**Groundwater quality index**

WQI is a tool aimed at simplifying and reporting scientific water quality information that reflects on the composite influence of different water quality parameters into a single-digit score that describes overall water quality in a catchment, thus providing policymakers and the public with water quality relevant information that is usable and easy to understand(Nzama et al., 2021). To get a comprehensive picture of the overall groundwater quality in the study area, the WQI methodology was used to calculate the groundwater quality index (GQI) of the study area. In calculating GQI and setting of groundwater quality reserve limits in the present study, the South African water quality guidelines WRC (1998) and SANS 241(2015) for domestic use were taken into consideration. A five-step procedure was followed in undertaking the process of determining GQI. The first step involved assigning weight (wi) to the selected water quality parameters such as pH, electrical conductivity, calcium, magnesium, sodium, chloride, sulphate, nitrate, and fluoride according to their relative importance for domestic water use. In the second step, a relative weight (Wi) for each of the selected water quality parameters was calculated using Eq. (1).

(1)

The third step involved calculating and assigning a quality rating scale (*qi*) for each parameter by dividing the concentration of each water quality parameter (*Ci*) by its respective South African water quality standard for domestic use (*Si*). In the case where WRC (1998) guideline was used, numerical limits for class I were considered, and in the case where SANS 241(2015) standard was used, numerical limits as specified in the standard were considered. The results were converted to percentage using Eq. (2).

(2)

The sub-index (*SIi*) for each water quality parameter was calculated in the fourth step using the formula in Eq. (3).

(3)

In the fifth step, *GQI* for the entire study area was calculated using Eq. (4).

(4)

The classification of water quality, based on its water quality index (WQI) after Brown et al. ([1972](https://link.springer.com/article/10.1007/s13201-021-01376-7#ref-CR15)); Chatterjee and Raziuddin ([2002](https://link.springer.com/article/10.1007/s13201-021-01376-7#ref-CR19)) and Shankar and Kawo ([2019](https://link.springer.com/article/10.1007/s13201-021-01376-7#ref-CR76)) have been considered here in this study for further reference which is mentioned in Table [xx](https://link.springer.com/article/10.1007/s13201-021-01376-7#Tab3).



**Case study 1:Upper Berg**

In the 2011 GRDM training manual, groundwater quality classification was mainly based on EC parameter. This has a limitation as not only EC is responsible for the apparent water quality of a particular system, but also other parameters influence the groundwater quality. A holistic approach is proposed to use a Groundwater Quality Index (GQI). This approach combines multiple parameters to get the overall water quality. The results are then interpreted using table 1. The approach allows the user to select the parameters for their specific site and give weight to the different parameters. In the current manual this approach was tested in two separate catchments i.e., G10A and G50. In previous studies (Saleem et al., 2016;Ram et al., 2021; Nzama et al., 2021), the limit when using this approach is set using the water quality standards, however, since the water is coming from the aquifer then environment should set the limit. In this manual the maximum from long term monitoring data is used to the limit. In figure X below, the quality of water is between 0 and 25 for much of the catchment. The upper Berg is a pristine environment. It was expected that a large portion of the catchment would fall in this category. The other part is between 26 – 50, this suggests that the section is minimally impacted. This was expected as that section falls with the Franschhoek area, in the area farming takes place and there are settlements in that part. The section below the confluence also shows signs of being impacted; across the road from the confluence a wastewater treatment plant can be found.

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**Figure x:**

It is understood that not all catchments have historical data, in case like that it is suggested that the water quality standards be used with caution until background data is available. Based on the analysis of groundwater quality using the drinking water guidelines, figure xx below shows that the catchment has shifted from the range of 0 to 25 and now includes values greater than 100. This means that the water is not good for drinking but good for environment, this is why guidelines in such cases should be applied with caution. One needs to understand the use of the water when monitoring, the guidelines tend to more stringent on the environment.

