GCS Newcastle Office
1 Karbochem Rd, Newcastle, 2940
Cell: +27 (0) 71 102 3819 **Fax:** +27 (0) 31 764 7140 **Web:** www.gcs-sa.biz

Desktop Hydrological Assessment for the Nomamix (Pty) Ltd - Mareesburg Non-Invasive Prospecting Right Application

Report

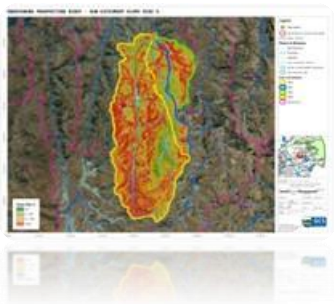
Version – Final 2

08 September 2022

Environmental Management Assistance (Pty) Ltd

GCS Project Number: 22-0831

Client Reference: BCR_MB002



DESKTOP HYDROLOGICAL ASSESSMENT FOR THE NOMAMIX (PTY) LTD - MAREESBURG NON-INVASIVE PROSPECTING RIGHT APPLICATION

Report
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Environmental Management Assistance (Pty) Ltd

22-0831

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LEGAL NOTICE

DECLARATION OF INDEPENDENCE

GCS (Pty) Ltd was appointed to conduct this specialist surface water study and to act as the independent hydrological specialist. GCS objectively performed the work, even if this results in views and findings that are not favourable. GCS has the expertise in conducting the specialist investigation and does not have a conflict of interest in the undertaking of this study. This report presents the findings of the investigations which include the activities set out in the scope of work.

APPENDIX 6 OF THE EIA REGULATION – CHECKLIST AND REFERENCE FOR THIS REPORT

Table 1 - Requirements from Appendix 6 of GN 326 EIA Regulation 2017

Requirements from Appendix 6 of GN 326 EIA Regulation 2017	Chapter
(a) Details of: (i) The specialist who prepare the reports; and (ii) the expertise of that specialist to compile a specialist report including a curriculum vitae	Document Issue (Page ii) Appendix D.
(b) Declaration that the specialist is independent in a form as may be specialities by the competent authority	Document Issue (Page ii) Appendix D.
(c) Indication of the scope of, and purpose for which, the report was prepared	Section 1.
(cA) Indication of the quality and age of base data used for the specialist report	Sections 1, 2 and 3.
(cB) A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change	Section 6.
(d) Duration, Date and seasons of the site investigation and the relevance of the season to the outcome of the assessment	Section 1.4.
(e) Description of the methodology adopted in preparing the report or carrying out the specialised process include of equipment and modelling used	Section 2.
(f) Details of an assessment of the specifically identified sensitivity of the site related to the proposed activity or activities and its associate's structures and infrastructure, inclusive of a site plan identifying alternative	Sections 1, 4 and 6.
(g) Identification of any areas to be avoided, including buffers	Section 8.1
(h) Map superimposing the activity and associated structures and infrastructure on environmental sensitivities of the site including areas to be avoided, including buffers	Section 1, 3.
(i) Description of any assumptions made and uncertainties or gaps in knowledge	Section 2, 4, 5.
(j) A description of the findings and potential implications of such findings on the impact of the proposed activity including identified alternatives on the environment or activities	Executive summary, Section 8.
(k) Mitigation measures for inclusion in the EMPr	Section 8.2
(l) Conditions for inclusion in the environmental authorisation	Refer to Section 8.
(m) Monitoring requirements for inclusion in the EMPr or environmental authorisation	Refer to Section 8.
(n) Reasoned opinion – (i) as to whether the proposed activity, activities or portions thereof should be authorised. (iA) regarding the acceptability of the proposed activity or activities; and (ii) if the opinion is that the proposed activity, activities or portions thereof should be authorised, and avoidance, management, and mitigation measures should be included in the EMPr, and where applicable, the closure plan	Section 8.3
(o) Description of any consultation process that was undertaken during preparing the specialist report	*This document will form part of the Basic Assessment Report (BAR) and Environmental Management Programme (EMPr) required by the Environmental Impact Assessment Regulations (GNR 982 GG 38282 dated 4 December 2014, as amended).*
(p) A summary and copies of any comments received during any consultation process and where applicable all responses thereto	*None required.*
(q) Any other information requested by the competent authority	*None required.*

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LIST OF ACRONYMS

Acronym	Description
BA	Basic Assessment
BOD	Biological oxygen demand
COD	Chemical oxygen demand
CSWMP	The conceptual stormwater management plan
DEM	Digital Elevation Model
DWS	Department of Water and Sanitation
GCS	GCS Water and Environment (Pty) Ltd.
SW	Surface Water
GN704	General Notice 704
ha	Hectare
HRU	Hydrological Response Unit
IWULA	Integrated Water Use Licence Application
m^3	Cubic Metres
MAE	Mean annual evaporation
MAR	Mean Annual Runoff
MIPI	Midgley and Pitman
NEMA	National Environmental Management Agency
n-Value	Manning’s Roughness Coefficients
NWA	National Water Act, 1998 (Act No. 36 of 1998)
PCD	Pollution Control Dam
PFD	Process flow diagram
SDF	Standard design flood
SPP	Sewage Package Plant
TDS	Total dissolved solids
TIN	Triangulated Irregular Network
WMA	Water Management Area
WR2012	Water Resources of South Africa 2012

1 INTRODUCTION

GCS Water and Environment (Pty) Ltd (GCS) was appointed by Environmental Management Assistance (Pty) Ltd (EMA) to undertake a hydrological assessment for the proposed Mareesburg Prospecting right application, situated near Mareesburg, about 32km west of Lydenburg, in Limpopo Province. (refer to Figure 1-1). The project falls in quaternary catchment B41G of the Olifants Water Management Area (WMA) (DWS, 2016).

1.1 Project background

The Nomamix (Pty) Ltd prospecting right area entails an area of about 2 082 Ha, near Mareesburg, about 32km west of Lydenburg, in Limpopo Province. EMA is currently busy with the Basic Assessment (BA) for a **non-invasive prospecting right** application for the proposed mining area. As part of the environmental screening that was undertaken, a hydrological assessment was flagged as a requirement for the BA.

The **non-invasive prospecting** process will involve the following:

- **Data search, Field Mapping and Desktop Studies**
    - Tracing and purchasing of all available geological data in the form of geological maps, geochemical and geophysical surveys, gravimetric, radiometric, magnetic, seismic data, remote sensing data, borehole data, as well as any information about previous invasive or non-invasive exploration will be consulted and integrated. All data from the old and current mining operations will be sourced, like geological maps, mining maps, survey maps, assay maps, laboratory results and any other reports or information relevant. As soon as this data is located and gathered, all information will be analysed for relevance to the project. Non-digital information will be successively scanned and captured in digital format. All information (soft and hard copies) will be QA/QC'ed to assess their value relevant to internationally recognised compliant resource estimation. The above and any additional knowledge will be integrated into a geological database for the area that will be used to present the relevant geological data in electronic formats. These data sets will be plotted on a base map of the project and surrounding areas to develop a geological model that elucidates resource potential. This model will be used to further refine the exploration programme for the target area. 2D and 3D geological models will be initiated.

  - A reconnaissance field visit will be undertaken to identify any factors that may impact the exploration programme, to familiarise the applicant with surface features in the project area (such as infrastructure and outcrops) and to meet the landowners/ occupants. During this visit, property boundaries within the project area and farming and all activities will be verified. This will be followed up by detailed geological field mapping. Geological features, in combination with existing maps, remote sensing images, etc. will be mapped professionally. The field mapper will also take grab samples for further analyses and potential assaying. The gathered data will be compared with historical information and so will steer the field exploration in focusing on potential targets.

- **Logging and sampling of historical core**
  - If any historical core can be found, at least ten per cent of the (usually) halved core will be logged in detail and sampled professionally and according to industry standards. The samples will be submitted to an accredited laboratory for analysis. This exercise will be needed for QA/QC purposes and confirmation of the historical data.

1.2 Study relevance to the season in which it was undertaken

This study was undertaken as a once-off study and relies on historical hydrological and climate data for the site, as well as recognised hydrological and water resource databases for South Africa. Data generated during the time of this study is not seasonally bound as average yearly data was applied where required and as scientifically acceptable.

1.3 Objectives

The objectives of this study, were as follows:

- Evaluate the site's hydrological setting (i.e., climate, rainfall, drainage, etc.).
- Determine the 1:50, and 1:100-year peak flows for the non-perennial stream associated with the site.
- Undertake a hydrological risk assessment and compile mitigation measures; and
- Compile a surface water monitoring plan to monitor the impact on the receiving environment.

1.4 Scope of Work

The scope of work completed, was as follows:

1. **Baseline Hydrology Review:**
    a. Hydro-meteorological data collection and analysis.
    b. Catchment delineation and drainage characteristics.
    c. Determination of catchment hydraulic and geometric parameters.
    d. A conceptualisation of the project-specific hydrological cycle and hydrological components.
2. **Peak Flows & Flood Line Modelling:**
    a. Peak flood volume calculation for the 1:50, and 1:100-year recurring events.
    b. Flood line modelling using HEC-RAS hydraulic software – 1:50 and 1:100-year flood lines were presented; and
    c. Analysis of the modelling results.
3. **Preliminary risk assessment:**
    a. A hydrological risk assessment was undertaken, to contextualize the potential surface water risk of the project.
4. **Surface Water Monitoring Plan:**
    a. A surface water monitoring plan was developed.
5. **Reporting**
    a. This report was compiled, composing the components above.

