comment
103/444	Hennie v d Watt	0761077808		Whatsapp	no GW use
44/444	Volker Baechle	0825558506	wis@iafrica.com	Whatsapp	no GW use
9/444	Lombard Loubscher (Denron)	0845131883	lombard@denron.co.za	Email	Well point
16/444					
17/444					
RE/6/444					
RE/97/444					
114/444	Dean Rochat (Polo Farm)	0714144840	deanrochat@gmail.com	Email	no GW use
115/444					
116/444					
117/444					
118/444					
11/305	Attie&Andries Coetzee	0824950410	andriesatc@gmail.com	Whatsapp	no GW use
2/445	Grant Valentine	0445012500		Whatsapp	no GW use
22/444	Robert Cowley	0832325708		Whatsapp	no GW use
Rem/444					
RE/26/444	J.P. V Rooyen	0824777380		Email	no GW use
44/305	Nikki Wales	0716789788		Email	Sprite
7/306	Mike Mouat (honeybosch)	0825629806	jillmouat@yedo.co.za	Email	Borehole
66/444	Andre Jerling	0832754993		Whatsapp	no GW use
67/444					
11/444	MR/MRS N NEL	0445330567	nataliedupnel@gmail.com	Email	Against anyone extracting groundwater
41/444	M.T.C.(PTY) LTD	0824628089	mattie@produkta.co.za	Email	no GW use
56/444	STEENKAMP FAMILIETRUST	0825540125	meiguest@mweb.co.za	Email	no GW use
85/444	MR/MS IB INAUEN	0818652069	ivan.inauen@gmail.com	Email	no GW use

87/444	MR/MRS BL OOSTHUIZEN	044-5331894	buksbloos@gmail.com	Email	no GW use
90/444	MR/MRS IA SMYTH	0836558267	plett.anne@gmail.com	Email	no GW use
54/444	Peter Hird	0833261102	Peter.Hird@mweb.co.za	Email	No GW use
98/444	MR J CAVILL	447714672/671	Could not reach at the time of completing this report.		
53/444	WIDEPROPS 1054 CC		Could not reach at the time of completing this report.		
86/444	WIDEPROPS 1052 CC				

Table 2: Municipal water supply borehole information

Area	BH No	Y-coord	X-coord	Depth (m)	Rest Water Level (mbgl)	Blow Yield (L/s)	EC (mS/m)	Date	Rec. PID (mbgl)	Rec. (L/s)	Max (L/s)	Distance from Telluric
Kwanokuthula	GWA 5C	-34.0469	23.30999	292	132	7	68	Not provided in the report.				6.8 km
Kranshoek	GWA 7	-34.0859	23.29258	98	69	1	538					10.9 km
Golf Course	GWA 8A	-34.0675	23.34445	43	2.4	1	-					6.6 km
Golf Course	GWA 8B	-34.0676	23.34431	4	1.8	3.7	65					6.6 km
Golf Course	GWA 8C	-34.068	23.34424	109	Artesian	20	54					6.6 km
Golf Course	GWA 9	-34.0649	23.34865	192	Artesian	20	74					6.1 km
Ebeneezer	GWA 10	-34.0467	23.33286	222	118	7	230					5.3 km
Town	WTW 1	-34.056	23.36739	142	56	1.3	81					4.7 km
Town	WTW 2	-34.056	23.36739	126	56	1	81					4.7 km
Town	WTW 3	-34.056	23.36738	181	56	10	81					4.7 km
Kurland	GWA-Kur1	-33.9272	23.4961	265	3.1			15-Jul-17	68	1.2	2.2	15.9 km
Kurland	GWA-Kur2	-33.9271	23.49633	259	1.6			11-Nov-17	58	2.7	2.7	15.9 km
Kurland	GWA-Kur3	-33.9273	23.4959	301	12.6			14-Nov-21	71	2.3	2.3	15.9 km
Kurland	GWA-Kur4	-33.9269	23.49598	277	12.7			17-Nov-21	63	2	2	15.9 km

3.3 GEOPHYSICAL SURVEY AND RESULTS

No geophysical survey was conducted as part of this study.

3.4 SITING AND DRILLING OF BOREHOLES

A borehole was originally drilled on Telluric in September 2021 to a depth of 199 meters. After drilling and when an attempt was made to conduct an electrical conductivity (EC) profile of the borehole it was found that the borehole collapsed at 75 mbs. The borehole could not be stabilised to install casing and a new borehole was drilled at the end of November 2021 three meters south of the original borehole to a final depth of 151 mbs. The new borehole was equipped with a grout seal around solid steel and solid uPVC casing down to 123 meters, and perforated uPVC casing within a gravel pack from 123 meters to 147 mbs.

The result of the drilling can be summarised as follows:

- The first water was encountered at a depth of 35m, but was of poor quality having an EC of up to 1600 mS/m.
- Fresher water was intersected at a depth of 130 mbs.
- The borehole was drilled to a depth of 151 mbs and casing was inserted to 147 mbs and a final electrical conductivity of 97 mS/m.

A map of the location of the borehole is provided in **Figure 7**. The drill log of the first boreholes is provided in **Figure 9**. Down to its final depth of 151 mbs the final borehole is the same as the first one.

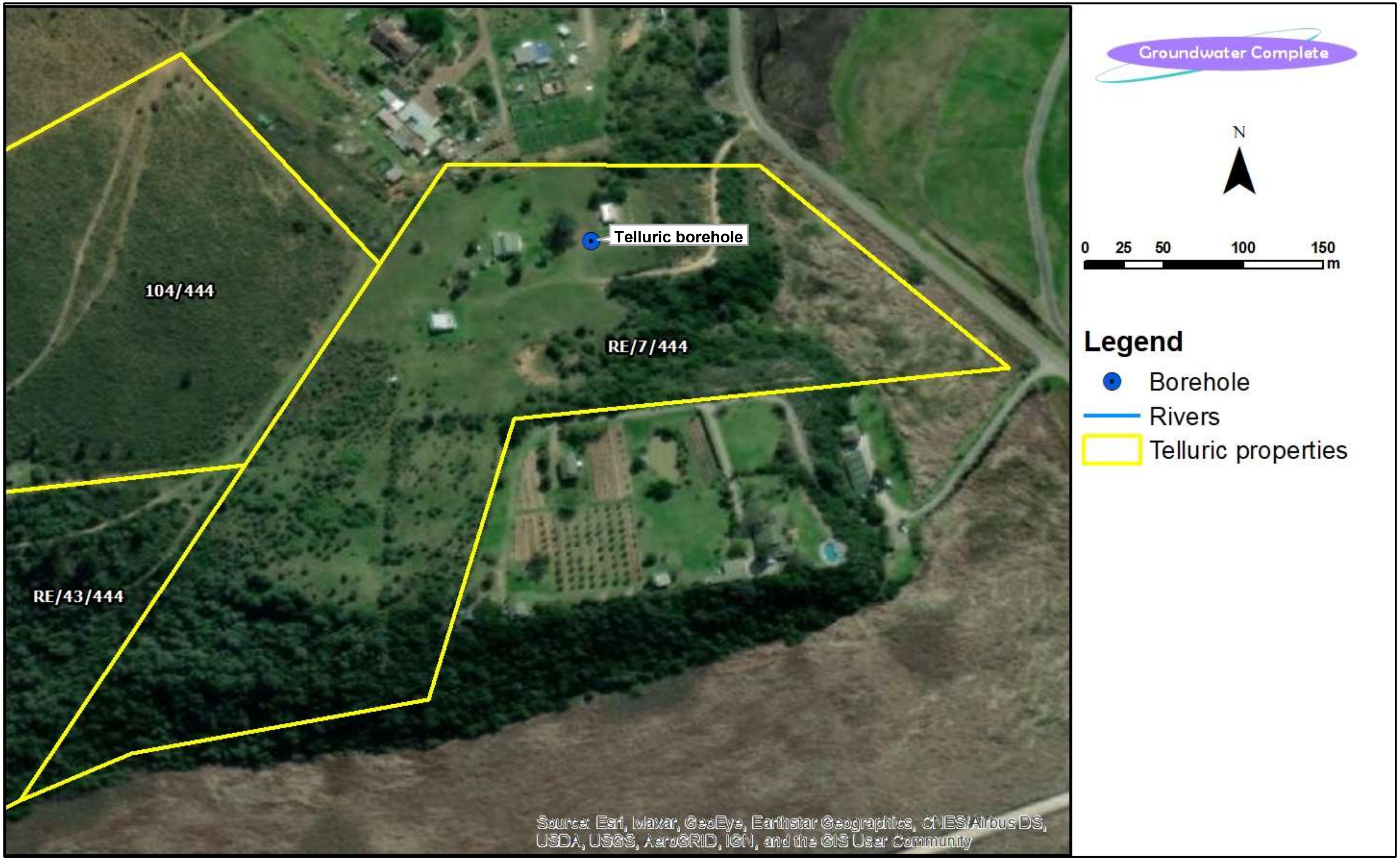

Figure 7: Map indicating the location of the Telluric borehole

3.5 AQUIFER TESTING

An aquifer test (also referred to as a pump test) is performed to determine aquifer parameters, especially transmissivity or hydraulic conductivity. Aquifer parameters play an important role in the conceptualisation of the project area (i.e. conceptual model), which ultimately forms the foundation of the numerical groundwater flow- and mass transport models. The test basically involves the abstraction of groundwater from a borehole by means of a pump (submersible- or mono pump) at a known rate. Measurements of the decreasing water level within the borehole are taken at predetermined intervals, which are generally short at the start of the test and increase as the test progresses. After the test has been completed and the pump has been shut down, measurements are again taken of the water level as it starts to recover/rise in the borehole (i.e. recovery test).

During the drilling (and re-drilling) of the Telluric borehole, it was apparent from the blow yield that the borehole could yield a significantly larger volume of water than the client would be applying for. A suitably sized submersible pump that could comfortably supply the peak demand was thus installed in the borehole and the pump was used for conducting a constant rate pumping test. With the estimates from the blow yield together with the relatively low pumping rate, it was deemed unnecessary to conduct any step tests as the step test are only used to determine the optimal rate at which the constant rate test should be performed.

