# **STRESS INDEX**

## Data Required

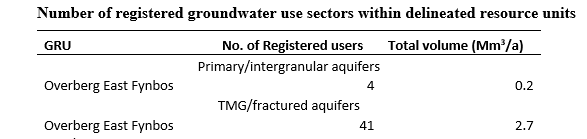
|  |  |  |
| --- | --- | --- |
| **Data Needed** | **Data and Information** | **Source** |
| Groundwater use (for vegetation, mining, agriculture, forestry, domestic supply, etc.) | WARMS database | DWA Regional Offices |
| Catchment study reports | General and historical information relating to water resources | DWA |
| Catchment area | Quaternary catchment shapefile | DWS |
| Groundwater Recharge |  |  |
| Groundwater contribution to baseflow | River flows from DWS database, EC concentrations | Field & Desktop |
| EWR\_MLF |  | DWS (surface water) |

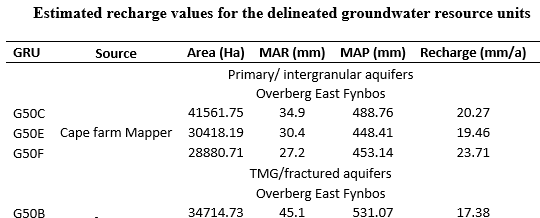
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## **Step by step procedure for aquifer stress index**

**Step 1: Acquisition of data and calculations where necessary**

* Acquire groundwater use of the delineated aquifer types in the interested study area from WARMS
* Acquire groundwater recharge data from previous reports/ Estimate groundwater recharge of the delineated aquifer types in the study area based on the aquifer types.

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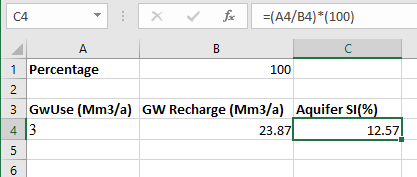
**Step 2: Convert units**

* Convert groundwater recharge from mm/a to m/a by dividing by 1000
* Convert the area covered by the aquifer system from Km2 to m2 by multiplying by 1000
* Then multiply the groundwater recharge values (m3/a) with the area covered by the delineated aquifer system (m2) to get groundwater recharge in Mm3/a

**The message here is to convert whatever units the data is represented in, to have similar units for calculation purposes.**

**Step 3: Calculate the aquifer stress index**

Use the equation below to calculate the aquifer stress index per delineated aquifer systems.

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Example of displaying the calculation of aquifer stress index

**Step 4: Identify whether the aquifer system is stressed or not**

Use the guide for determining the level of stress of a groundwater unit table to identify which class the delineated aquifer system in interest belongs to.

**Table 1. guide for determining the level of stress of a groundwater unit**

|  |  |  |
| --- | --- | --- |
| **PRESENT CLASS** | **DESCRIPTION** | **COMPLIANCE (SPATIAL/TEMPORAL)** |
| I | Minimally used | ≤20% |
| II | Moderately used | 20% – 65% |
| III | Heavily used | > 65% |

**guide for determining the level of stress of a groundwater unit**

## **Step by step procedure for environmental stress index**

**Step 1: Acquisition of data and calculations where necessary**

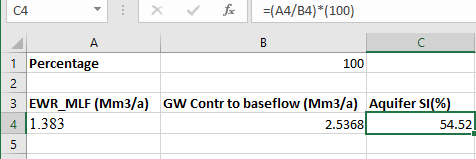
* Acquire environmental water requirements maintenance low flows (EWR-MLF) of the interested study area from WARMS.
* Acquire groundwater contribution to baseflow data from previous reports/ Estimate groundwater contribution to baseflow in the study area based on the aquifer systems.

**Step 2: Convert units**

Convert the units for groundwater contribution to baseflow and EWR-MLF to be similar for calculation purposes.