1.5 Recognised limitations

Due to the prospecting phase being **non-invasive**, only **a desktop-level hydrological assessment** was undertaken. Therefore, no intrusive work, water quality sampling or topographic surveys were completed in the project area, and the conceptual flood lines were produced only for perennial drainage lines / perennial rivers and dedicated tributaries thereof (i.e. for larger catchment drainage areas) associated with the project area.

A ground-truthed hydrological survey and lidar survey, with updated flood lines for non-perennial drainage lines (ephemeral streams) would only be required if an invasive prospecting phase is implemented and if prospecting methods and prospecting areas that could change runoff patterns or impact the hydrological cycle take place.

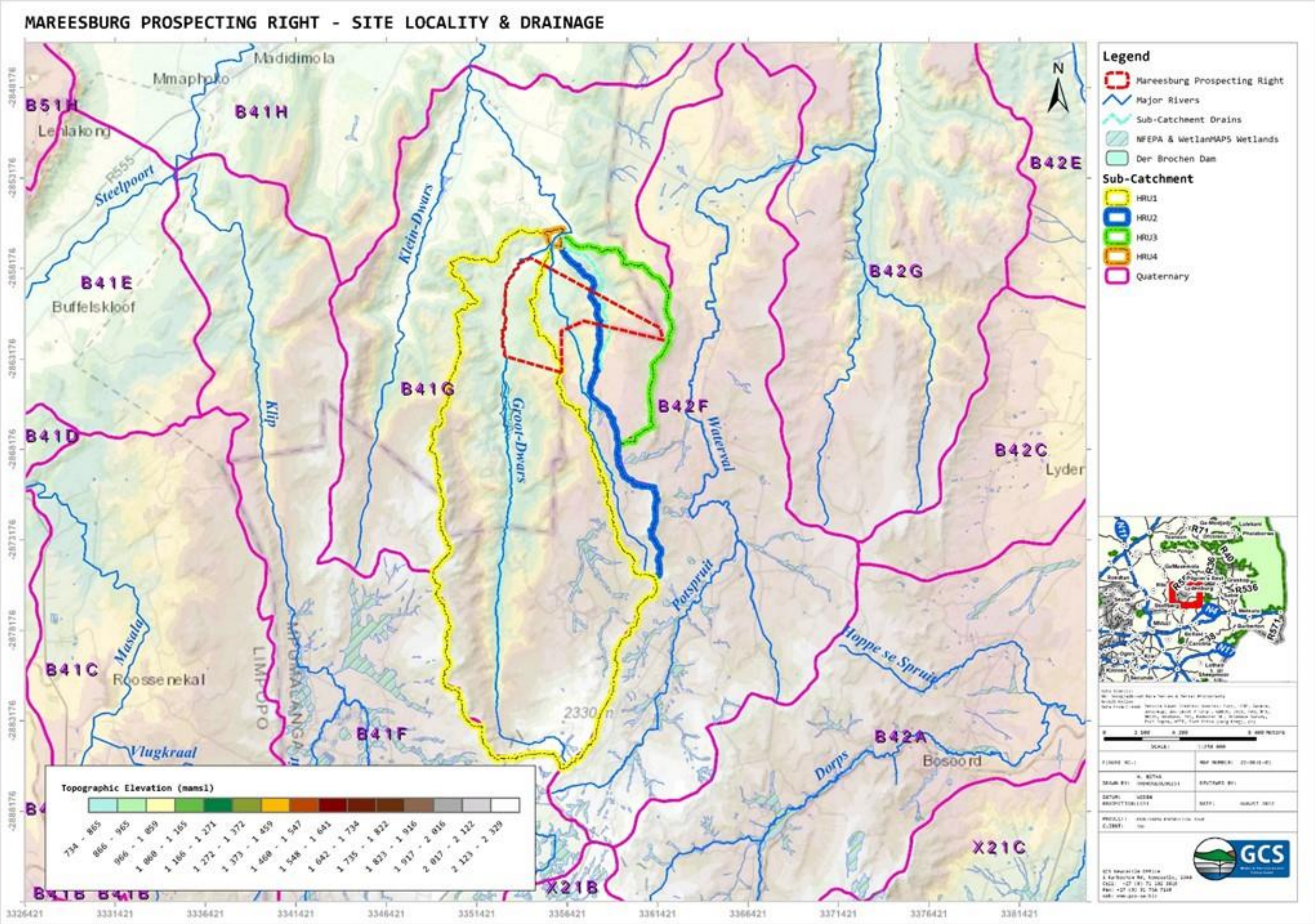

Figure 1-1: Site locality and drainage

2 METHODOLOGY

The methodological approach for the study is described in the sub-sections below.

2.1 Legal considerations

The National Water Act, (Act 36 of 1998) (NWA) governs the use of water and protection of water resources in South Africa. There are two sets of regulations on water use thus far:

- Government Notice No. 704, 4 June 1999, National Water Act, 1998 (No. 36 of 1998): Regulations on the use of water for mining and related activities aimed at the protection of water resources (GN704).
- Government Notice No. 1352, 12 November 1999, National Water Act, 1998 (No. 36 of 1998): Regulations requiring that water use be registered.

In terms of Section 144 of the National Water Act of 1998 (Act 36 of 1998), a flood line, representing the highest elevation that would probably be reached during a storm with a return interval of 100 years, must be indicated on all plans for the establishment of townships. The term, "establishment of townships" includes the subdivision of stands or farm portions in existing townships/development, if the 100-year flood lines are not already indicated on these plans, or when the land-use category of a particular portion of land is changed.

The National Environmental Management Act (Act 107 of 1998) (NEMA) stipulates that all relevant factors be considered for proposed developments to ensure that water pollution and environmental degradation are avoided. Section 2 of the Act establishes a set of principles that apply to the activities of all organs of the state that may significantly affect the environment. These include the following:

- Development must be sustainable
- Pollution must be avoided or minimized and remedied
- Waste must be avoided or minimized, reused or recycled
- Negative impacts must be minimized.

The requirements laid down by the National Building Regulations and Building Standards Act (Act 103 of 1977) in terms of development within the 1:50-year flood line area are based only on safety considerations without proper consideration and understanding of the underlying natural streamflow processes. The Town Planning and Townships Ordinance (Ordinance 15 of 1986) also makes provision in Regulation 44(3) for the extension of flood line areas up to 32 m from the centre of a stream in instances where the 1:50-year flood line is less than 62 m wide in total (CSIR, 2005).

2.1.1 EIA screening protocols

Appendix 6 of GN 326 EIA Regulation 2017 regulations further govern hydrology assessments for EIAs. Various protocols (GN 320 (GG 43110 dated 20 March 2020) require that before commencing with the said specialist assessment, the current use of land and the environmental sensitivity of the site must be confirmed by undertaking a site sensitivity verification) have been published for the specialist assessments. Where no specific assessment protocol has been prescribed a site sensitivity was performed using accepted verification techniques and by following the general protocols in line with Appendix 6 of the NEMA 2014 EIA Regulations.

The Screening Report For An Environmental Authorization As Required By The 2014 EIA Regulations – Proposed Site Environmental Sensitivity for the Mareesburg Prospecting was considered, and the prospecting area was flagged as follows:

- Relative agricultural sensitivity – High
- Animal specialises sensitivity – High
- Biodiversity sensitivity – Very high (Aquatic and freshwater ecosystem priority areas)
- Archaeological and cultural heritage sensitivity – High
- Civil aviation sensitivity – High
- Defence sensitivity – Low
- Plant species sensitivity - Medium
- Biodiversity sensitivity – Very high

This hydrology report conforms to Appendix 6 of the EIA regulations, which include the following aspects (where applicable to this study) to be addressed:

(a) Details of:

(i) The specialist who prepare the reports; and

(ii) the expertise of that specialist to compile a specialist report including a curriculum vitae

(b) Declaration that the specialist is independent in a form as may be specialities by the competent authority.

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(o) Description of any consultation process that was undertaken during preparing the specialist report.

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(q) Any other information requested by the competent authority.

2.2 Hydrological assessment

Hydrometeorological data for the study area were obtained from various sources including the South African Water Resources Study WR2012 database (Bailey & Pitman, 2015), South African Atlas of Agrohydrology, and Climatology (Schulze, 1997), and the Daily Rainfall Data Extraction Utility (Lynch, 2004). Moreover, sources such as the Köppen Climate Classification (Kottek, et al., 2006), World Climate Data CMIP6 V2.1 (Eyring, 2016), and Meteoblue (Meteoblue, 2022) were used to refine hydrological data.

These sources provided means of determining the Mean Annual Precipitation (MAP), Mean Annual Runoff (MAR), and Mean Annual Evaporation (MAE) of the study site as well as the design rainfall data. Data was applied to the site water balance calculations, runoff peak flow estimates for flood line modelling and stormwater runoff peak flow estimates for stormwater system sizing (where applicable to this study).