The Telluric borehole was tested in the abovementioned manner in January 2022 with a 48 hour constant rate pump test (followed by a recovery test) and the pump test data was analysed with the FC Program and AQTESOLV Professional software package, which offers a wide range of mathematical equations/solutions for the calculation of aquifer parameters. The time-water level data collected during the constant rate pump test is plotted on a log-linear graph. A straight line or curve (depending on equation used) can then be fitted to the different flow stages on the graph (process known as curve matching) and the aquifer transmissivity and storativity are calculated in accordance with the preselected analytical equation. Aquifer parameters provided in this report were calculated with the *Cooper-Jacob (1946)* equation.

It is important to note that the abovementioned equation for pump test analysis was designed for pump test interpretation in a primary porosity aquifer environment with the following assumptions:

- The aquifer is a homogeneous medium,
- Of infinite extent,
- No recharge is considered, and
- An observation borehole is used for water level recording at a distance from the pumped borehole.

Although few of these assumptions apply to the project area, the methods/equations could still be used as long as the assumptions and 'shortcomings' are recognized and taken into account.

3.6 GROUNDWATER RECHARGE CALCULATIONS

According to **Figure 8** the mean annual recharge to the aquifer underlying the project area should be in the order of 45 mm, which based on an average rainfall of approximately 650 mm/a **(Figure 3)** translates to a recharge percentage of ± 7%. Recharge to the deeper Cape Supergroup **(Figure 9)** aquifer/s into which the underlying the project area, according to most recharge maps, represents some off the highest recharge values in the country. The annual recharge estimate of around 7% is therefore considered to be a conservative estimate.

The recharge to the aquifer into which the borehole is drilled and from which water will be extracted receives recharge from some distance away from the borehole. The recharge occurs at higher elevations in the outcrop regions of the sandstone that occur in the form of a synclinal basin to the south, west and north of Telluric. The recharge at higher surface elevations results in a higher piezometric head in the sandstone aquifer than that of the Kirkwood formation aquiclude that forms the surface geology at the position of the borehole. This phenomenon and concepts will be explained and discussed in Section 4 and illustrated in Figure 11.

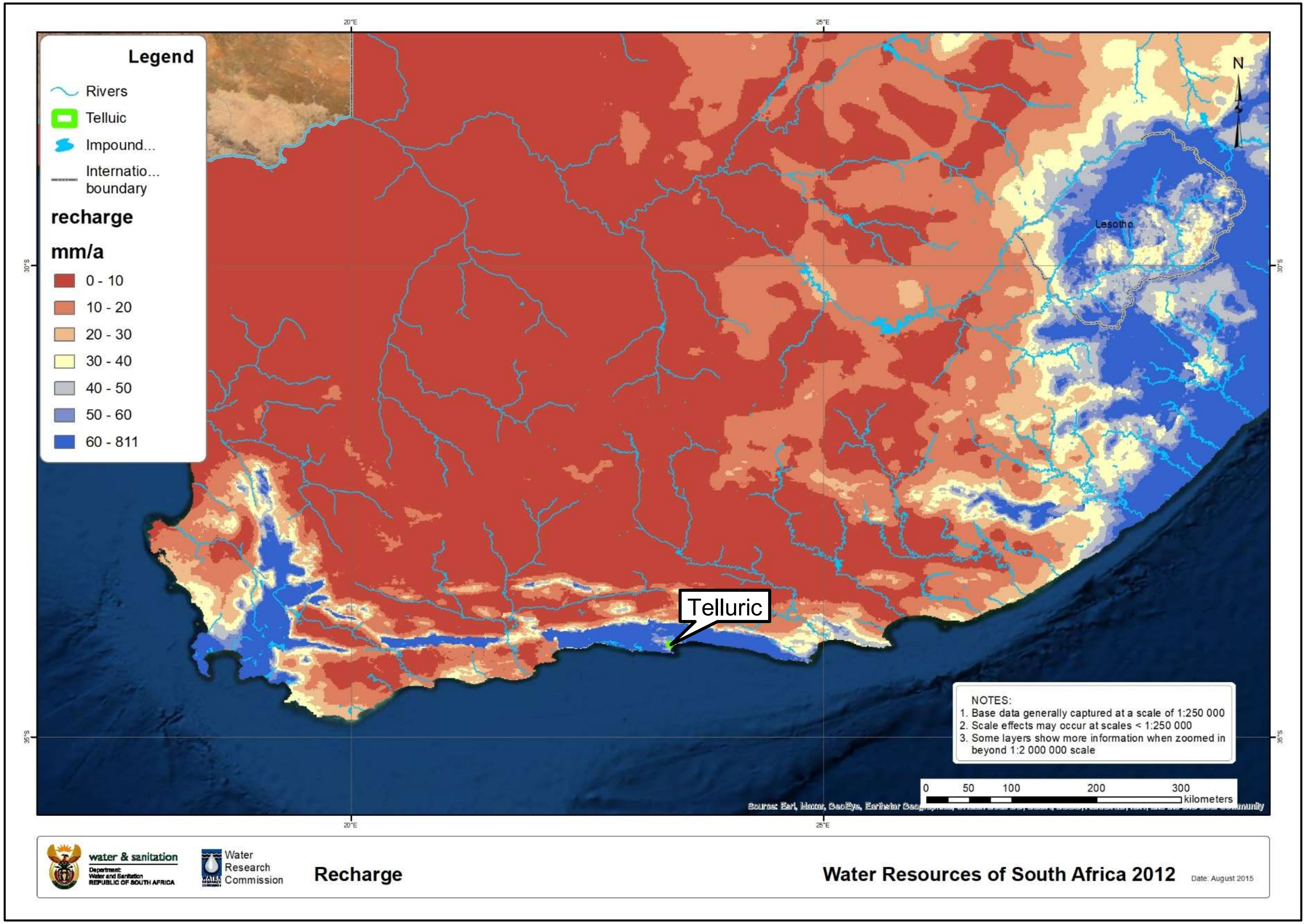

Figure 8: Mean annual aquifer recharge for South Africa *(Vegter, 1995;Water Research Commission, 2012)*

3.7 GROUNDWATER AVAILABILITY ASSESSMENT

A rapid reserve determination for Telluric is conducted in this section. The following assumptions were made in terms of groundwater use and surface area:

- By far the most significant ''use'' of groundwater at Telluric will be the water pumped from the borehole for irrigation purposes.
- There will be some seepage water returning to the groundwater, however because of the depth of the borehole, the water is more likely to return to another aquifer.

The property boundaries fall within quaternary catchment K60F which has a surface area of 242 km^2. The property itself has a total area of 0.07 km^2. The study area falls within in the Bitou River catchment. The general authorised groundwater use in the catchment is in the order of 275 m^3/ha/year.

Table 3: Most salient parameters relevant to Catchment K60F

Description	*Unit*	Value	Comment
Catchment Area	*km^2*	242	K60F
Project area	*km^2*	0.07	1% of catchment
General Authorised Use (GA)	*m^3/ha/a*	275	Sourced from, "*Government Gazette, No. 40243"*
General Authorised Use	*m^3/a*	1 925	(275 m^3/ha/a * 7 ha)
Mean Annual Rainfall	*mm/a*	650	Figure 3
Effective Annual Recharge to catchment	*Mm^3/a*	10.9	Effective recharge to catchment area
Effective Annual Recharge	*mm/a*	45	Section 3.6
Annual Recharge Volume	*m^3/a*	3150	Recharge over project area**
Groundwater use	*m^3/a*	36 000	Amount of water being applied for
Current use	*m^3/a*	0	Current use in catchment according to WR90 data (1990)
Exploitation potential	*m^3/a*	12	Exploitation potential for catchment according to WR90 data (1990)

*** - please note that the amount of recharge reported on the property surface area cannot be correlated with the amount of abstraction applied for because the abstraction will not take place from an unconfined shallow aquifer. Instead, recharge to the confined Baviaanskloof and Goudini aquifers occurs some kilometres away from Telluric where the formation outcrops.*

There are very few other groundwater users near Telluric, due to the depth of the fresh water aquifer. The groundwater in the area is a resource that goes mostly unutilised. The current groundwater use is 0 m^3/a according to the WR90. While the data is undoubtedly outdated (we know, for example, that there is use by the municipality), it does give some indication of the status of groundwater availability. The exploitation potential also gives a good indication of the large amount of groundwater that is available for use in the catchment area on a sustainable basis.

While the annual abstraction volume applied for by Telluric is much larger than the recharge to its surface area, such comparison is irrelevant point in this case since the recharge takes place far away from the borehole (refer to **Figure 11**) in its outcrop area.

4 PREVAILING GROUNDWATER CONDITIONS

4.1 GEOLOGY

All geological information provided in this report was interpreted from the 1:250 000 scale geological map of the project area provided in **Figure 9** and the borehole logs collected during drilling **(Figure 10)**.

4.1.1 REGIONAL GEOLOGY

The project area is underlain by various formations of the Cape Supergroup sedimentary rocks. The Cape Supergroup occurs on the surface along the southern coast of South Africa. The supergroup is known for deformation of the rock creating the Cape fold mountain range. These folds create good confined and semi-confined aquifers, with generally high rainfall and a high (relative to most other regions in South Africa) percentage of effective recharge due to the highly permeable fractured rock outcrop (when fresh) or highly permeable sandy soil cover where the outcrop is weathered.

4.1.2 LOCAL GEOLOGY

The geology in the area plays a crucial role in the characteristics and behaviours of the different groundwater systems. The groundwater quality, yield, storage properties and recharge rate all depend at least to some degree on the type of host rock of the aquifer.

An aquifer can be defined as a groundwater source that can provide an economically viable source of water. An aquiclude is defined a rock layer with no, or very low, permeability and does not readily allow movement of water through it.

Telluric is located on a large deposit of **Kirkwood** conglomerate, siltstone and mudstone. The silt and mudstone usually contain very brackish (saline) water, high in sodium and chloride. The Kirkwood formation is underlain by the **Baviaanskloof** (Fine- to medium-grained, dark to light grey, feldspathic sandstone, shale), **Skurweberg** (thick-bedded, medium- to coarse-grained, cross-bedded, white-weathering, quartzitic sandstone) **Goudini** (Brownish-weathering, quartzitic sandstone, subordinate shale and siltstone), **Cedarberg** (shale, siltstone, subordinate sandstone) and **Peninsula** (quartzitic sandstone, minor conglomerate and shale) formations. Of the aforementioned formations, the Peninsula sandstone/quartzite formation is generally accepted as having the best water supply potential in terms of its yield and excellent (low salinity) water quality.