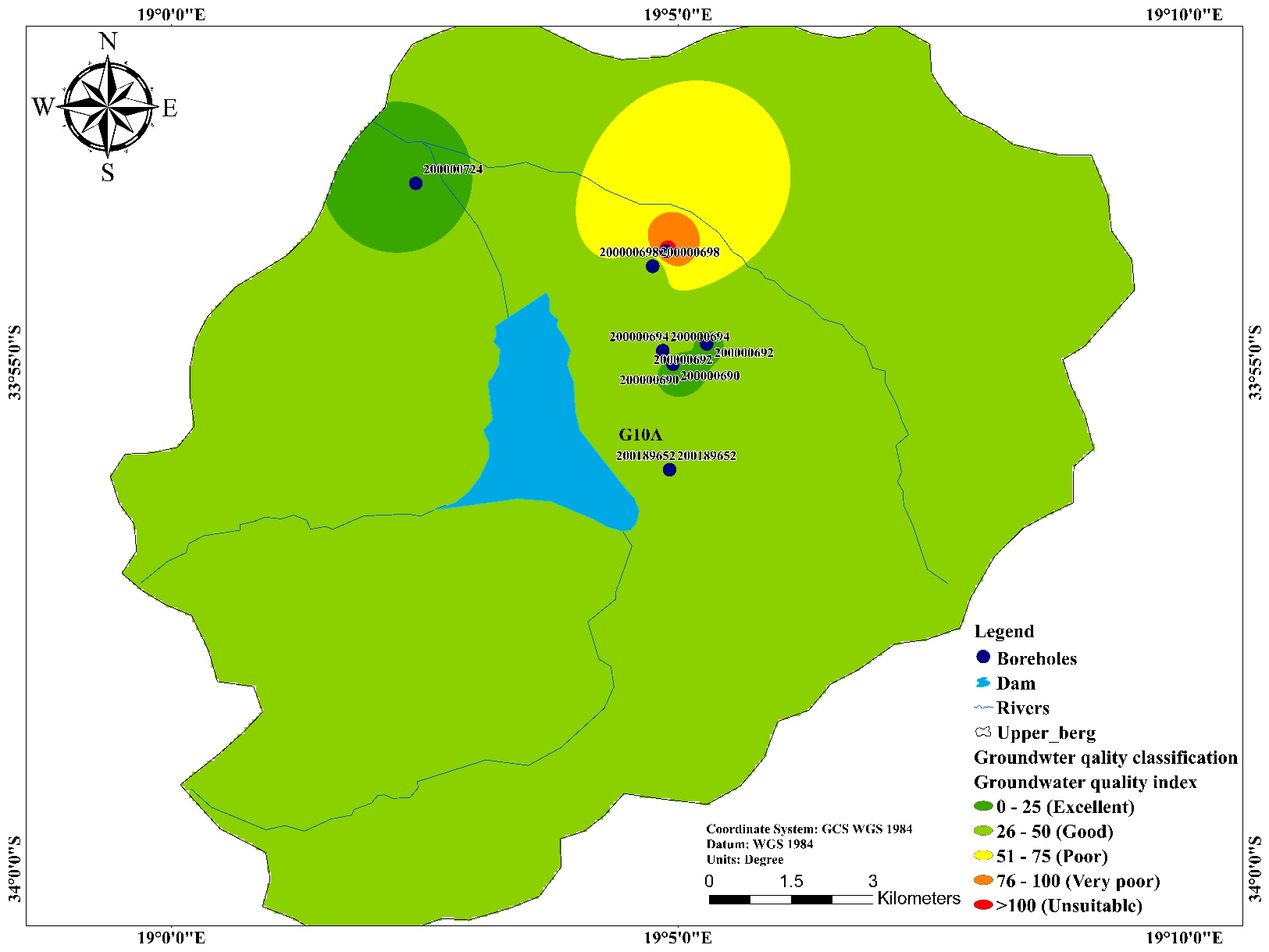


Figure:

**Case study 2: Heuningnes catchment**

The procedure for determining GQI has been stated in the above sections and the importance of using such an approach over the use of EC alone has been stated in the case of upper Berg. The one element that was not demonstrated in the above case study is the application of the GQI on different aquifer system. The reason for this was the lack of lithological logs for the unconfined aquifer system in the upper Berg. In the delineation step, aquifer systems need to be delineated and as such groundwater quality index needs to be determined for the delineated aquifer systems. In figure X below, the quality of water is between 0 and 25 for much of the catchment. The Heuningnes catchment is a rural environment and there are not many activities taking place in that area. It was expected that a large portion of the catchment would fall in this category. The other part is between 26 – 50, this suggests that the section is minimally impacted. The section that is minimally impacted forms part of the area that has the highest salinity levels in the unconfined aquifer system.