2.2.1 Catchment description and delineation

A 30 m Digital Terrain Model (DTM) data from the Advanced Land Observing Satellite (ALOS) (JAXA, 2022) were used to delineate the area draining to the streams relevant to this study, sub-catchment flow path as well as to derive river geometry characteristics. These characteristics (area, slopes, and hydraulic parameters) are used to parameterize the site hydraulic model for flood line modelling, water balance modelling or stormwater modelling (where applicable with regards to this hydrological assessment).

2018-2019 South African (SA) National Land Cover Data (DEA, 2019) was used to characterize the sub-catchment vegetation and derive manning surface roughness (n-values) coefficients.

2.2.2 Design rainfall and peak flow

The Design Rainfall Estimation Software (Smithers & Schulze, 2002) data from the rainfall stations surrounding the study site were used to calculate the 24-hour design rainfall depths for various return periods. Critical storm durations for Rational Methods Alternative 3 were calculated using the Modified Hershfield Equation (Adamson, 1981).

The streams/drainage sections that were modelled applying the three widely used methods were used to calculate 1:10, 1:20, 1:50, and 1:100-year peak flows. These are the Rational Method, Midgley and Pitman (MIPI), and the Standard Design Flood (SDF) methods. A brief description of each of the peak flow methods can be seen in Table 2-1, below.

Methodologies for using the applied peak flow models are explained broadly in the South African Drainage Manual (SANRAL, 2013). Calibration of the runoff coefficients for the drainage areas was guided by the manual, the understanding of the runoff-generating processes as well as land cover attributes. The resulting peak flows calculated using the selected methods were evaluated and conservative values provided inputs into the 1D HEC-RAS flood line model.

Table 2-1: Summary of peak flow methods

<u>Rational Method</u> The rational method was developed in the mid-19th century and is one of the most widely used methods for the calculation of peak flows for small catchments (< 15 km^2). The formula indicates that Q = CIA, where I is the rainfall intensity, A is the upstream runoff area and C is the runoff coefficient. Q is the peak flow. There are 3 alternatives to the Rational Method which differ in the methodology used to calculate rainfall intensities. The first alternative (RM1) uses the depth-duration frequency relationships approach, the second uses the modified Hershfield equation and the third alternative uses the Design Rainfall software for South Africa (SANRAL, 2013).
<u>Midgley and Pitman</u> The Midgley and Pitman (MIPI) method is an empirical method that relates peak discharge to catchment size, slope, and distance from the drainage point to the centroid of the catchment (Campbell, 1986). The MIPI method uses 10-unit hydrographs for 10 zones in South Africa. The method does not consider overland flow as a component separate from streamflow but considers only the total longest flow path (Campbell, 1986).
<u>Standard Design Flood Method</u> The Standard Design Flood (SDF) method was developed specifically to address the uncertainty in flood prediction under South African conditions (Alexander, 2002). The runoff coefficient (C) is replaced by a calibrated value based on the subdivision of the country into 26 regions or Water Management Areas (WMAs). The design methodology is slightly different and looks at the probability of a peak flood event occurring at any one of a series of similarly sized catchments in a wider region, while other methods focus on point probabilities (SANRAL, 2013).

2.3 Flood line modelling

A 30 m ALOS digital terrain model (DTM) (JAXA, 2022) was used to derive the hydraulic and river geometry parameters. River/stream cross-sections and flow paths were prepared using RAS Mapper software and provided input into a 1D HEC-RAS (US Army Corps of Engineers, 2016) flood model. Visual assessment of riverbanks from the Google Earth Imagery and land cover types (DEA, 2019) was used to estimate the Manning's n coefficients along the river/streamlines. The 1:50 and 1:100-year flood lines were generated and mapped in Global Mapper and ArcGIS (ESRI, 2018).

2.4 Hydrological risk assessment

As per GNR 982 of the EIA Regulations (2014), the significance of potential hydrological impacts was assessed. The risk assessment methodology and ratings applied to the study area and proposed activities are available in **Appendix C**.

2.5 Surface water monitoring plan

The monitoring network is based on the principles of a monitoring network design as described by the DWAF Best Practice Guidelines: G3 Monitoring (DWAF, 2007). The methodological approach that the monitoring plan follows is represented in Figure 2-1, below.

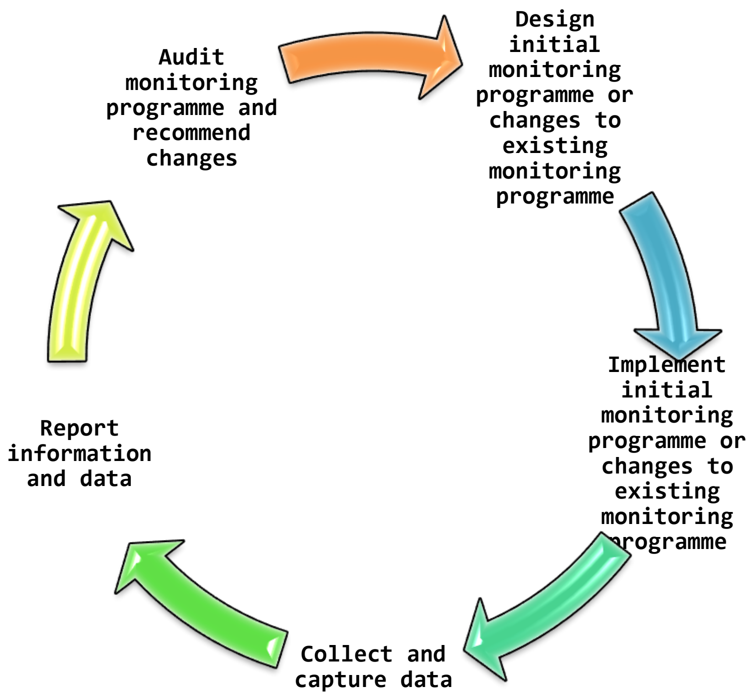


Figure 2-1: Monitoring Process

A surface water monitoring program that presents water quality constituencies to be analysed, the frequency of sampling, and the locality of sampling points were drafted. This plan included the construction and operational phase monitoring.

3 SITE OVERVIEW AND HYDROLOGY

As mentioned previously, the site is situated in Quaternary Catchment B41G of the Olifants Water Management Area (DWS, 2016). Elevations for the project area typically range from 768 to 1500 meters above mean sea level (mamsl).

In terms of the greater hydrological area, the prospecting right area is drained by the Groot-Dwars River (western boundary of the prospecting area) and a perennial tributary of the Groot-Dwars River (middle portion of the prospecting right area). The eastern portion of the prospecting area is drained via a non-perennial tributary of the Groot-Dwars River. Towards the south of the site, and in the Groot-Dwars River the Der Brochen Dam is found. The dam consists of an earth-fill embankment, stand-alone intake and a side-channel spillway. The dam has a maximum height of 30.5 m and is classified as large (DWAF, 2011). The dam was constructed to withstand a designed flow of 886 m^3/sec (RMF was calculated at 715 m^3/s and SEF 1 000 m^3/s) (DWAF, 2011). Drainage from the Dwars River is towards the Steelpoort River, situated approximately 15km downstream of the site.

3.1 Sub-catchments / hydrological response units (HRUs)

Four (4) hydrological response units (HRUs) describe the natural drainage for the study area (using a 1:10 000 stream count and 30m DTM fill) – refer to Figure 1-1 and Figure 3-1. The sub-catchment relates well to major desktop delineated drainage lines for the project area and describes the primary drainage towards the Groot-Dwars River.

Drainage within the demarcated prospecting right area is from higher laying areas towards lower laying areas via several ephemeral (non-perennial) streams with the end receptors being the Groot-Dwars River, a tributary of the Groot-Dwars River and a non-perennial stream associated with the Groot-Dwars River (refer to Figure 1-1). Primary drainage is towards the north via the aforementioned rivers and streams.

Surface water drainage for the Mototolo Mine TSF facility appears to have changed and would need to be confirmed if the prospecting phase is changed to invasive.

3.2 Land cover & slope rise

Open woodland, natural grassland, dense forest & woodland and several other land types occur in the project area (DEA, 2019) – refer to Figure 3-1. The land cover was simplified into 4 categories and is summarised in Table 3-1. Slope % rise for the general area is shown in Figure 3-2. Slope rise % was used to characterise the sub-catchment slope and runoff generation.

In the modelling process of the flood lines or stormwater runoff (whichever applies to this study), Manning's coefficient (n-values) values were set to represent natural stream systems and were supplemented by Google Earth imagery. These "n" values were further derived from the available vegetation and land cover data for the site.

Table 3-1: Summary of sub-catchments characteristics

Sub-Catchment		HRU1	HRU2	HRU3	HRU4
Area (km^2)		181.756	31.355	28.993	0.54
Longest Drainage Line (km)		25.10	13.21	8.41	0.84
Average Slope (%)		1.28%	4.71%	5.82	0.77%
Slope (%)	<3	2.34%	1.78%	1.72%	5.52%
	3-10	16.48%	30.75%	18.46%	53.99%
	10-30	40.19%	50.01%	43.96%	32.37%
	>30	40.99%	17.45%	35.86%	8.13%
Land Cover	Thick bush & plantation	9.33%	5.29%	5.36%	3.85%
	Light bush & farm-lands	38.88%	23.47%	31.81%	53.28%
	Grasslands	44.27%	60.75%	58.57%	42.39%
	No Vegetation	7.43%	10.14%	4.20%	0.14%

3.3 Local geology & soils

According to the 2530 Barberton-1:250 000 Geological map series (DMEA, 1986), the surface geology is characterised by quaternary sand deposits, Valium aged anorthosite, gabbro and norite (pyroxenite) of the Rustenburg Layered Suite, and cross-bedded quartzite with arenite, shale and conglomerate layers of the Pretoria Group, of the Transvaal Sequence (refer to Figure 3-3).