It is derived from the dip directions and drilling results that Telluric is situated on the Kirkwood Formation at surface, which is underlain in an open syncline structure by sandstone of one of the older Table Mountain Group Sandstone formations, probably the Baviaanskloof or Skurweberg Formation.

A cross-section is provided in **Figure 11** to illustrate the expected hydrological system of the borehole. The constituents of the different geological formations display significant variance in a vertical sense, i.e. between argillitic sediments such as mudstone and siltstone layers (which mostly act as aquicludes) and arenitic sediments sandstone and conglomerate layers (which form the main aquifers). Due to these geological variations, aquifers are often isolated from each other in a hydraulic sense since they are separated by impervious layers. It is due to this that the deeper aquifer has better quality than the aquifers above it and can be used by Telluric farm.

Saltwater intrusion may often occur during massive over-exploitation of coastal aquifers. It is, however, more common in unconfined aquifers where water more readily moves in all directions where the pressure potential is lower. The fact that the Telluric borehole draws water from the confined sandstone aquifer below the Kirkwood formation aquiclude will minimise the risk of salt water intrusion when using the borehole. The recharge take place to the sandstone aquifer creates a piezometric pressure head towards the ocean, “pushing back” the saline water.

<u>The following extract from Makiwane, N., 2019 further enlightens us on the aquifer interrelations of the area:</u>
The TMG aquifer is classified as a semi-confined aquifer since it is phreatic in some areas but confined below an impermeable layer in other areas. The installation of groundwater abstraction boreholes in the TMG aquifer often requires drilling through a confining layer (Aston, 2007). Some boreholes in the TMG have free-flowing artesian conditions, confirming that the aquifer is confined and under positive pressure. The formations making up the TMG differ widely in their ability to store and transmit water.

The sandstones of the Nardouw and Peninsula Subgroups generally act as aquifers, while the shale layers in these subgroups act as aquitards (Aston, 2007). Two main aquifer systems have been identified in the TMG, namely the Nardouw aquifer and the Peninsula aquifer. The Nardouw - 53 - aquifer consists of two sub-aquifers (the Rietvlei and Skurweberg sub-aquifers) separated by the Verlorenvalley mini-aquitard. The Peninsula aquifer is separated from the Nardouw aquifer by the Winterhoek mega-aquitard, which consists of the Goudini, Cedarberg and Pakhuis meso-aquitards.

The Peninsula aquifer itself is subdivided into two sub-aquifers, namely the Platteklip and Leeukop sub-aquifers (Blake et al., 2010). The extraction of groundwater from the Nardouw aquifer is mainly for farm water supply. The deeper Peninsula aquifer requires deeper drilling and has been exploited to a lesser extent (TMGA Alliance, 2016). However, the Peninsula aquifer is thought to have a greater potential for bulk abstraction than the Nardouw aquifer (Rosewarne & Weaver, 2002). It is much thicker but, more importantly, has a lower shale content and faults are therefore expected to remain open to great depths (Rosewarne & Weaver, 2002).

Notes:

- *No prominent faults and/or dykes are indicated in **Figure 9**, however the possible presence of faults cannot be denied due to their widespread occurrence throughout* *the cape fold mountains. These geological structures have specific relevance to the geohydrology as they have the potential to act as preferred pathways along which groundwater and potential contamination may flow at increased rates.*