**Step 3: Calculate the aquifer stress index**

Use the equation below to calculate the environmental stress index per delineated aquifer systems



## **HEUNINGNES CATCHMENT**

### **Catchment area**

The Heuningnes catchment is situated in the eastern Overberg district of the Cape Agulhas Municipality in the Western Cape Province of South Africa. Within the wider Breede-Gouritz Water Management Area, the Heuningnes Catchment is located in the tertiary catchment G50. The five quaternary catchments in the catchment are G5 0B, G50C, D, E, and F. (Figure 1). The Heuningnes catchment covers an area of 1400 km2 which was converted into m2 (1400000000 m2). The area covered by the delineated aquifer systems in the Heuningnes catchment is uknown.

### **Groundwater Use**

Table 2 below indicates groundwater recharge estimated in the delineated aquifer systems of the Heuningnes catchment ( primary and fractured aquifer systems)

**Table 2: Estimated recharge values for the delineated groundwater resource units**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **GRU** | **Source** | **Area (Ha)** | **MAR (mm)** | **MAP (mm)** | **Recharge (mm/a)** |  |
| Primary/ intergranular aquifers | | | | | |
|  | | | | | |
| G50C | Cape farm Mapper | 41561.75 | 34.9 | 488.76 | 20.27 |  |
| G50E | 30418.19 | 30.4 | 448.41 | 19.46 |  |
| G50F | 28880.71 | 27.2 | 453.14 | 23.71 |  |
| **Average recharge 21.15** | | | | | |
| TMG/ Fractured aquifers | | | | | |
| G50B | Cape farm Mapper | 34714.73 | 45.1 | 531.07 | 17.38 |  |
| G50C | 30418.19 | 30.4 | 448.41 | 20.27 |  |
|  | | | | | |
| G50D | Cape farm Mapper | 57276.53 | 27.1 | 431.43 | 11.07 |  |
| G50E | 30418.19 | 30.4 | 448.41 | 19.46 |  |
| **Average recharge** |  |  |  |  | **17.05** |  |

### **Groundwater recharge**

Table 3 below indicates groundwater use estimated in the delineated aquifer systems of the Heuningnes catchment ( primary and fractured aquifer systems)

**Table 3: Number of registered groundwater use sectors within delineated resource units**

|  |  |  |
| --- | --- | --- |
| **GRU** | **No. of Registered users** | **Total volume (Mm3/a)** |
| Primary/intergranular aquifers | | |
|  | | |
| Overberg East Fynbos | 4 | 0.2 |
| **Total GwUse in primary aquifers** |  | **0.2** |
| TMG/fractured aquifers | | |
| Overberg East Fynbos | 41 | 2.7 |
| Overberg East Renosterveld | 9 | 0.3 |
| **Total GwUse in fractured aquifers** |  | **3** |

### **Primary/ Intergranular aquifers stress index**

* Groundwater use = 0.2 Mm3/a shown in table 3
* Groundwater recharge = 21.15 mm/a = 0.02115 m/a shown in table 2

To convert groundwater recharge from m/a to m3/a , groundwater recharge in the primary aquifer system was multiplied by the area covered by the Heuningnes catchment (1400000000 m2) as the area covered by the primary aquifer system was unknown. Where the area covered by the aquifer system is known then it is recommended to be used rather than the usage of the catchment area.

* Heuningnes catchment area: 1400000000 m2
* Groundwater recharge: 0.02115 m/a x 1400000000 m2 = 29610000 m3/a = 29.61 Mm3/a

Therefore,

Primary / intergranular aquifer stress index of Heuningnes Catchment (%)

=

=

= 0.68 %

This index shows that the unconfined aquifer(inter granular) receives more groundwater recharge than it is being used within the system. This implies that the unconfined system is not stressed with more groundwater availability for abstraction, therefore a license can be issued from this aquifer.

### **TMG/fractured aquifers stress index**

* Groundwater use = 3 Mm3/a as shown in table 3
* Groundwater recharge = 17.05 mm/a = 0.01705 m/a as shown in table 2

To convert groundwater recharge from m/a to m3/a , groundwater recharge in the fractured aquifer system was multiplied by the area covered by the Heuningnes catchment (1400000000 m2) as the area covered by the TMG / fractured aquifer system was unknown. Where the area covered by the aquifer system is known then it is recommended to be used rather than the usage of the catchment area.