According to the Land types of South Africa databases (Land Type Survey Staff, 1972 – 2006c), the soils in the area typically conform to land types of the Dc31, Ib31, Ib154, Ab 29 and Fa327 groups, which typically entail:

- Dc Type = Either red or non-red duplex soils (sandier topsoil abruptly overlying more clayey subsoil) comprise >50% of land type; plus >10% occupied by black or red clays
- Ib Type = Rock outcrops comprise >60% of land type
- Ab Type = Freely drained, red and yellow, dystrophic/mesotrophic, apedal soils comprise >40% of the land type (yellow soils <10%)
- Fa Type = Shallow soils (Mispah & Glenrosa forms) predominate; little or no lime in landscape (ARC, 2006).

According to WR2012 soil data for the area, the erodibility of the soils for the area can be considered “High” (WRC, 2015). As such, there is potential for river bank erosion as well as stormwater rainfall erosion.

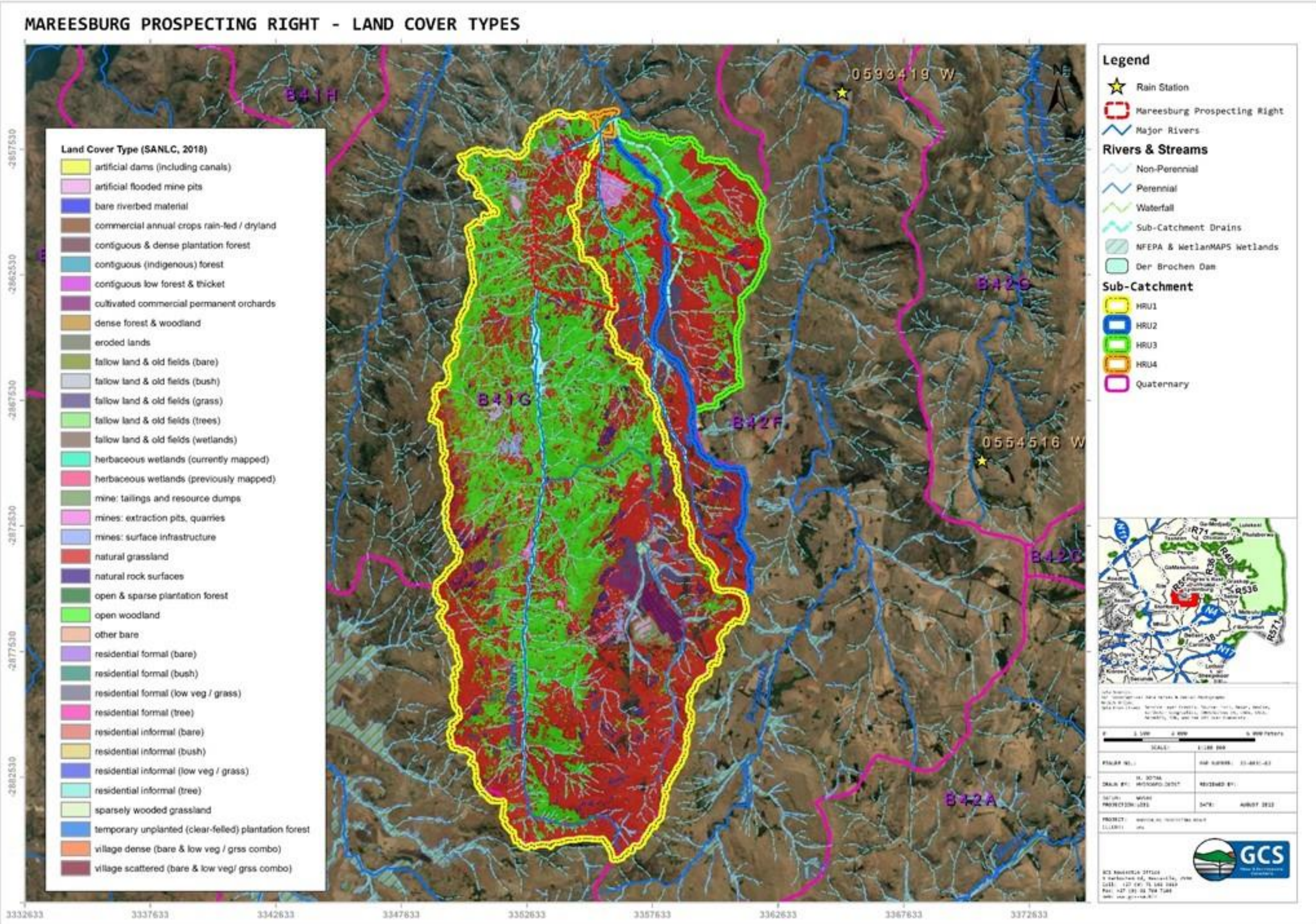


Figure 3-1: Sub-catchments & land cover

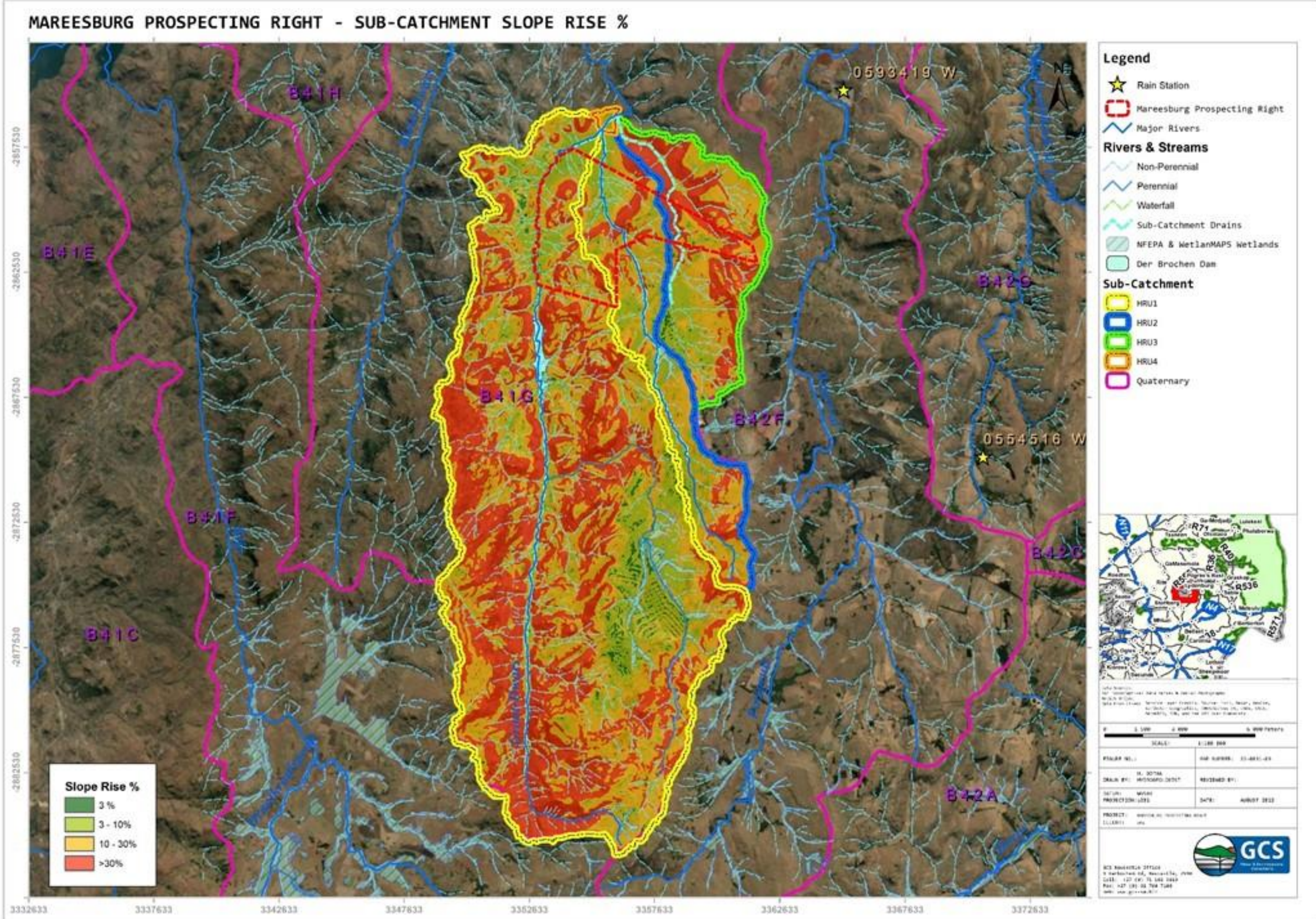


Figure 3-2: Sub-catchments & surface slope rise %

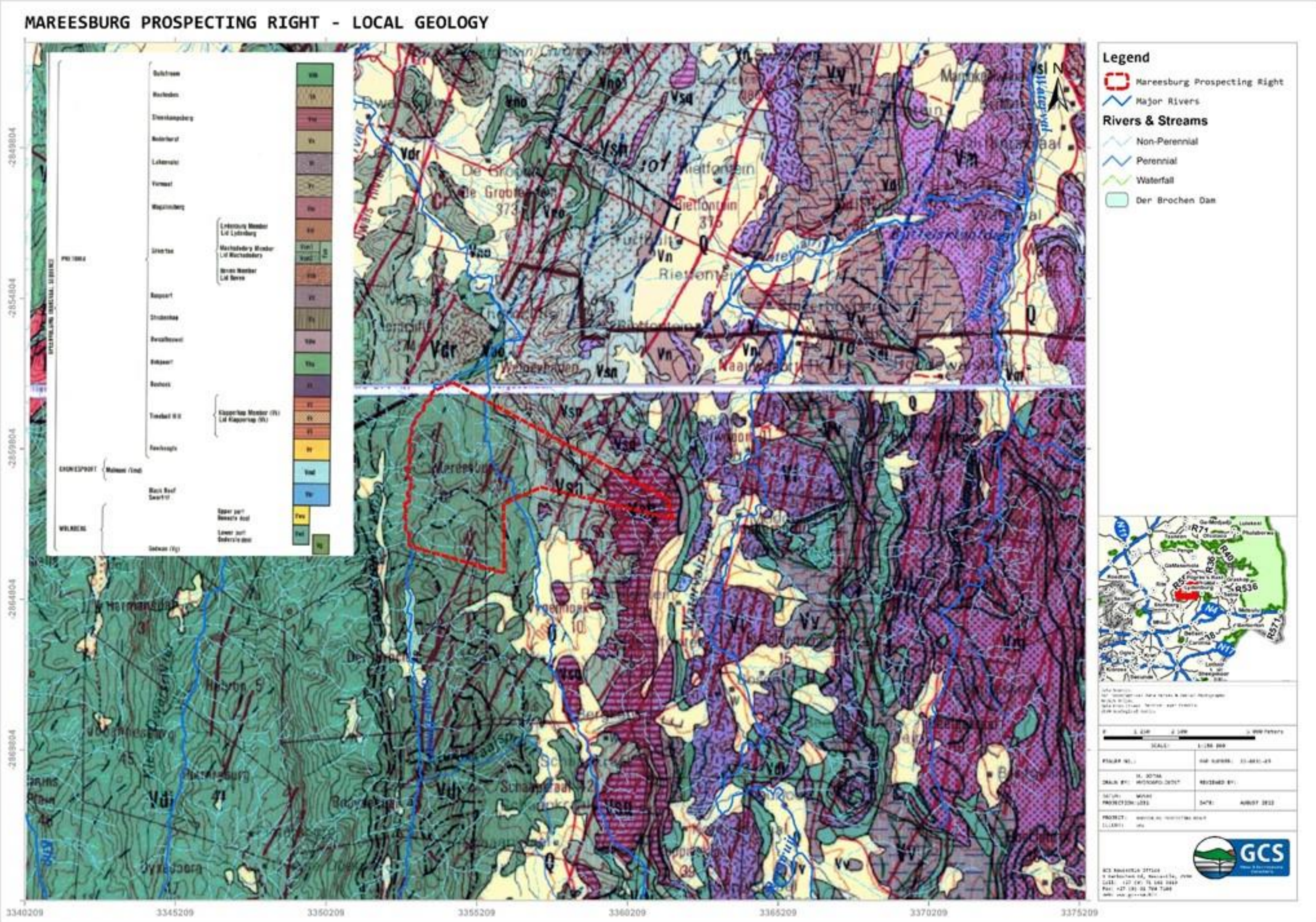


Figure 3-3: Local geology

3.4 Climate