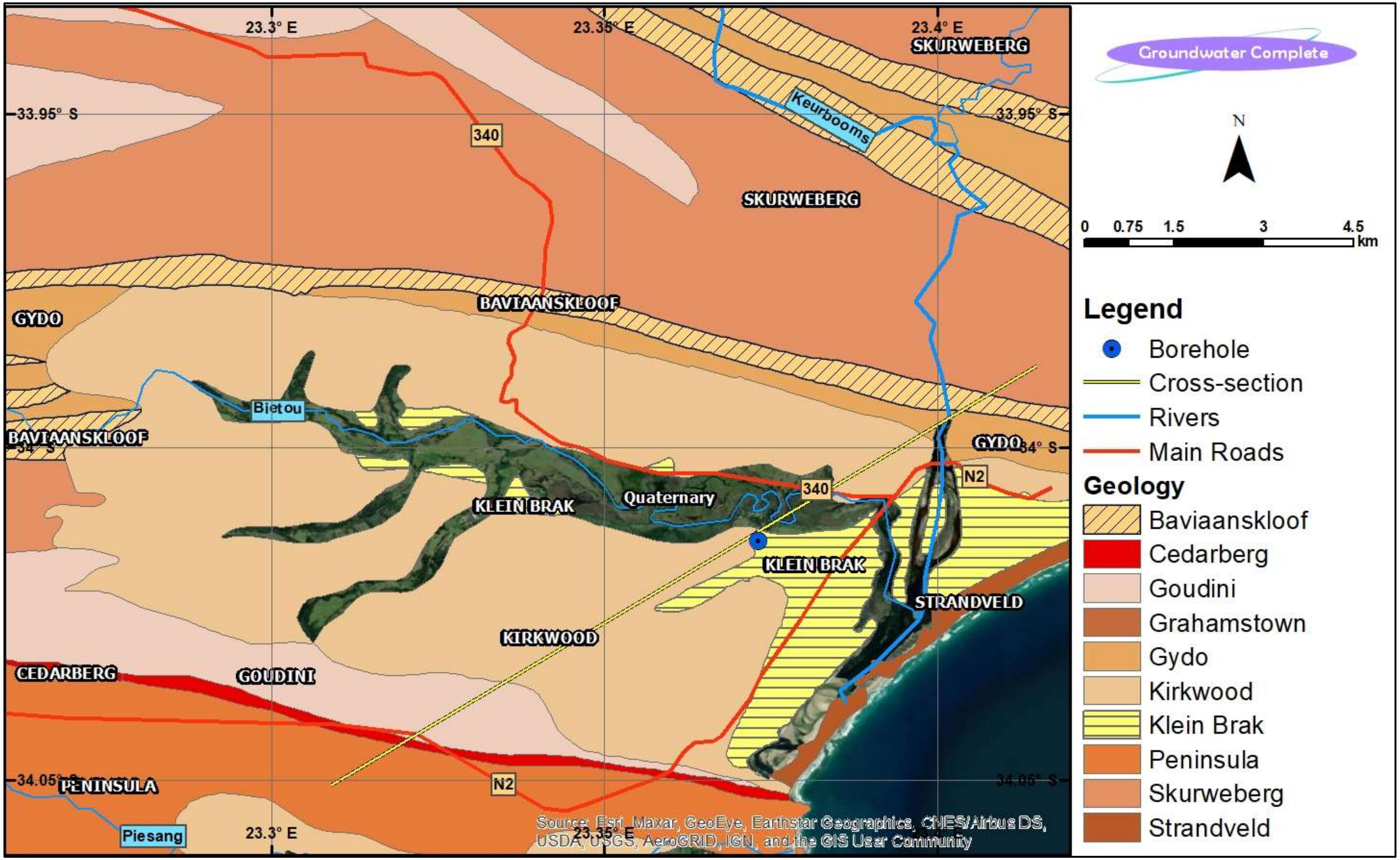

Figure 9: 1:250 000 scale geological map of the project area

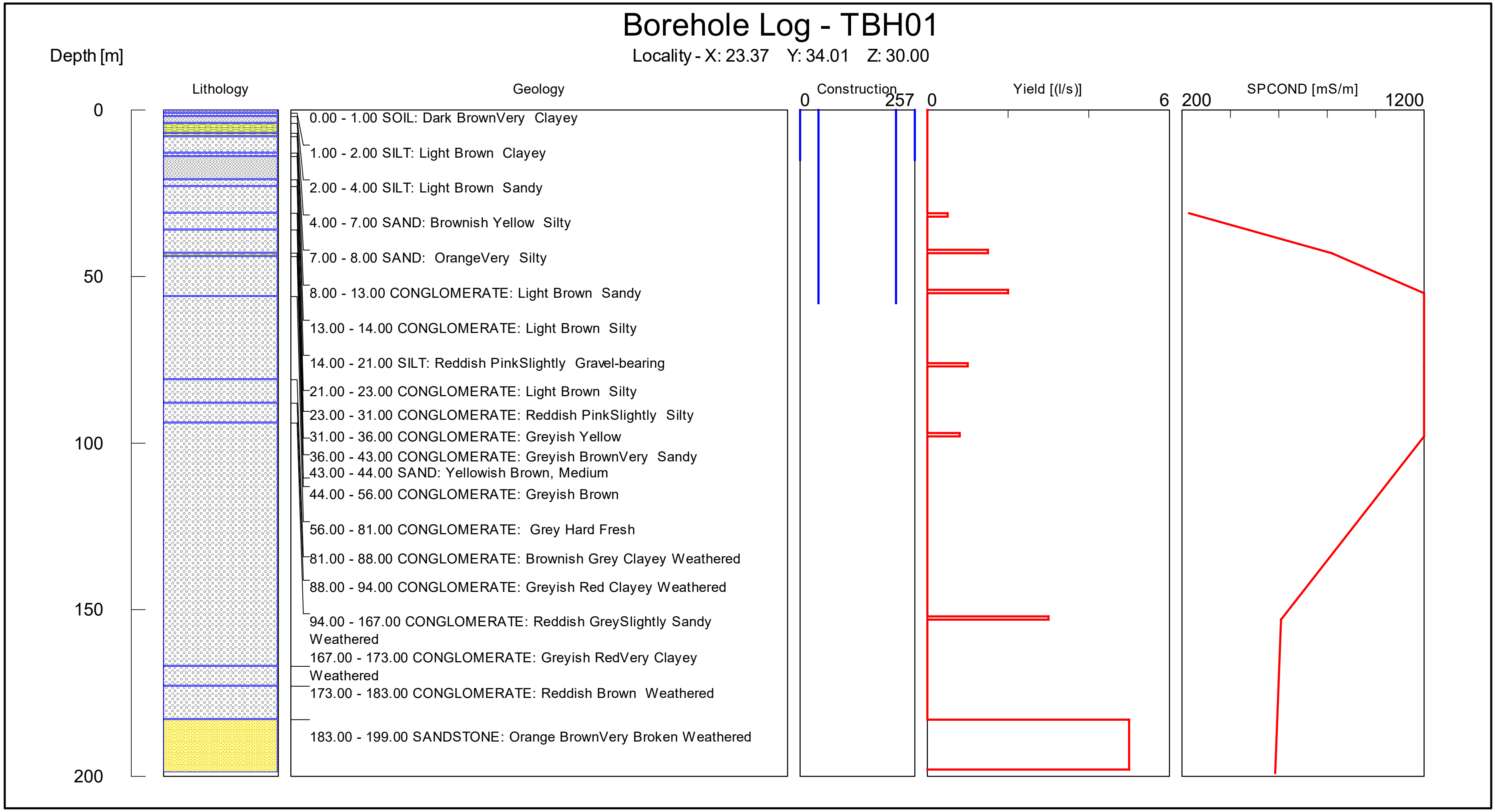

Figure 10: Borehole log for the Telluric borehole

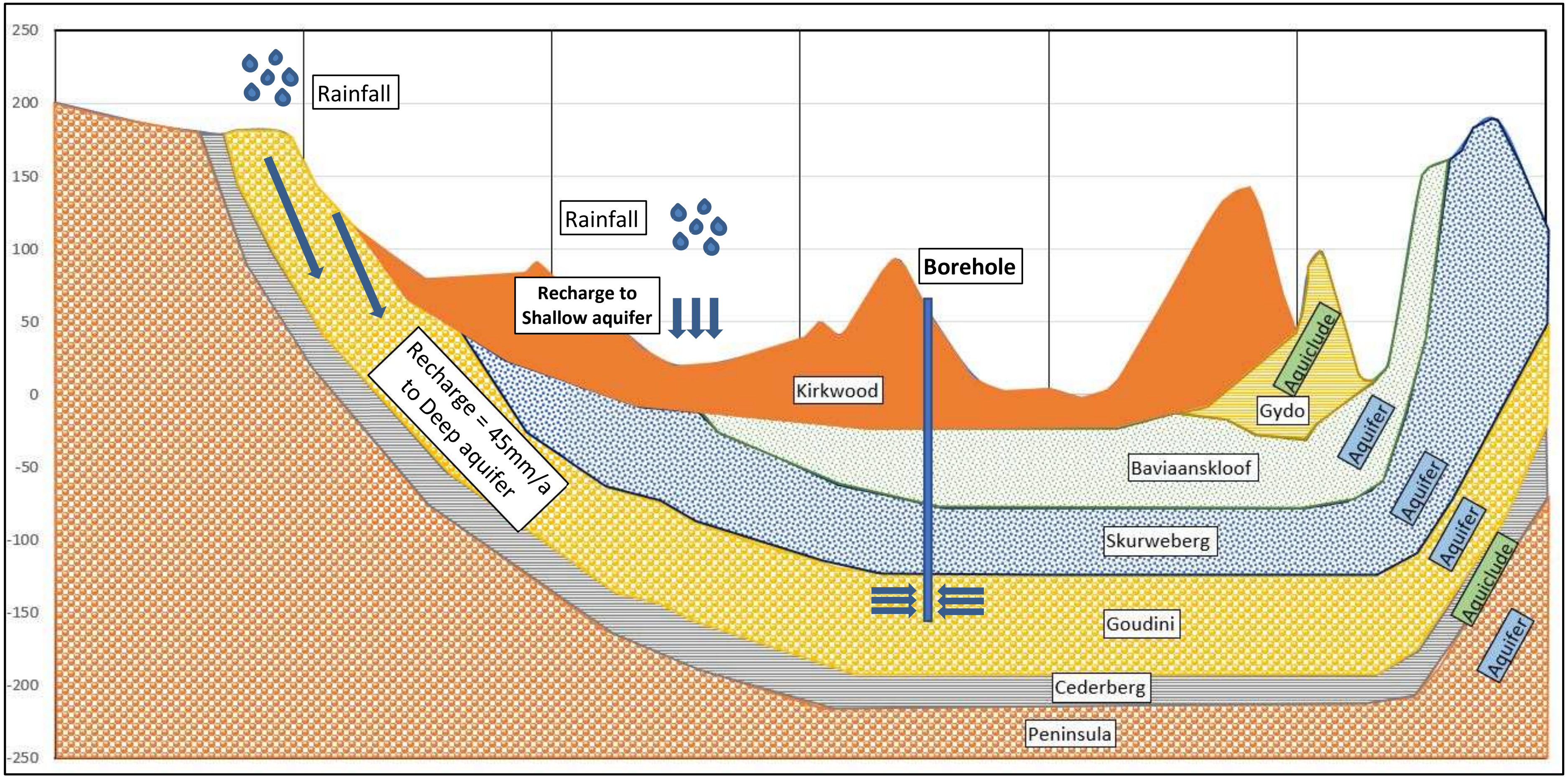

Figure 11: Cross-section of the geological stratigraphy of the Telluric area

4.2 HYDROGEOLOGY

4.2.1 UNSATURATED ZONE

The unsaturated zone refers to the portion of the geological/soil profile that is located above the static groundwater elevation or water table. Based on the drilling results of the boreholes, the unsaturated zone is predominantly composed of soil on top followed by clay, sandstone and conglomerates. In areas where weathering is less intense and/or water levels are deeper, the unsaturated zone may also extend into the fresh bedrock.

The unsaturated zone affects both the quality and quantity of the underlying groundwater. The type of material forming the unsaturated zone as well as the permeability and texture thereof will significantly influence aquifer recharge as well as the mass transport of surface contamination to the underlying aquifer(s). Factors like ion exchange, retardation, bio-degradation and dispersion all play a role in the unsaturated zone.

The thickness of the unsaturated zone is determined by subtracting the static water level elevation in the project area from the surface elevation, or simply by measuring the depth of the groundwater level below surface. The thickness of the unsaturated zone (where no impacts from groundwater abstraction occur) can range between 20 and 30 meters in the Telluric area.

4.2.2 SATURATED ZONE

The saturated zone, as the name suggests, is the portion of the geological/soil profile that is located below the static groundwater elevation or water table and is therefore saturated with water. The depth to the saturated zone is therefore equal to the thickness of the unsaturated zone, which can range between 20 and 30 meters below surface in the Telluric area.

The saturated zone is important as it forms the groundwater zone or system on which groundwater users rely for their water supply.

4.2.3 HYDRAULIC CONDUCTIVITY

Constant rate pumping tests were performed on the Telluric borehole for the purpose of calculating representative aquifer parameters such as transmissivity or hydraulic conductivity **(Section 4.5)**.

Due to a lack of boreholes to calculate an average mean the hydraulic conductivity calculated for the single borehole will be the sole representative of the aquifer. An average matrix transmissivity of 4.5 m^2/d was calculated, which is equal to average hydraulic conductivities of approximately 0.015 m/d.

4.3 SUSTAINABLE YIELD ESTIMATION

An aquifer test was performed on the borehole January 2022. The pumping test was conducted for a 48-hour period and the borehole allowed to recover for the same amount of time. The data obtained from the pump tests is displayed in **Figures 12 and 13**.

The pumping test determined that the matrix transmissivity of the borehole is approximately 4.5 m^2/s. The storage coefficient cannot be determined with a high degree of accuracy in a secondary, fractured rock aquifer and a value of 0.01 were used for the aquifer matrix of the borehole.

The Telluric borehole has an available drawdown of about 160m from the static water level to its main water strike at around 180mbs.

If this data is then entered into the FC pump test analysis program, an average sustainable yield of about 2.3 l/s is calculated when the borehole is pumped for 24-hours a day, 365 days a year. If the operational cycle is 12 hours a day, the borehole can be pumped at a rate of 3.25 l/s.

Due to the extremely heterogeneous nature of the fractured rock aquifer system, sustainable yields were calculated for four main aquifer scenarios/systems, namely:

- An open aquifer system that is not restricted by any boundaries (never found in practice),
- An aquifer bounded by a single no-flow boundary e.g. an impervious dolerite dyke,
- An aquifer restricted by two no-flow boundaries, and
- A closed aquifer system (absolute worst-case scenario).

These yields were estimated based on an average of the four types of boundaries considered to provide a conservative estimate of the long-term sustainable yield.

After completing the pumping test, the recovery of the borehole was also measured. Analysis of the recovery data is another way to estimate the hydraulic parameters of the borehole. The recovery test data can be viewed in **Figure 13.**

The recovery rate of the piezometric head in the borehole was good. The borehole water level recovered to around 90 % after only 13 hours of recovery (following 48 hours of pumping). A transmissivity of 11 m^2/d was calculated from the recovery data. This transmissivity is somewhat higher than the transmissivity calculated during the pumping test, however the recovery test often indicates a higher transmissivity and shows that the calculated pump test transmissivity can be considered as a conservative estimate.