* Heuningnes catchment area: 1400000000 m2
* Groundwater recharge: 0.01705 m/a x 1400000000 m2 = 23870000 m3/a = 23.87 Mm3/a

TMG / fractured aquifer stress index of Heuningnes Catchment (%)

=

=

= 12.57 %

This index less than 20 % shows that the TMG/ Fractured aquifer (confined) system of the Heuningnes catchment is not stressed which implies that the water abstracted from this system is less than the water coming into the system. This provides the insurance of groundwater availability in the system to sustain the ecosytem.

### **Environmental Stress Index**

The environmental stress index was computed for the confined aquifer system (TMG/ fractured) of the Heuningnes quaternary catchment of G50B for the year 2020.

* EWR\_MLF = 1.383 Mm3/a (Spatsim)
* Annual flows received by the aquifer system in 2020 = 9.060 Mm3/a ( Mazvimavi et al.,2021)
* Baseflow index estimated using the mass balance equation using natural EC = 28% (Mazvimavi et al., 2021)

To get the flows contributed to annual river flow by the aquifer system, the annual flows received were multiplied by the baseflow index.

* Groundwater contribution to baseflow by the confined aquifer system of the G50B quaternary catchment of the Heuningnes catchment in 2020 = 2.5368 Mm3/a

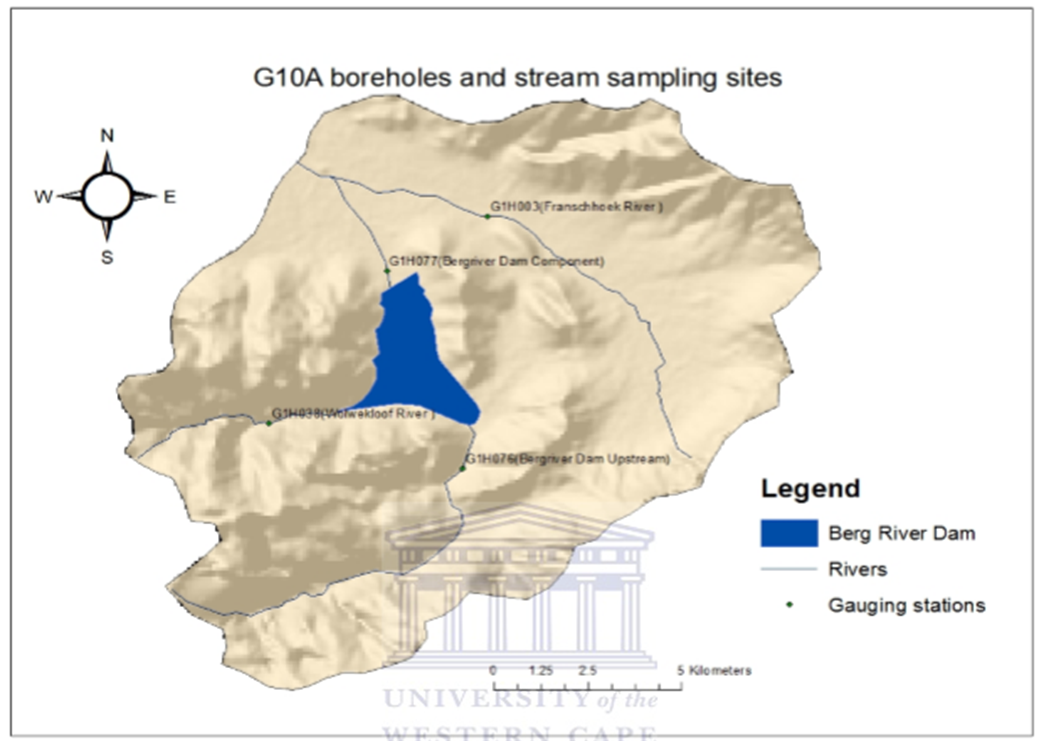
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This index indicates that groundwater from the confined aquifer system of the GB50 sustains the ecosystem in the area. This represents the non-perennial river system whereby the river dries up in dry seasons, resulting in the ecosystem total dependence on groundwater.