Climate, amongst other factors, influences soil-water processes. The most influential climatic parameter is rainfall. Rainfall intensity, duration, evaporative demand and runoff were considered in this study to indicate rainfall partitioning within the project area.

3.4.1 Temperature

The average yearly temperature (refer to Figure 3-4) for the project area ranges from 22 to 36 °C (high) and 3 to 19 °C (Low). The study area is situated in a subtropical highland climate or temperate oceanic climate with dry winters (Cwb), as per the Köppen Climate Classification (Kottek, et al., 2006). The project area receives summer rainfall.

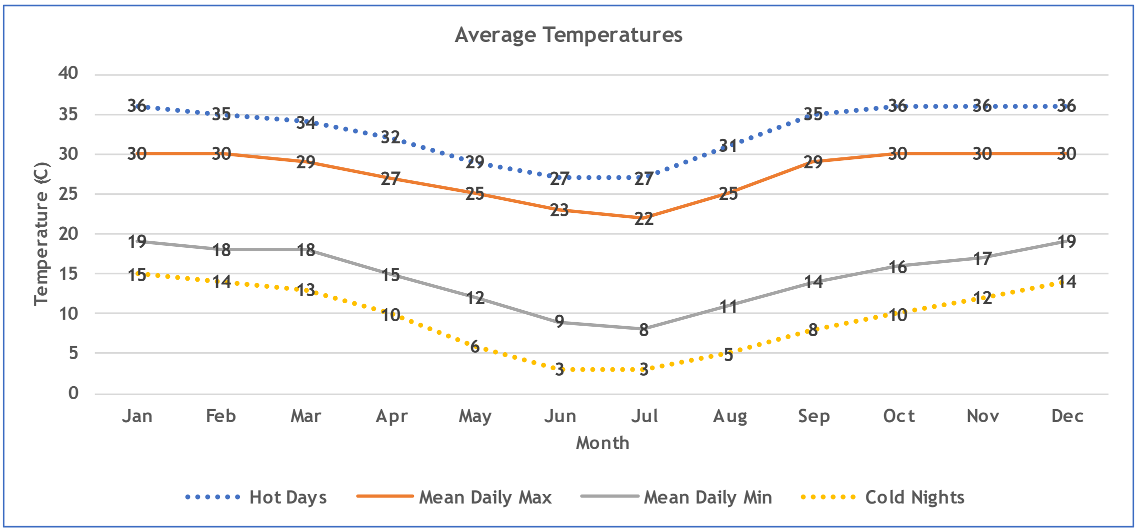


Figure 3-4: Average yearly temperatures (Meteoblue, 2022)

3.4.2 Wind speed and direction

Figure 3-5 shows the wind rose for the project area (Saint George used as reference) and presents the number of hours per year the wind blows from the indicated direction. The wind blows from NNE, NE, ENE, N and E more often, at velocities ranging from 1 km/hr to 28 km/hr; and from other directions but less frequently. Precipitation intensity during wind will likely cause precipitation intensity changes on slopes perpendicular to the wind direction, throughout the year.

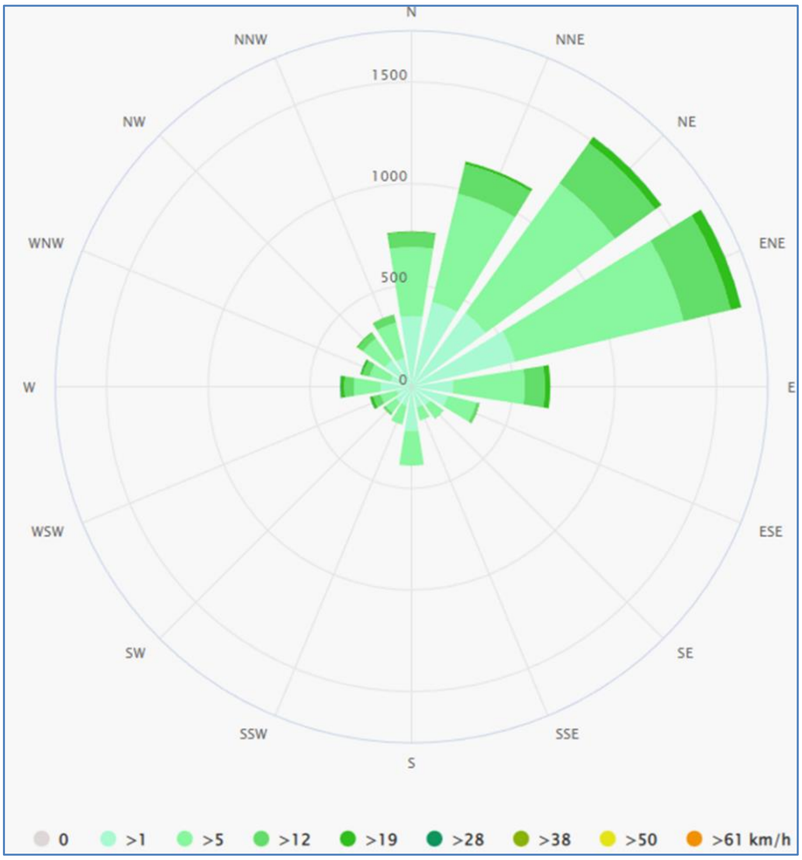


Figure 3-5: Wind rose (Meteoblue, 2022)