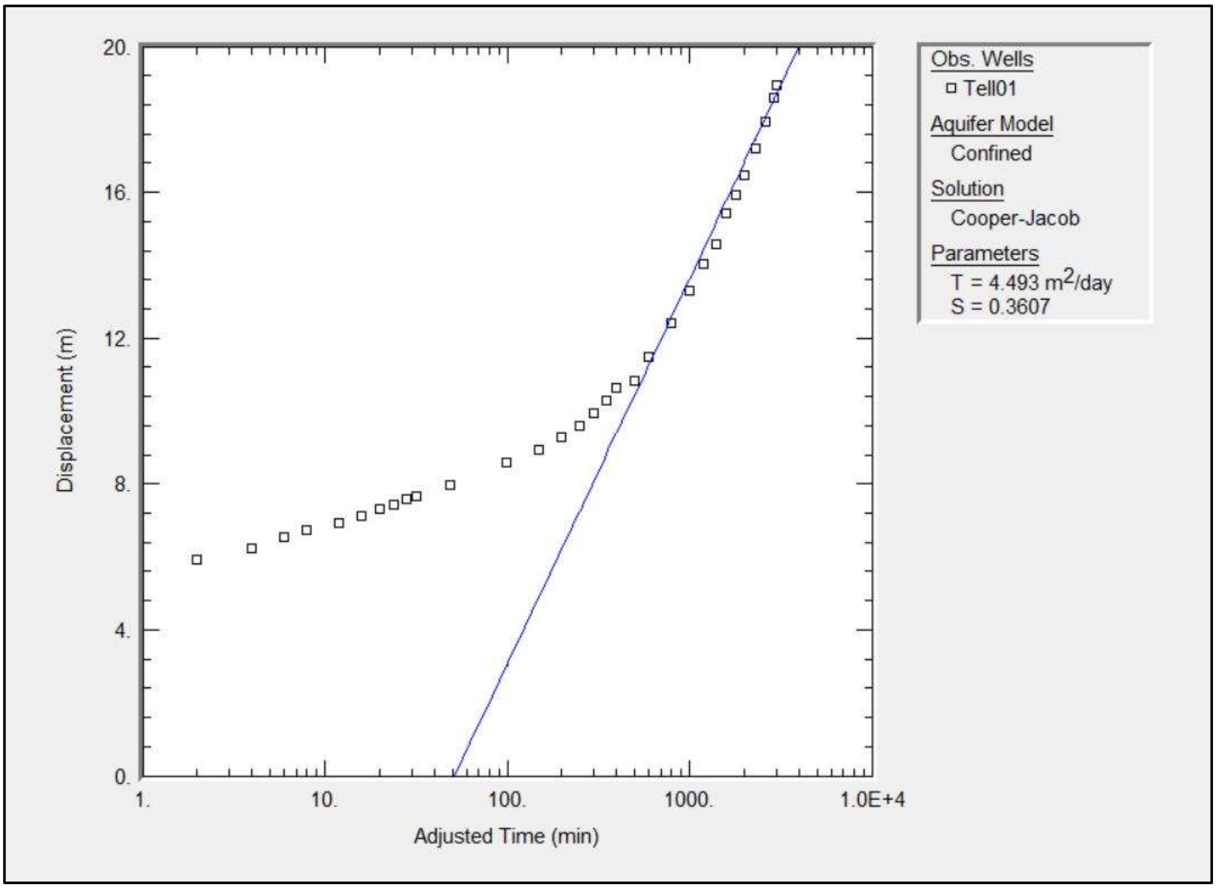

Figure 12: Cooper-Jacob plot for analysis of pump test data for the Telluric borehole

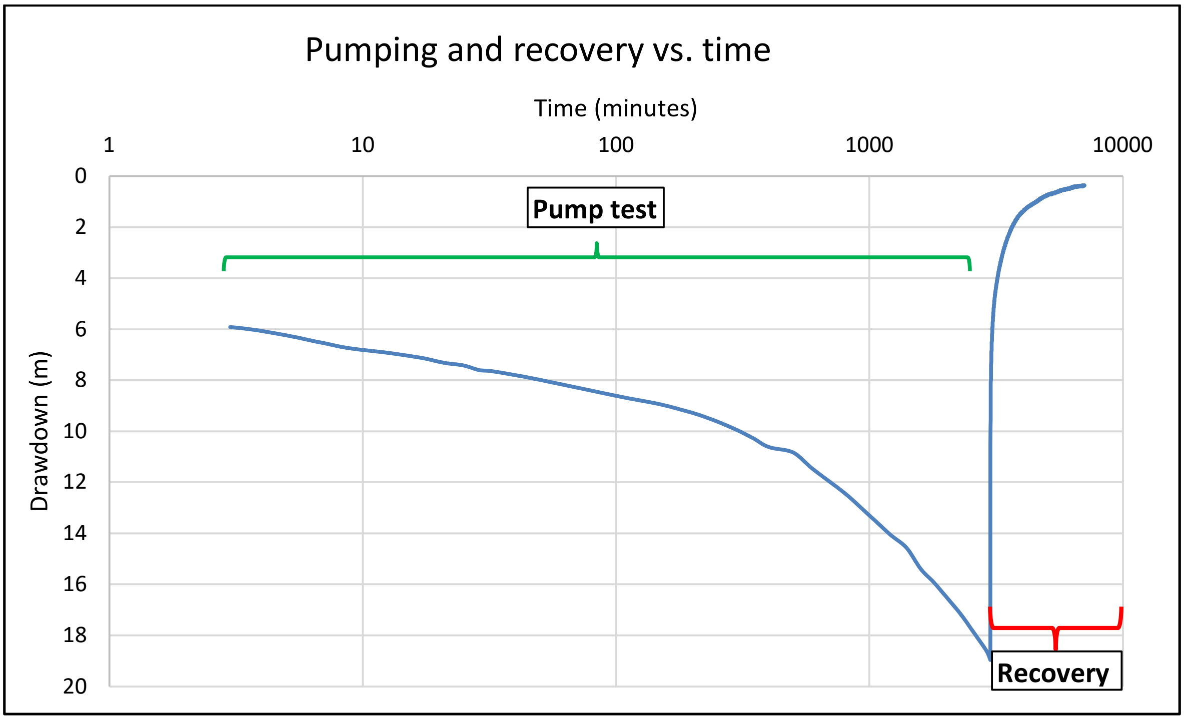

Figure 13: Recovery data measured after the pump test for the Telluric borehole

The cone of depression was calculated using the Cooper-Jacob equation **(Equation 1)**. The Cooper Jacob formula uses pumping rate, transmissivity and storativity to calculate the radius on influence. Which is in turn used to calculate the Cone of depression caused by the borehole. The radius of influence calculated for the borehole for after 1 year of constant pumping 525 meters.

The radius of influence was calculated mathematically with the *Cooper-Jacob* approximation:

$$s = \frac{Q}{4\pi T} \ln\left[2.2459 \frac{Tt}{r^2 S}\right]$$

Equation 1: Cooper-Jacob Equation

Where *s* = *Drawdown*
Q = *Pumping rate*
T = *Transmissivity*
t = *Time*
r = *Radial distance from pumping well and*
S = *Storage coefficient*

Table 4: Summary of parameters determined by the pumping tests

Parameter	Determined value
Available Drawdown (m)	160
Radius of influence (m)	525
Matrix Transmissivity (m^2/d)	4.5
Estimated Storativity	0.01
Recommended Q (l/s) for 24 hour cycle	2.3
Average annual yield (m^3)	72 500

4.4 GROUNDWATER QUALITY

Groundwater Complete collected three water quality samples in January 2022. One sample was groundwater from the Telluric borehole, the remaining samples were from the watercourses north (Bitou River) and south (Diep River) of the property. The positions where the samples are indicated in **Figure 14**.

The data was evaluated with the aid of diagnostic chemical diagrams and by comparing the inorganic concentrations to the South African National Standards for drinking water **(Table 5).** The once-off sampling data does not allow for any statistical analyses or trend identification.

The four main factors usually influencing groundwater quality are:

- **Annual recharge** to the groundwater system,
- **Type of bedrock** where ion exchange may impact on the hydrogeochemistry,
- **Flow dynamics** within the aquifer(s), determining the water age and
- **Source(s) of pollution** with their associated leachates or contaminant streams.

Where no specific source of groundwater pollution is present up gradient from the borehole, only the other three factors play a role.

One of the most appropriate ways to interpret the type of water at a sampling point is to assess the plot position of the water quality on different analytical diagrams like a Piper, Expanded Durov and Stiff diagrams. Of these three types, the Expanded Durov diagram probably gives the most holistic water quality signature. The layout of the fields of the Expanded Durov diagram (EDD) is shown in **Figure 15**.

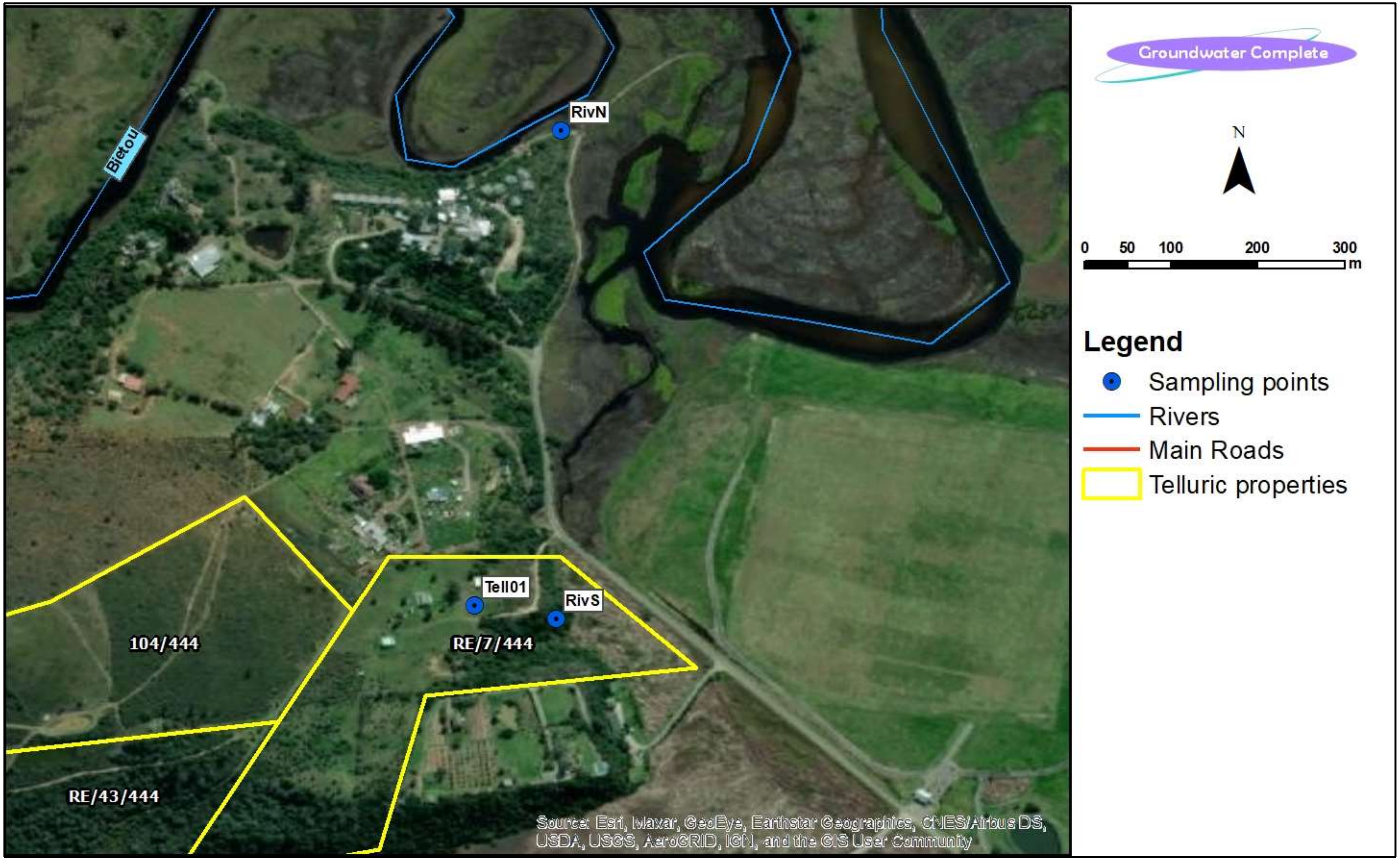

Figure 14: Locations of the sampling points.