**Unconfined aquifer system**

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**Figure x:** **Groundwater quality index based on the background condition of the unconfined aquifer system.**

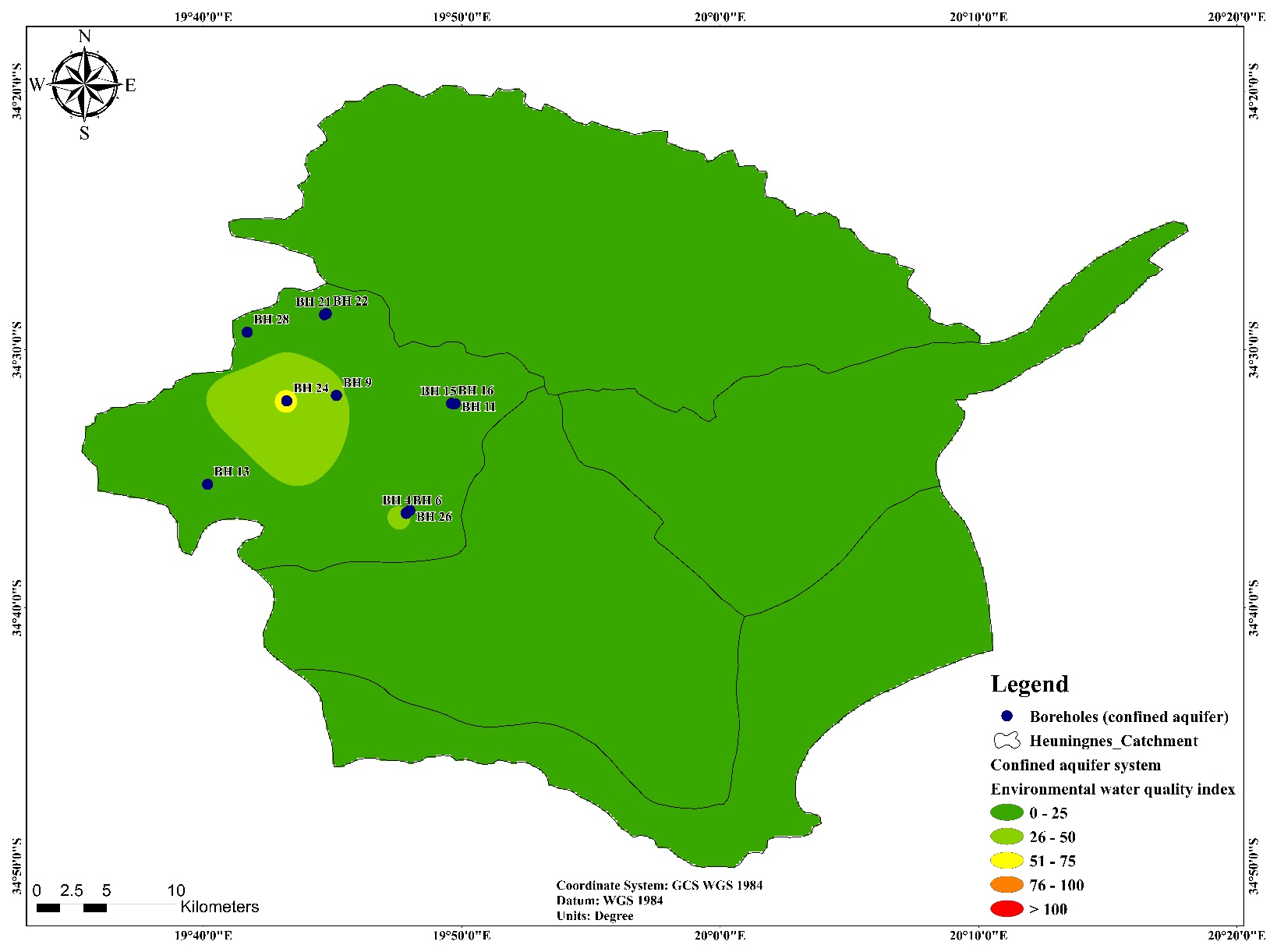
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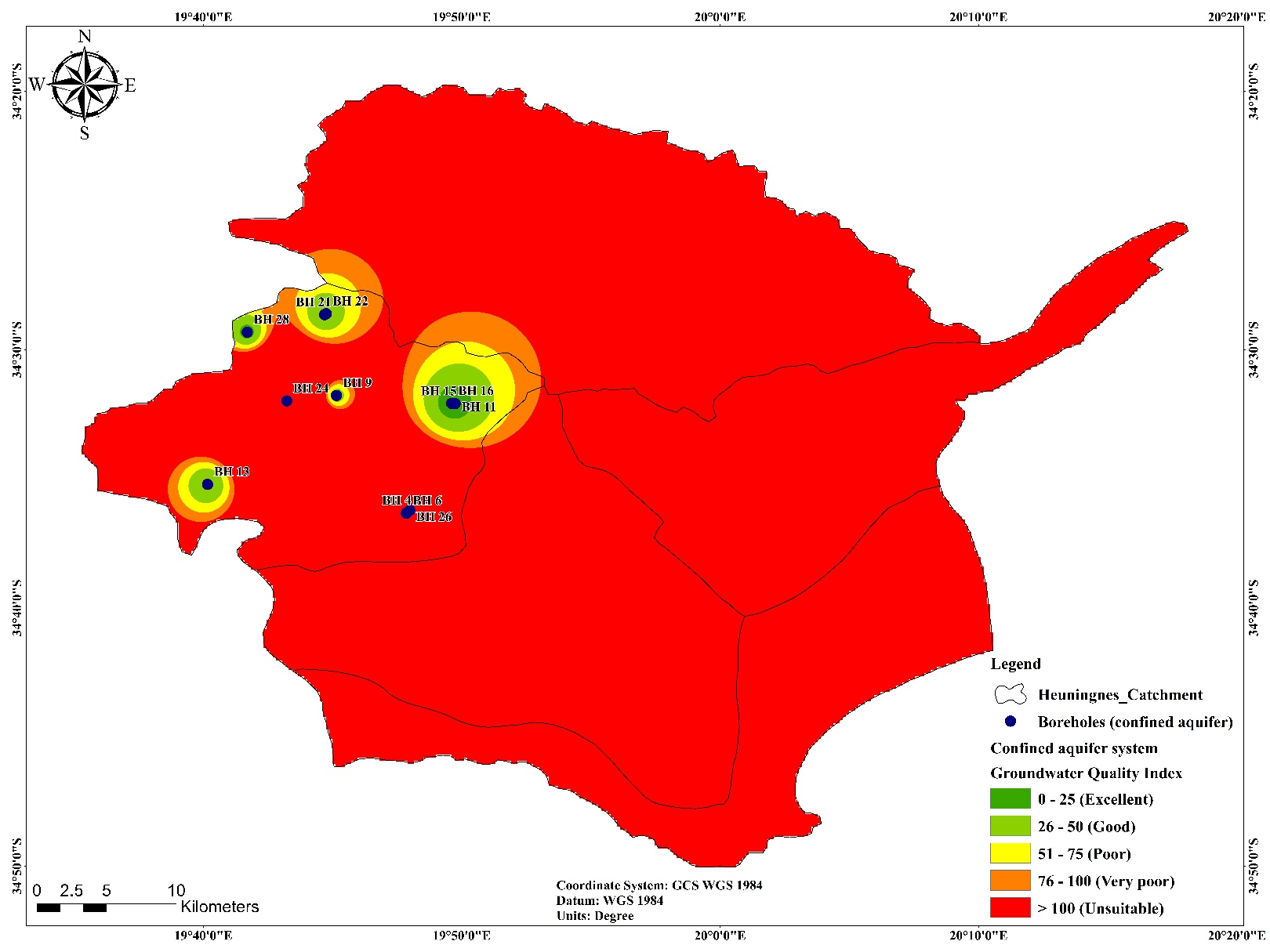
**Figure xx: Groundwater quality index based on the water quality standards for drinking water.**

Based on the analysis of groundwater quality using the drinking water guidelines, figure xx below shows that the catchment has shifted from the range of 0 to 25 and now includes values greater than 100. The high range is a result of the high salinity levels.

**Confined aquifer system**

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**Figure xxx: Groundwater quality index based on the background condition of the confined aquifer system.**

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**Figure xx: Groundwater quality index based on the water quality standards for drinking water.**

Monitoring groundwater quality needs to be done at the delineated aquifer systems. This has been demonstrated in this case study as in the unconfined aquifer system the range of 26 to 50 was closer to the coast. Whereas, in the confined aquifer system it is in the upper section of the catchment. So if monitoring is not done based on the delineated aquifer systems the in accurate conclusions could be drawn from such studies.

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