3.4.3 Rainfall and evaporation

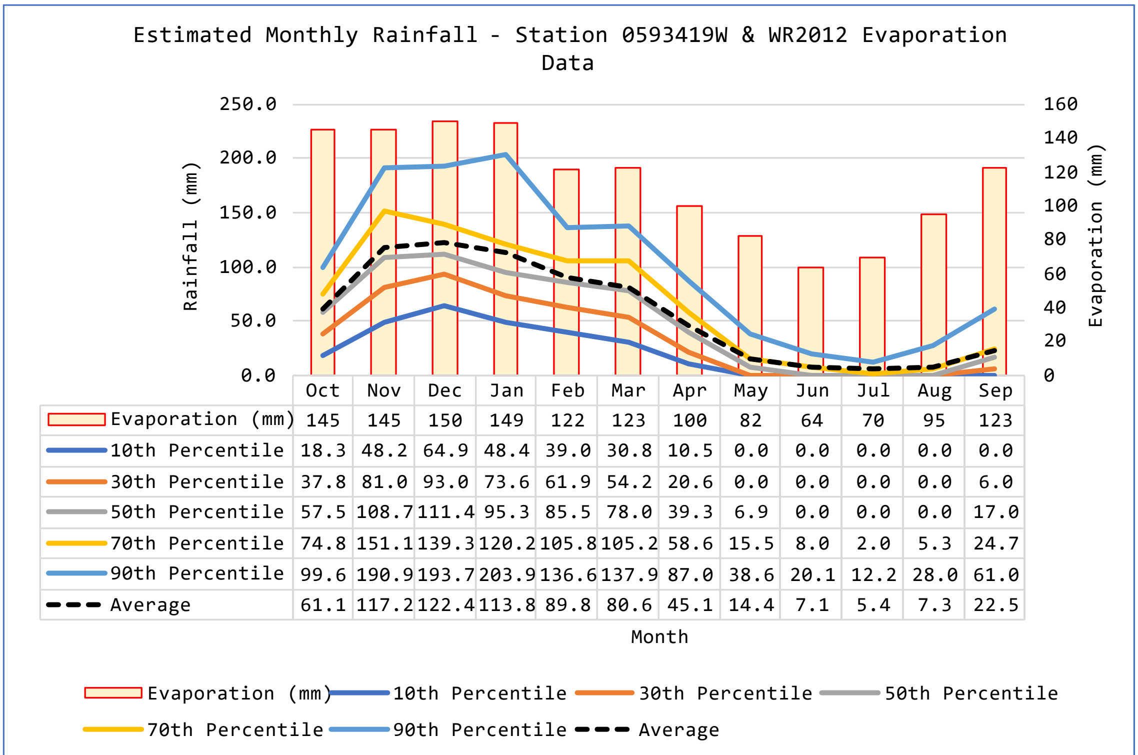
The project area is situated in rainfall zone B4B. Several rainfall stations are situated close to the project area and are listed in Table 3-2. Rainfall stations have recorded annual rainfall in the same order of magnitude. Martenshoop (POL) was chosen to represent the site and has the longest rainfall record available.

Table 3-2: Closest rainfall stations to the project area

Name	Station ID	MAP (mm/yr)
MARTENSHOOP (POL)	*0593419_W*	*689*
BEETGESKRAAL	0554516_W	749
KLIPFONTEIN	0593778_W	674
LEIDENBURG 111	0554752_W	703
Average		703.75

The monthly rainfall data used to calculate Mean Annual Precipitation (MAP) was obtained from rainfall station 0593419W (Martenshoop (Pol)). The rainfall record is for the period 1915 to 2000 (85 years). Monthly rainfall for the site is likely to be distributed as shown in Figure 3-6, below.

Available rainfall data suggest a MAP ranging from 427 (30^{th} percentile) to 1209 (90^{th} percentile) mm/yr. The average rainfall is in the order of 686 mm/yr. The project area falls within evaporation zone 4A, of which Mean Annual Evaporation (MAE) ranges from 1 300 to 1 400 mm/yr. The MAE far exceeds the MAP for the site, which implies greater evaporative losses when compared to incident rainfall. Monthly evapotranspiration for the site is likely to be distributed as shown in Figure 3-6, below.

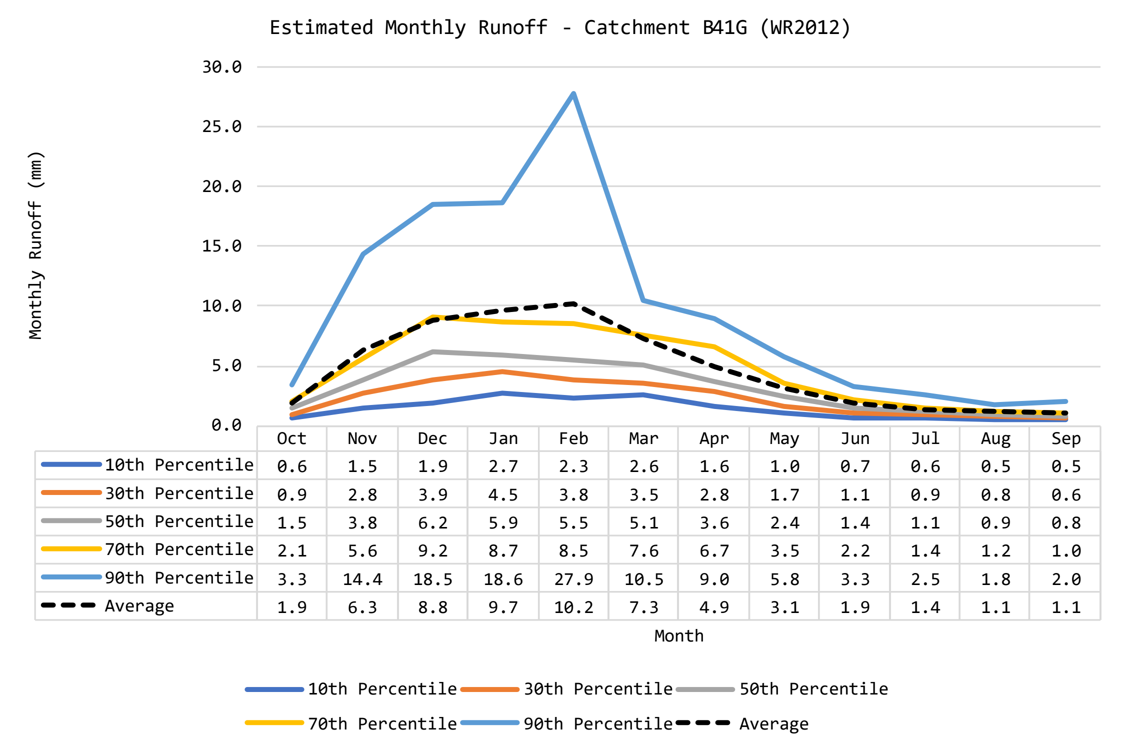


	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Evaporation (mm)	145	145	150	149	122	123	100	82	64	70	95	123
10th Percentile	18.3	48.2	64.9	48.4	39.0	30.8	10.5	0.0	0.0	0.0	0.0	0.0
30th Percentile	37.8	81.0	93.0	73.6	61.9	54.2	20.6	0.0	0.0	0.0	0.0	6.0
50th Percentile	57.5	108.7	111.4	95.3	85.5	78.0	39.3	6.9	0.0	0.0	0.0	17.0
70th Percentile	74.8	151.1	139.3	120.2	105.8	105.2	58.6	15.5	8.0	2.0	5.3	24.7
90th Percentile	99.6	190.9	193.7	203.9	136.6	137.9	87.0	38.6	20.1	12.2	28.0	61.0
Average	61.1	117.2	122.4	113.8	89.8	80.6	45.1	14.4	7.1	5.4	7.3	22.5

Figure 3-6: Average rainfall for Station 0593419W & WR2012 evaporation

3.4.4 Runoff

Runoff from natural (unmodified) catchments for quaternary catchment B41G is simulated in WR2012 (WRC, 2015) as being equivalent to 57.6 mm/yr (or 8% of the MAP). This is approximately 25.456 Mm^3/yr NMAR for the surface area of B41G.



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
10th Percentile	0.6	1.5	1.9	2.7	2.3	2.6	1.6	1.0	0.7	0.6	0.5	0.5
30th Percentile	0.9	2.8	3.9	4.5	3.8	3.5	2.8	1.7	1.1	0.9	0.8	0.6
50th Percentile	1.5	3.8	6.2	5.9	5.5	5.1	3.6	2.4	1.4	1.1	0.9	0.8
70th Percentile	2.1	5.6	9.2	8.7	8.5	7.6	6.7	3.5	2.2	1.4	1.2	1.0
90th Percentile	3.3	14.4	18.5	18.6	27.9	10.5	9.0	5.8	3.3	2.5	1.8	2.0
Average	1.9	6.3	8.8	9.7	10.2	7.3	4.9	3.1	1.9	1.4	1.1	1.1

Figure 3-7: Simulated natural (unmodified) runoff for B41G

3.5 Surface water and groundwater users in the study area

According to Water Allocation Registration Management System (WARMS, 2019), there are ten (10) WARMS water users falling in the sub-catchments associated with the project, seven (7) downstream WARMS users, and according to SADAC GIP groundwater data for the area there are seventy-seven (77) groundwater users within a 10 km radius of the site (of which 6 fall in the sub-catchments associated with the project) – refer to Figure 3-8.