## **UPPER BERG CATCHMENT**

### **Catchment area**

The Berg River catchment is the largest in the Western Cape province of South Africa. The Berg catchment covers a surface area of 9 000 km2 and is divided into 12 quaternary catchments each of which has a different size, starting with G10A near the Berg River's source and terminating with G10M at the Atlantic Ocean as shown in figure 3. The largest of them are the Quaternary catchments G10L and G10M, situated in the western drier portions of the Berg catchment covering a surface area of 1750 km2 and 2000 km2 respectively. G10A and G10B are the smallest quaternary catchment in this area and occupy 172km2 and 125 km2 respectively (Ratcliffe, 2007). There are two aquifer systems in the Upper Berg catchment but even though the area covered by the catchment is known, the area each system covers is not known.



Stream gauging stations around the Upper Berg River catchment (Madlala, 2015)

### **Groundwater Use**

For the Upper Berg catchment, groundwater use per delineated aquifer system data was not available hence groundwater use in the catchment was used (current approach used). We are however moving away from the usage of this current method of using the catchment, so where data is available, it is recommended to use groundwater from the delineated aquifer systems specifically and not the catchment in general. Groundwater use in the catchment is presented in the table below. The average groundwater use in the Upper Berg catchment of 3908318 m3/a which is a total of all activities utilizing groundwater in the catchment, see table below.

|  |  |
| --- | --- |
| **Sector** | **Water use (m3/a)** |
| Agriculture (irrigation) | 3 135 346 |
| Agriculture (Aquaculture) | 220 000 |
| Industry (Urban) | 208 989 |
| Industry (non-urban) | 323 811 |
| Water supply service | 4 050 |
| Schedule 1 | 16 122 |

### **Groundwater Recharge**

Groundwater recharge per delineated aquifer in the Upper Berg catchment data was not available hence the current method of using catchment groundwater recharge was applied. Where groundwater recharge per aquifer systems in the study area data is available or can be estimated, the usage of this is recommended as the new approach. The mean groundwater recharge values calculated in the Upper Berg catchment using the chloride mass balance, rainwater infiltration breakthrough, and water table fluctuation methods were 27.6 %, 23.67 %, and 22.7 % of the total precipitation received in the catchment, respectively (Mutoti, 2015). Using the average of these groundwater recharge percentages of 24.66 % and mean annual precipitation (MAP) in the catchment of 1603mm/a, the Berg catchment experiences groundwater recharge of 395.3 mm/a. Based on the area of the G10A catchment, groundwater recharge as a volume is estimated to be 68 335 000 m3/a.

### **Aquifer Stress Index**

The Aquifer Stress Index (SI) for an assessment area is defined as follows:

= 5,72%

Based on a guide for determining stress level in a groundwater unit (Table 1), the Berg catchment with a stress index (SI) of 5,72 % falls under class I where groundwater is minimally used and therefore not stressed. This implies that there is enough groundwater to be allocated to users as the used volumes are less than the water coming into the catchment.

### **Environmental Stress Index**

The Upper Berg catchment is divided into two sections which are the section before the dam (natural flows) and the section after the dam (modified flow). Two aquifer systems were observed in the Upper Berg catchment (Unconfined and Confined aquifers). Groundwater contribution to baseflow data from the unconfined aquifer system was unavailable, therefore the environmental stress index was estimated only for confined aquifer systems in the area. Groundwater contribution to baseflow was estimated from the confined aquifer system from both sections. The estimated groundwater contribution to baseflow from the confined aquifer system before and after the dam was 0.051942 m3/s and 0.399244 m3/s respectively. The addition of these two groundwater contribution to baseflow estimates produced the total groundwater contribution to baseflow from the confined aquifer system of the Upper Berg catchment which was 0.451186 m3/s. The total groundwater contribution to baseflow for the year 2022 was converted from m3/s to m3/a which was 14228601.7 m3/a (14.229 Mm3/a). The Ecological Water Requirements for Maintenance Low Flows for 2022 was 2.556 Mm3/a (WARMS).

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This index indicates that groundwater from the confined aquifer system of the Upper Berg catchment sustains the ecosystem in the area. The index however shows that the ecosystem does not only depend on groundwater contributions from the confined aquifer system even in the dry season meaning that except from groundwater contribution, the ecosystem could be receiving water from unconfined aquifer systems, river flow, etc.