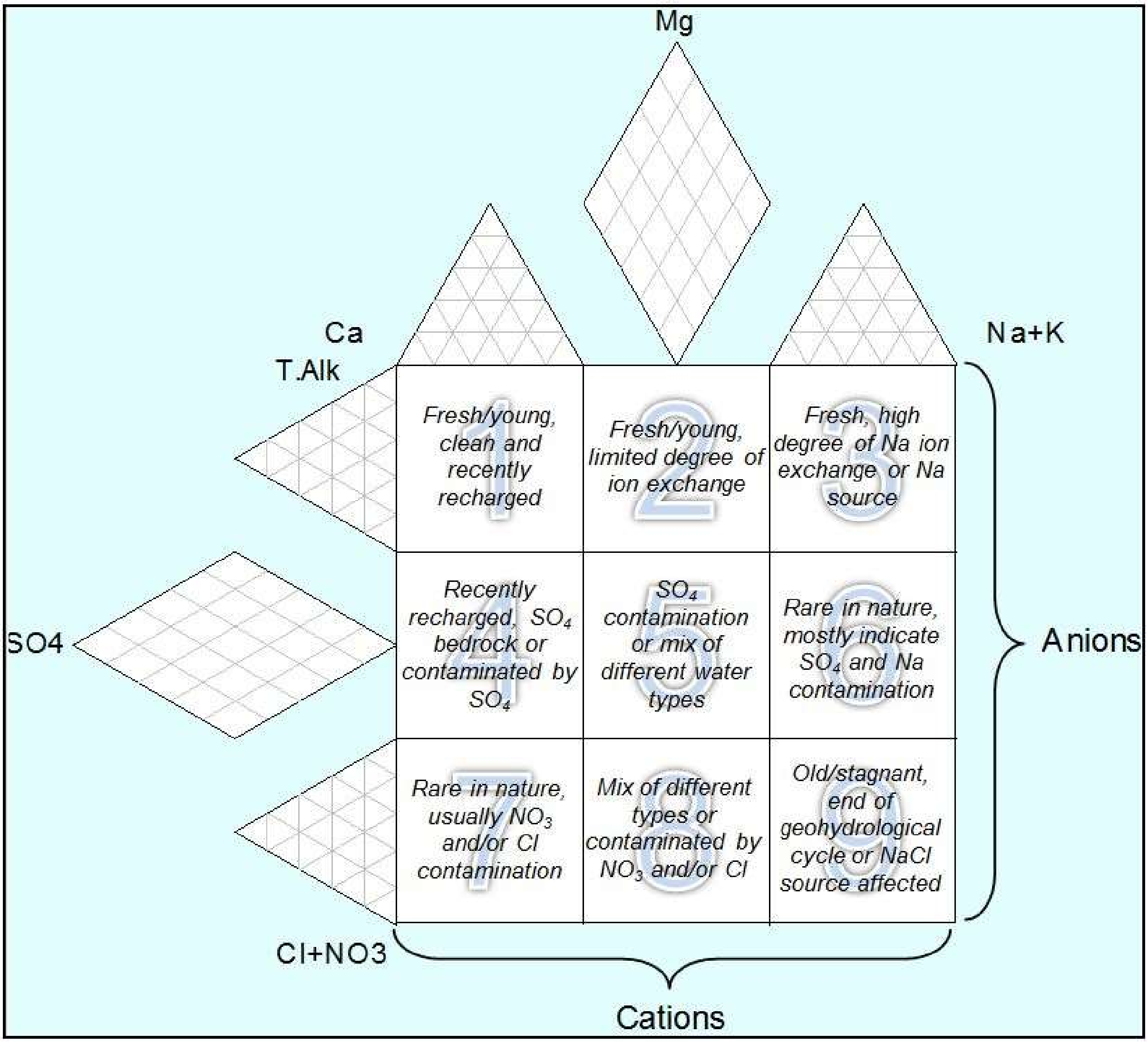

Figure 15: Layout of fields of the Expanded Durov diagram

Table 5: South African National Standards for drinking water *(SANS 241:2015)*

Determinant	Risk	Unit	Standard limits
Physical and aesthetic determinants			
Free chlorine	Chronic health	mg/l	≤ 5
Monochloramine	Chronic health	mg/l	≤ 3
Conductivity at 25 °C	Aesthetic	mS/m	≤ 170
Total dissolved solids	Aesthetic	mg/l	≤ 1 200
Turbidity	Operational	NTU	≤ 1
	Aesthetic	NTU	≤ 5
pH at 25 °C	Operational	pH units	≥ 5 to ≤ 9.7
Chemical determinants - macro-determinants			
Nitrate as N	Acute health – 1	mg/l	≤ 11
Nitrite as N	Acute health – 1	mg/l	≤ 0.9
Sulfate as SO_4^{2-}	Acute health – 1	mg/l	≤ 500
	Aesthetic	mg/l	≤ 250
Fluoride as F^-	Chronic health	mg/l	≤ 1.5
Ammonia as N	Aesthetic	mg/l	≤ 1.5
Chloride as Cl^-	Aesthetic	mg/l	≤ 300
Sodium as Na	Aesthetic	mg/l	≤ 200
Zinc as Zn	Aesthetic	mg/l	≤ 5
Chemical determinants - micro-determinants			
Aluminium as Al	Operational	µg/l	≤ 300
Antimony as Sb	Chronic health	µg/l	≤ 20
Arsenic as As	Chronic health	µg/l	≤ 10
Barium Ba	Chronic health	µg/l	≤ 700
Boron B	Chronic health	µg/l	≤ 2 400
Cadmium as Cd	Chronic health	µg/l	≤ 3
Total chromium as Cr	Chronic health	µg/l	≤ 50
Cobalt as Co	Chronic health	µg/l	≤ 500
Copper as Cu	Chronic health	µg/l	≤ 2 000
Cyanide (recoverable) as CN^-	Acute health – 1	µg/l	≤ 70
Iron as Fe	Chronic health	µg/l	≤ 2 000
	Aesthetic	µg/l	≤ 300
Lead as Pb	Chronic health	µg/l	≤ 10
Manganese as Mn	Chronic health	µg/l	≤ 400
	Aesthetic	µg/l	≤ 100
Mercury as Hg	Chronic health	µg/l	≤ 6
Nickel as Ni	Chronic health	µg/l	≤ 70
Selenium as Se	Chronic health	µg/l	≤ 40
Uranium as U	Chronic health	µg/l	≤ 15
Vanadium as V	Chronic health	µg/l	≤ 200
Organic determinants			
Total organic carbon	Acute health – 1	mg/l	≤ 10

Three samples were taken around the project area. Only one from a groundwater source (Tel01). The results of the chemical and physical analyses are provided in **Table 6**.

All boreholes drilled in the area previously had very poor quality, however none of previously drilled boreholes were drilled deeper than 100 mbs. The reason is simply that at depths of less than 120 mbs the groundwater is extremely saline with salinity levels in the shallow aquifer penetrated by the Telluric borehole measured at 1 900 mS/m during profiling.

Groundwater from the deep (sandstone) aquifer in the Telluric borehole was of very good quality according to the South African National Standards for drinking water purposes *(SANS 241:2015)* and still representative of the ambient or unaffected environment. The highly saline water from the shallow aquifer was thus sealed off with solid casing and grouting so that only the fresh water from the deep aquifer can penetrate the borehole through gravel packs and screens installed at depths of more than 150 mbs.

In **Figure 16** and **Figure 17** it is clear that the groundwater in the Telluric area is dominated one specific type:

- Groundwater that is usually a mix of different types – either clean water from fields 1 and 2 of the EDD that has undergone sulphate and chloride mixing/contamination, or old stagnant sodium chloride dominated water. Groundwater is consequently dominated by **sodium** cations and **chloride** anions.

Groundwater from the Peninsula layer is expected to have even better quality and is usually almost pure rainwater that falls into the first field of the EDD. However, it is due to surrounding layers of poor quality water and imperfect aquicludes that some of the poor quality seeps in and contaminates the water. The water from the borehole is however still of very good quality.

Groundwater from the Telluric borehole only exceeded the South African National Standards for drinking water purposes *(SANS 241:2015)* for manganese.

Summary:

- *Groundwater from the Bitou river (to the north) sampling point is considered to be of poor quality with numerous exceedances of the South African National Standards (SANS 241:2015).*
- *The southern Diep river sampling point*
- *Groundwater from the Telluric borehole is considered to be of very good overall quality.*

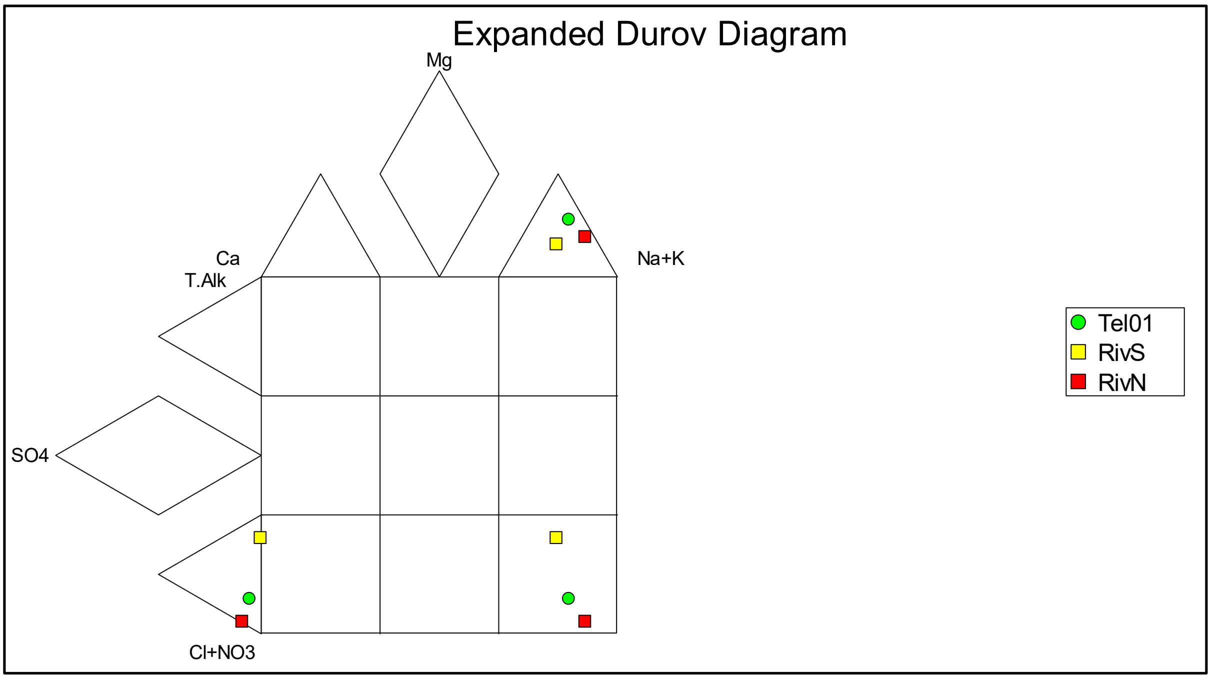

Figure 16: Expanded Durov diagram of Telluric groundwater chemistries.