The Groot-Dwars River, Spekboom River, surface water dams and boreholes appear to be primary sources of water for inhabitants/mines in the project area. Total water used (combined groundwater and surface water) is in the order of 3.25 Mm^3/yr for water users associated with the sub-catchments delineated for the projects, and 7.6 Mm^3/yr for downstream relative to the project area.

The registry entry into WARMS for water use is summarised in Table 3-3 and SADAC GIP boreholes are listed in Table 3-4.

Table 3-3: Summary of WARMS users identified in HRUs

ID	Latitude (WGS84)	Longitude (WGS84)	User	Resource Type	Resource	Register Status	Lawfulness Finding	Registered Volume (m^3/yr.)
24014870	-25.17000	30.16000	ME GROENEWALD	WETLAND	VLEI/ FOUNTAIN	ACTIVE	LAWFULNESS STILL TO BE DETERMINED	5840
24072959	-25.03260	30.11766	RUSTENBURG PLATINUM MINES	BOREHOLE	GROUNDWATER	ACTIVE	LAWFUL	511000
24074154	-25.04111	30.11944	RUSTENBURG PLATINUM MINES CORPORATE	BOREHOLE	GROUNDWATER	CLOSED	LAWFULNESS STILL TO BE DETERMINED	37670
24079373	-25.09633	30.11511	ANGLO AMERICAN PLATINUM: DER BROCHEN PROJECT AND MOTOTOLO JOINT VENTURE	DAM	SURFACE WATER	ACTIVE	LAWFUL	1122913
24091705	-24.98897	30.12964	GLENCORE MERAFE VENTURE	LAKE	DE GROOTE BOOM PIT (OPEN CAST VOID)	ACTIVE	LAWFUL	936955
24096372	-25.01030	30.11053	RUSTENBURG PLATINUM MINES: DER BROCHEN	BOREHOLE	NORTHERN PIT	ACTIVE	LAWFUL	86436
24097380	-25.13333	30.10000	BOOYSENDAL PLATINUM	BOREHOLE	GROUNDWATER	ACTIVE	LAWFULNESS STILL TO BE DETERMINED	57604.3
24102365	-25.05547	30.12069	SPITZKOP PLATINUM: MAREESBURG MINE	DAM	SURFACE WATER	ACTIVE	LAWFUL	96224
24102631	-25.09633	30.11511	BOOYSENDAL PLATINUM	SCHEME	NO DATA	ACTIVE	LAWFUL	346206
24102971	-25.06667	30.10000	NORTHAM PLATINUM	BOREHOLE	GROUNDWATER	ACTIVE	LAWFUL	59130
24053337	-24.95611	30.12861	GLENCORE MERAFE VENTURE	RIVER/STREAM	GREAT DWARS RIVER	ACTIVE	LAWFULNESS STILL TO BE DETERMINED	307200
24053346	-24.91493	30.10901	DWARSRIVIER CHROME MINE	DAM	KLEIN DWARS RIVER (JOUNIE DAM)	ACTIVE	LAWFULNESS STILL TO BE DETERMINED	1500000

ID	Latitude (WGS84)	Longitude (WGS84)	User	Resource Type	Resource	Register Status	Lawfulness Finding	Registered Volume (m³/yr.)
24090788	-24.98333	30.16667	SPEKBOOM RIVER IRRIGATION BOARD	RIVER/STREAM	SPEKBOOM RIVER	ACTIVE	LAWFULNESS STILL TO BE DETERMINED	5559900
24097460	-24.91639	30.11067	TWO RIVERS PLATINUM	BOREHOLE	GROUNDWATER	ACTIVE	LAWFULNESS STILL TO BE DETERMINED	9490
24100107	-24.95458	30.12347	XSTRATA THORNCLIFFE	BOREHOLE	GROUNDWATER	ACTIVE	LAWFUL	158045
24100116	-24.95458	30.12347	XSTRATA THORNCLIFFE	BOREHOLE	GROUNDWATER	ACTIVE	LAWFUL	109500
24102953	-24.93731	30.13578	DE GROOT BOOM MINERALS	BOREHOLE	GROUNDWATER	ACTIVE	LAWFUL	19760

Green = Downstream of sub-catchments for this project

Table 3-4: Groundwater users within a 10km radius of the prospecting right area

ID	Source	Latitude (WGS84) Decimal Degrees	Longitude (WGS84) Decimal Degrees	Elevation (mamsl)	Water Level (mbgl)
605898	SADAC GIP (2022)	-25.035	30.1201	1072	No Data
605899	SADAC GIP (2022)	-25.03	30.12	1062	No Data
605923	SADAC GIP (2022)	-25.03999	30.11961	1074	No Data
606095	SADAC GIP (2022)	-24.98436	30.08234	942	No Data
606096	SADAC GIP (2022)	-24.98249	30.08354	941	No Data
606097	SADAC GIP (2022)	-24.97902	30.0845	937	No Data
606151	SADAC GIP (2022)	-25.02573	30.12019	1061	No Data
609360	SADAC GIP (2022)	-24.98874	30.08092	945	No Data
609720	SADAC GIP (2022)	-24.926944	30.144167	1046	No Data
658594	SADAC GIP (2022)	-24.93397	30.09975	914	6.1
658609	SADAC GIP (2022)	-24.95064	30.19975	1369	6.1
658610	SADAC GIP (2022)	-24.95064	30.19976	1369	9.8
658611	SADAC GIP (2022)	-24.95065	30.19975	1369	4.6
658612	SADAC GIP (2022)	-24.95064	30.19977	1369	4.6
658613	SADAC GIP (2022)	-24.95066	30.19975	1369	No Data
658614	SADAC GIP (2022)	-24.95064	30.19978	1369	No Data
658615	SADAC GIP (2022)	-24.95067	30.19975	1369	No Data
658616	SADAC GIP (2022)	-24.95064	30.19979	1369	No Data
658632	SADAC GIP (2022)	-24.93397	30.14975	1044	8.8
658633	SADAC GIP (2022)	-24.93397	30.14976	1044	3.1
658634	SADAC GIP (2022)	-24.97563	30.15419	1052	12
658635	SADAC GIP (2022)	-24.97564	30.15419	1052	24
658636	SADAC GIP (2022)	-24.97563	30.1542	1052	20
658637	SADAC GIP (2022)	-24.97565	30.15419	1052	24
658644	SADAC GIP (2022)	-24.94425	30.15197	1080	No Data
658645	SADAC GIP (2022)	-24.94426	30.15197	1080	No Data
658646	SADAC GIP (2022)	-24.96008	30.18891	1365	No Data
658647	SADAC GIP (2022)	-24.96009	30.18891	1365	No Data
658648	SADAC GIP (2022)	-24.96009	30.18892	1365	No Data
658649	SADAC GIP (2022)	-24.9601	30.18892	1365	No Data
658650	SADAC GIP (2022)	-24.9601	30.18893	1365	28
658652	SADAC GIP (2022)	-24.96175	30.24558	1298	No Data
658653	SADAC GIP (2022)	-24.9748	30.24419	1363	No Data
658654	SADAC GIP (2022)	-24.99924	30.17753	1463	No Data
658655	SADAC GIP (2022)	-24.98035	30.19419	1375	No Data
658656	SADAC GIP (2022)	-24.97147	30.19808	1364	No Data
658657	SADAC GIP (2022)	-24.95203	30.22031	1433	No Data
658658	SADAC GIP (2022)	-24.98646	30.15169	1029	No Data
658659	SADAC GIP (2022)	-24.98674	30.15031	1059	8.2

ID	Source	Latitude (WGS84) Decimal Degrees	Longitude (WGS84) Decimal Degrees	Elevation (mamsl)	Water Level (mbgl)
658660	SADAC GIP (2022)	-24.97841	30.19281	1380	No Data
658665	SADAC GIP (2022)	-24.9612	30.18753	1364	No Data
658666	SADAC GIP (2022)	-24.96119	30.18753	1364	No Data
658667	SADAC GIP (2022)	-24.96119	30.18752	1364	No Data
658670	SADAC GIP (2022)	-24.96091	30.18613	1358	No Data
658671	SADAC GIP (2022)	-24.93758	30.14308	1019	No Data
658672	SADAC GIP (2022)	-24.92897	30.14558	1069	No Data
658673	SADAC GIP (2022)	-24.93231	30.14142	1014	No Data
658674	SADAC GIP (2022)	-24.96091	30.18558	1358	No Data
658675	SADAC GIP (2022)	-24.96092	30.18559	1358	No Data
658676	SADAC GIP (2022)	-24.96093	30.1856	1358	No Data
658677	SADAC GIP (2022)	-24.96093	30.18561	1358	No Data
658704	SADAC GIP (2022)	-24.96731	30.26643	1418	No Data
658705	SADAC GIP (2022)	-24.96731	30.26644	1418	6
680913	SADAC GIP (2022)	-25.0673	30.23308	1686	20.1
680914	SADAC GIP (2022)	-25.0673	30.23309	1686	No Data
680915	SADAC GIP (2022)	-25.06731	30.23308	1686	4.9
680916	SADAC GIP (2022)	-25.0673	30.2331	1686	No Data
680917	SADAC GIP (2022)	-25.06732	30.23308	1686	No Data
680918	SADAC GIP (2022)	-25.0673	30.23311	1686	No Data
680919	SADAC GIP (2022)	-25.06733	30.23308	1686	5.5
680920	SADAC GIP (2022)	-25.0673	30.23312	1686	16.8
680921	SADAC GIP (2022)	-25.06734	30.23308	1686	17.7
680933	SADAC GIP (2022)	-25.03396	30.23308	1526	No Data
680934	SADAC GIP (2022)	-25.03397	30.23308	1526	7
680935	SADAC GIP (2022)	-25.03396	30.23309	1526	14
680949	SADAC GIP (2022)	-25.03641	30.10669	1316	90
680950	SADAC GIP (2022)	-25.04369	30.09003	1367	128
680953	SADAC GIP (2022)	-25.0434	30.23586	1554	17
680954	SADAC GIP (2022)	-25.10896	30.06642	1932	No Data
680955	SADAC GIP (2022)	-25.06646	30.10781	1307	No Data
680956	SADAC GIP (2022)	-25.10063	30.26642	1739	9.1
680957	SADAC GIP (2022)	-25.10063	30.26643	1739	12.2
681062	SADAC GIP (2022)	-25.09054	30.27417	1595	17.1
681063	SADAC GIP (2022)	-25.09557	30.27321	1607	No Data
681064	SADAC GIP (2022)	-25.04709	30.28583	1468	5.7
681065	SADAC GIP (2022)	-25.07191	30.2856	1545	4
681071	SADAC GIP (2022)	-25.05535	30.27642	1506	4