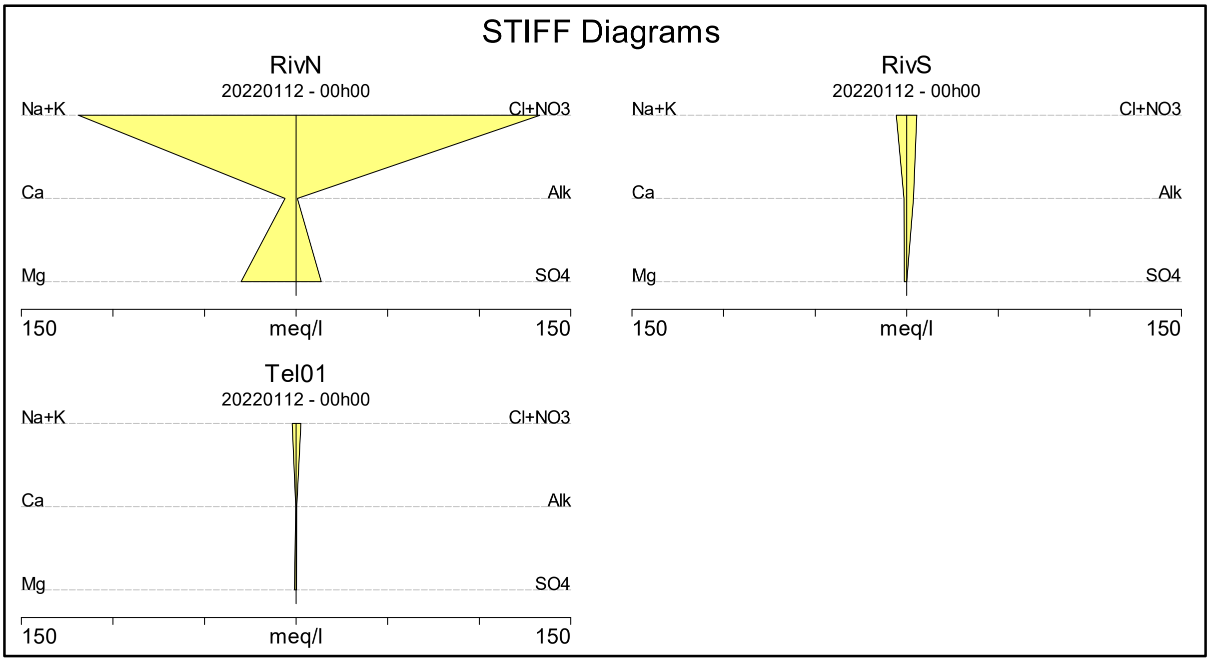

Figure 17:Stiff diagram of Telluric groundwater chemistries.

Table 6: Results of chemical and physical analyses for site specific monitoring boreholes

Site Name	Sampled date	pH	EC	TDS	Alk	Cl	SO4	NO3	NH4	PO4	F	Ca	Mg	Na	K	Al	Fe	Mn	Thard - cal	TON
			mS/m	mg/l	mg CaCO3/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg CaCO3/l	mg/l
Tel01	12-Jan-2022	6.6	44	201	19	93	9	0	0	0	0	4	11	49	7.8	0.0	0.0	0.8	56.0	0.3
RivN	12-Jan-2022	7.5	1693	8752	36	4720	660	0	0	0	0	121	365	2732	126.0	0.0	0.0	0.0	1806.0	0.3
RivS	12-Jan-2022	7.0	93	515	185	194	2	0	0	2	0	31	17	131	10.3	0.0	0.4	0.3	145.0	0.3
SANS standard		**5-9.7**	**170**	**1200**	**-**	**300**	**500**	**11**	**1.5**	**-**	**1.5**	**-**	**-**	**200**	**-**	**0.3**	**2**	**0.6**	**-**	**-**

Note: ***Red*** *- Value exceeds the maximum permissible SANS concentration allowed in drinking water (Table 5).*

5 AQUIFER CHARACTERISATION

5.1 GROUNDWATER VULNERABILITY

The *Groundwater Vulnerability Classification System* used in this investigation was developed as a first order assessment tool to aid in the determination of an aquifer's vulnerability/susceptibility to groundwater contamination. This system incorporates the well-known and widely used *Parsons Aquifer Classification System* as well as drinking water quality guidelines as stated by the *Department of Water Affairs and Forestry*. This system is especially useful in situations where limited groundwater related information is available and is explained in **Table 6** and **Table 7**. The project area achieved a score of 8 **(Table 5)** and the underlying aquifer can therefore be regarded as having a medium vulnerability.

Table 7: Groundwater vulnerability rating for project area

	Rating
Depth to groundwater level	1
Groundwater quality	4
Aquifer type	3
Total score:	**8**

Table 8: Groundwater vulnerability classification system

Rating	***4***	***3***	***2***	***1***
Depth to groundwater level	0 – 3 m	3 – 6 m	6 – 10 m	>10 m
Groundwater quality *(Domestic WQG*)*	Excellent (TDS < 450 mg/l)	Good (TDS > 450 < 1 000 mg/l)	Marginal (TDS > 1 000 < 2 400 mg/l)	Poor (TDS > 2 400 mg/l)
Aquifer type *(Parsons Aquifer Classification)*	Sole aquifer system	Major aquifer system	Minor aquifer system	Non-aquifer system

** WQG = Water Quality Guideline.*

Table 9: Groundwater vulnerability rating

Vulnerability	**Rating**
Low vulnerability	≤ 4
Medium vulnerability	> 4 ≤ 8
High vulnerability	≥ 9

5.2 AQUIFER CLASSIFICATION

Geological maps and experience gained from numerous studies conducted in similar geohydrological environments suggest that two possible aquifer types may be present in the project area. For the purpose of this study an aquifer is defined as a geological formation or group of formations that can yield groundwater in economically useable quantities. Aquifer classification according to the Parsons Classification system is summarised in **Table 6**.

The **first aquifer** is a shallow, semi-confined or unconfined aquifer that occurs in the transitional soil and weathered bedrock zone or sub-outcrop horizon and often displays characteristics of a **primary porosity aquifer** (i.e. **weathered zone aquifer**). Yields in this aquifer are generally low (less than 0.5 l/s) and the aquifer is usually not fit for supplying groundwater on a sustainable basis. Consideration of the shallow aquifer system becomes important during seepage estimations from pollution sources to receiving groundwater and surface water systems because the lateral seepage component in this aquifer often dominates the flow. According to the Parsons Classification system, this aquifer is usually regarded as a minor- and in some cases a non-aquifer system. **In the case of Telluric, this aquifer contained poor quality water and was sealed off from the borehole.**

The **second aquifer** system is the deeper **double porosity aquifer** that is hosted within the sedimentary rocks of the Karoo Supergroup (i.e. **fractured rock aquifer**). Groundwater yields, although more heterogeneous, can be higher. This aquifer system usually displays semi-confined or confined characteristics with piezometric heads often significantly higher than the water-bearing fracture position. Fractures may occur in any of the co-existing host rocks due to different tectonic, structural and genetic processes. **According to the Parsons Classification system, the aquifer could be regarded as a minor aquifer system, but also a sole aquifer system in some cases where groundwater is the only source of domestic water.**

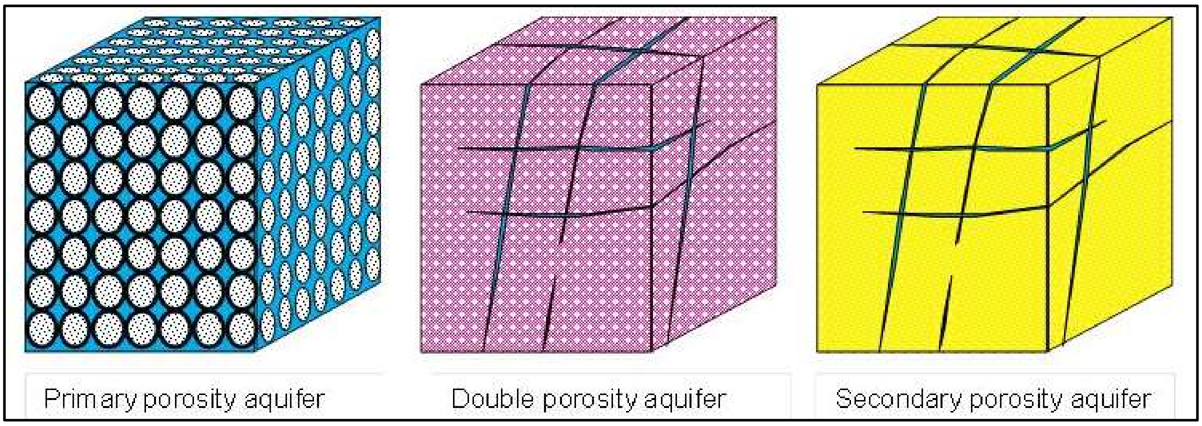

Figure 18: Types of aquifers based on porosity

Table 10: Parsons Aquifer Classification *(Parsons, 1995)*

Sole Aquifer System	An aquifer that is used to supply 50% or more of domestic water for a given area, and for which there is no reasonably available alternative sources should the aquifer be impacted upon or depleted. Aquifer yields and natural water quality are immaterial.
Major Aquifer System	Highly permeable formation, usually with a known or probable presence of significant fracturing. They may be highly productive and able to support large abstractions for public supply and other purposes. Water quality is generally very good (less than 150 mS/m).
Minor Aquifer System	These can be fractured or potentially fractured rocks that do not have a primary permeability, or other formations of variable permeability. Aquifer extent may be limited and water quality variable. Although these aquifers seldom produce large volumes of water, they are important both for local suppliers and in supplying base flow for rivers.
Non-Aquifer System	These are formations with negligible permeability that are generally regarded as not containing groundwater in exploitable quantities. Water quality may also be such that it renders the aquifer unusable. However, groundwater flow through such rocks, although impermeable, does take place, and needs to be considered when assessing the risk associated with persistent pollutants.
Special Aquifer System	An aquifer designated as such by the Minister of Water Affairs, after due process.

5.3 AQUIFER PROTECTION CLASSIFICATION

The combination of Aquifer Vulnerability Classification rating and Aquifer System management Classification provides a protection level referred to as Groundwater Quality Management Classification (GQM).

GQM = Aquifer System Management (ASM) x Aquifer Vulnerability (AV)

ASM Classification		AV Classification		GQM		Telluric GQM
Class	**Points**	**Class**	**Points**	**Index**	**Level of protection**	
Sole Source Aquifer System	6	High	3	<1	Limited	
Major Aquifer System	4			1 - 3	Low	
Minor Aquifer System	2	Medium	2	3 – 6	Medium	8
Non-aquifer System	0			6 – 10	High	
Special Aquifer System	0 - 6	Low	1	>10	Strictly non-degradation	

The GQM for Telluric calculates to 8, which indicates a high level of protection. Therefore, it is recommended that the monitoring system outlined in **Section 7** be in place for the proposed project.

6 CONCEPTUAL MODEL

A conceptual model is formed from the available data to better understand and analyse the area of study. The conceptual model also plays a key role in explaining the interactions between different boreholes. From all the geological information, drilling logs, pump tests and climate data available for the Telluric area, the following model is formed:

- The geology is made up of many alternating layers of siltstone, mudstone, sandstone and conglomerate.
- The Telluric borehole is located in the centre of a more-or-less north-west to south-east syncline beneath the project area.
- The sandstone and conglomerate layers (especially Peninsula formation) generally act as aquifers, known bearing a serviceable amount of fresh water.
- The siltstone and mudstone layers act as aquicludes or groundwater barriers, that do not allow movement between upper and lower layers.
- Due to the dipping nature of the Table Mountain Group geology to form a synclinal structure below Telluric, the groundwater recharge to the deep sandstone aquifer place far away from the borehole where the sandstone formation outcrops.
- The difference in water quality between samples from the rivers and the sample taken from the borehole rules out the possibility of “stealing” from the river, as it indicates that there is no similarity between the river water quality and groundwater quality and thus no connection between the surface water and the deeper aquifer.
- Any groundwater that will accidentally or otherwise discharge into either rivers will improve the quality of the river water.

7 IMPACT ASSESSMENT

7.1 IMPACTS ON GROUNDWATER QUANTITY

Groundwater will regularly be extracted from the boreholes on Telluric. The pumping test provides a sustainable yield for the aquifer system around the borehole of 2.3 l/s (± 72 500 m^3/y). Water level recovery after pumping of the borehole was rapid and confirms that the borehole can maintain pump and recovery cycles on a sustainable basis.

Recharge to the mostly confined Baviaanskloof or Skurweberg Formation aquifer occurs on and near the outcrop areas, which then replenishes the aquifer and maintains the piezometric head. Although the Telluric borehole can be considered to be situated 'downstream' in the aquifer relative to the municipal boreholes, the annual volume that applied for use is insignificant compared with the recharge and aquifer storage in the aquifer.

The radius of influence (to less than 1 meter influence on piezometric head) as a result of long-term abstraction from the Telluric borehole at its maximum sustainable yield is expected to be less than 600m **(Section 4.3)**. With the nearest municipal supply borehole being situated more than 4.5 km away, the Telluric borehole is not expected to have a measurable influence on the municipal boreholes.

If the recommended yield is not exceeded the abstraction should have no lasting adverse impacts on the groundwater.

7.2 IMPACTS ON GROUNDWATER QUALITY

No negative impacts are expected as a direct consequence of the proposed groundwater abstraction and use at Telluric, thus no adverse impact is foreseen on groundwater quality.

The only identified potential risk in terms of groundwater quality as a result of the proposed abstraction is salt water intrusion. No deterioration of groundwater quality is expected due to the proposed abstraction in close proximity of the Keurbooms River Estuary. The main reason for the expected absence of salt water intrusion lies in the geological make-up of the aquifer that will be exploited.

To confirm the abovementioned statement, please note the following:

- The sandstone aquifer from which the Telluric borehole sources its water is overlain by the Kirkwood shale Aquiclude (please refer to Section 4.1.2 and Figure 9, 10 and 11).
- The fact that the Telluric borehole draws water from the confined sandstone aquifer below the Kirkwood formation aquiclude will nullify the risk of saltwater intrusion unless the borehole is grossly over-exploited.

- The piezometric pressure head of the underlying sandstone aquifer is higher than the head in the Kirkwood aquiclude, which results in fresh water flowing vertically upwards from the lower aquifer into the aquiclude.
- The presence of fresh water in the Skurweberg or Goudini sandstone formations with saline water in the Kirkwood conglomerates above proves the absence of interaction between different layers – after thousands (or millions) of years, the estuary or ocean, has not penetrated the fresh water from the sandstone aquifer through the saline conglomerate and siltstone layers at surface.
- The recharge to the sandstone aquifer also creates a pressured flow towards the ocean, “pushing back” the saline water.
- With regular monitoring of the EC of the groundwater as well as monitoring the water level reaction to abstraction, all of the above can be confirmed and salt water intrusion can be prevented.

Also refer to Section 3.6 where it was discussed that no recharge to the aquifer takes place in the direct vicinity of the Telluric borehole but that recharge takes place where the freshwater-containing sandstone formations outcrop.

7.3 GROUNDWATER MANAGEMENT

The following guidelines can be followed to ensure that the aquifer is not overstressed or abused:

- Use water only at the recommended sustainable yield so as to not over-exploit the aquifer.
- When reservoir is full and the water is not being used, switch of pumps and let the borehole recover.
- Conduct continuous monitoring of the EC of the groundwater as well as monitoring the water level reaction to abstraction. Have the water quality, level and discharge results reviewed by a competent person to serve as an early warning system against salt water intrusion

7.4 SUMMARY

Impacts on the groundwater quantity/availability are expected to be insignificant during the operational phase as a result of pumping and no of the existing lawful users will be affected to a measurable extent if a stringent monitoring program is followed and results are interpreted regularly.

8 GROUNDWATER MONITORING SYSTEM

Groundwater monitoring should be conducted to assess the potential impacts (if any) of the proposed new facility on groundwater quality and water levels. A monthly groundwater depth monitoring should be sufficient to determine whether the pumping is adversely affecting the groundwater levels.

The maintenance and continued use of the installed 32mm PVC or HDPE pipe in the borehole is recommended to make the measurements of water levels more efficient. A tap will also need to be designated at which regular water quality samples can be taken. Monthly recording of at least the EC of the groundwater is recommended.

The water level measurement should be conducted before the pump is started to reflect the rest water level in the aquifer. The duration of recovery after the last pump event should be at least 12 hours, but preferably 24 hours.

The water level data should be recorded on a database or spreadsheet with at least the following information:

- The date and time of measurement;
- The time since the last pump cycle ended; and
- The date and values of rainfall during the month.

A flow meter should be installed at the well head and the flow meter readings (abstraction rates) should be recorded on at least a monthly basis. The meter readings should be recorded in the same database as the water levels and rainfall data to enable easy compilation of hydrographs and trend analysis.

9 CONCLUSIONS AND RECOMMENDATIONS

The geohydrological environment can be summarised as follows:

- The geology in the Telluric area created a highly varying secondary, fractured rock aquifer system with various unconnected or poorly connected aquifers.
- The area is underlain by Cape Supergroup sedimentary rocks.
- The Cape Supergroup is known for deformation and creating the cape fold belt mountain ranges. The deformation can also form high-yielding fractured aquifers.
- The borehole was drilled to a depth of 195 m and casing was inserted to 150m and sealed off.
- The upper part of the borehole was sealed of due to the poor water quality in the upper aquifers.
- The static groundwater level depth varies greatly due to the poorly connected aquifers and ranges between 18 and 20 mbs.
- The aquifer at Telluric receives on average approximately 7 % recharge of the MAP, which is estimated to be a conservative value.
- There are no other groundwater users nearby who will be influenced by the water use applied for in this application.

The aquifer test program revealed the following:

- The transmissivity for the Telluric borehole is approximately 4.5 m^2/d.
- The sustainable yield for the borehole was calculated to be 8 280 l/h, respectively for a 24-hour per day pumping cycle.
- The total daily sustainable yield is 198 000 l/d, which translates to 72 500 m^3/a.

The baseline assessment, geology and aquifer test results led to the following conceptual model:

- Telluric is located on a large deposit of **Kirkwood** conglomerate, siltstone and mudstone.
- The Kirkwood formation is underlain by the Baviaanskloof and Skurweberg formations, which is likely where the groundwater from the borehole is sourced from.
- The shale, siltstone and mudstone layers act as aquicludes or groundwater barriers, that do not allow movement between upper and lower layers.
- Due to the dipping/sloping nature of the geology the groundwater recharge to the deeper aquifers does not take place around the borehole but to the west and north of the borehole where the aquifer outcrops.

Conclusions and recommendations from the impact assessment are provided below:
If the recommended sustainable yields per borehole are not exceeded, the proposed groundwater abstraction is not expected to neither have significant immediate effects on groundwater availability of nearby groundwater users not would it have lasting adverse impacts on the groundwater system.

The pumping tests have shown that after extensive pumping:

- During the pumping test, the borehole responded well to pumping and used very little of the available drawdown.
- After pumping was ceased, the borehole recovered quickly and completely, further indicating the strength of the borehole.
- The estimated sustainable yield of 2,3 l/s is a safe and conservative rate for the borehole to be used at.
- The estimated sustainable yield is more than sufficient to provide the volume of 1.7 l/s applied for in the WUL application.
- There is low risk of saltwater intrusion due to the piezometric pressure of the sandstone aquifer and the integrity of the Kirkwood formation.
- Monitoring of the quality and groundwater level will be conducted to ensure that the borehole does not impact the groundwater quantity or quality.

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