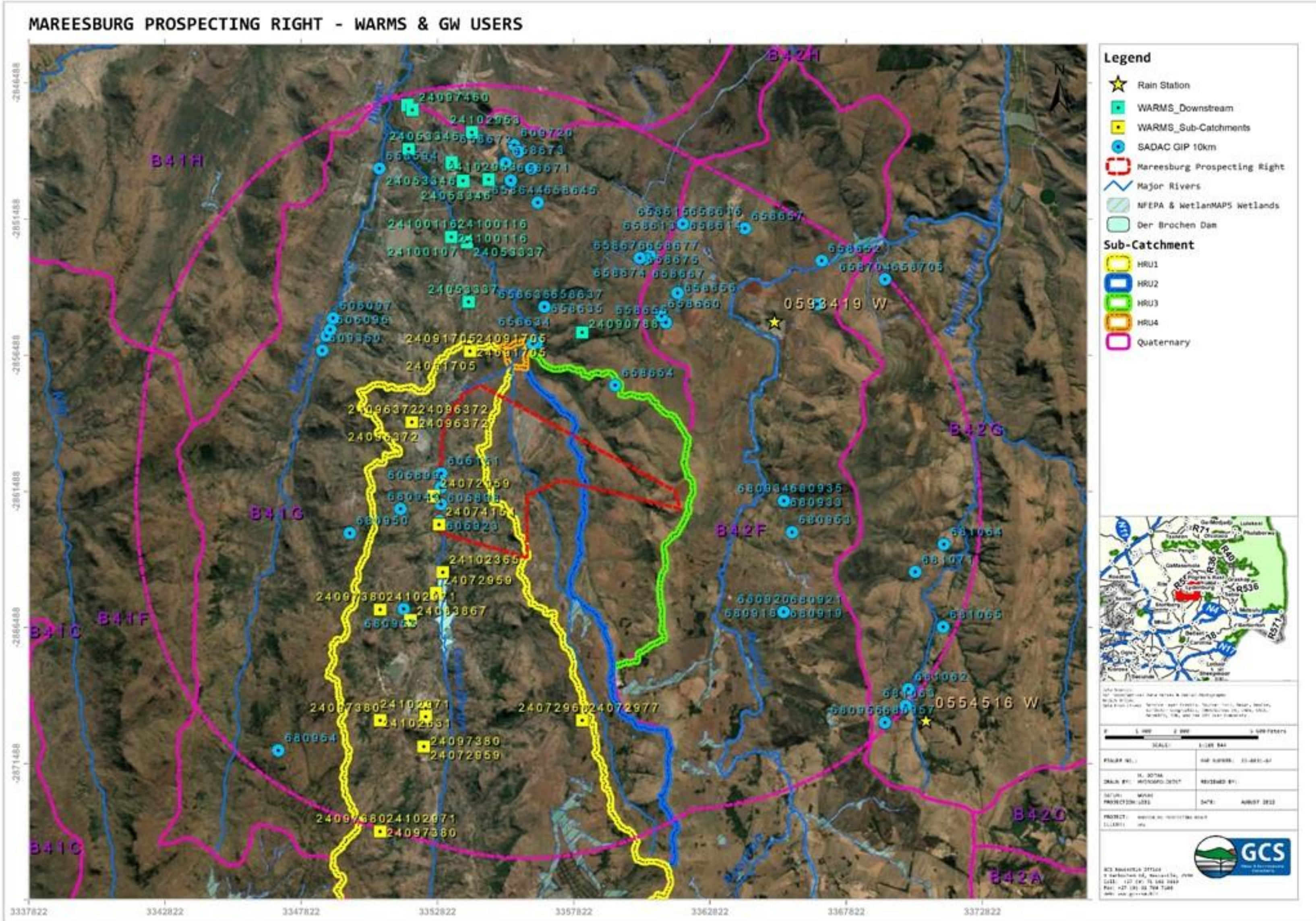


Figure 3-8: **Surface water users and groundwater users identified in the project area**

3.6 Depth to groundwater

According to (Vegter, 1995) and (DWAF, 2006), the average groundwater level for the project area is in the order of 17 mbgl (meters below ground level). SADAC GIP boreholes within a 15 km radius of the site suggest a water level range from 3 to 128 mbgl, and an average of 17 mbgl (correlates well to literature data). Moreover, available data suggest that there is a good correlation (R ~ 98%) between groundwater and surface topography elevations (refer to Figure 3-9). Hence, the groundwater table is expected to mimic the topography and be shallower closer to perennial streams (i.e. these are prominent groundwater contributions to baseflow areas or areas where groundwater seepage from the resource into the aquifer units may take place).

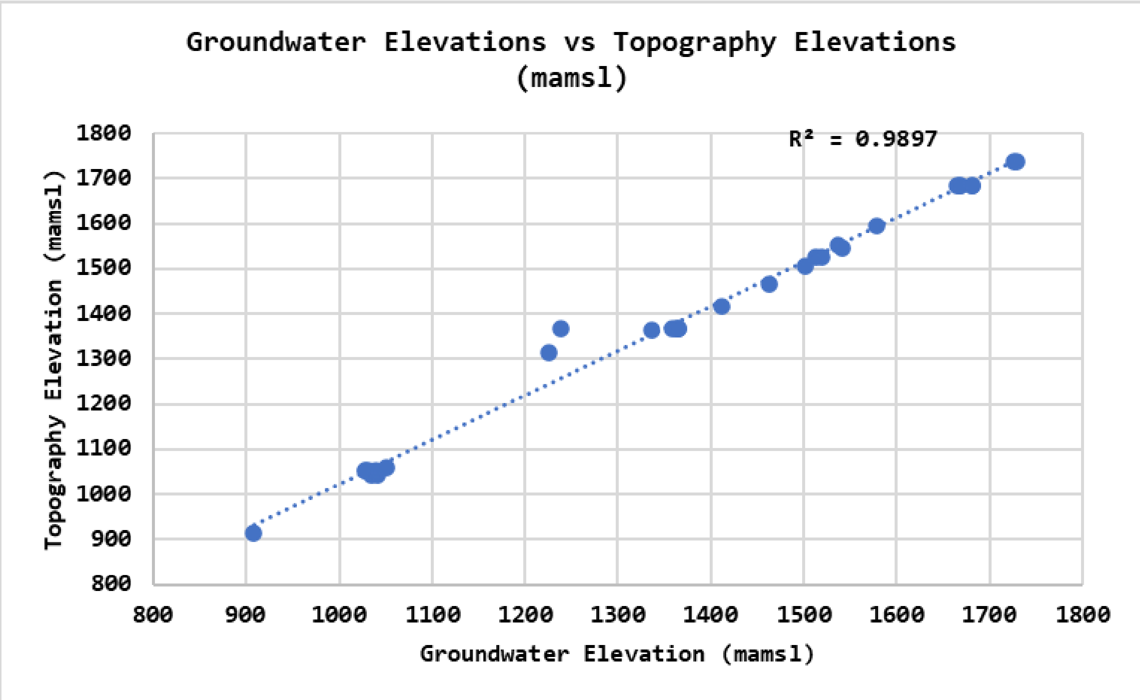


Figure 3-9: Groundwater elevation vs topography elevation - correlation

3.7 Wetland areas

Based on available National Wetland Freshwater Ecosystem Priority Areas (NFEPA) (Van Deventer, 2018) no desktop-identified wetlands were identified. However, due to the perennial nature of the Dwars River and Tributary thereof, groundwater contribution to baseflow is expected.

Baseflow (refer to Figure 3-10) is a non-process-related term to signify low amplitude high-frequency flow in a river during dry or fair-weather periods. Baseflow is not a measure of the volume of groundwater discharged into a river or wetland, but it is recognised that groundwater contributes to the baseflow component of river or wetland flow.

Available literature (WRC, 2015; DWAF, 2006) suggests groundwater contribution to baseflow ranges from 9.76 mm/yr (PITMAN MODEL) to 21.5 mm/yr (HUGHES MODEL). This relates to approximately 1.4% to 3% of rainfall.

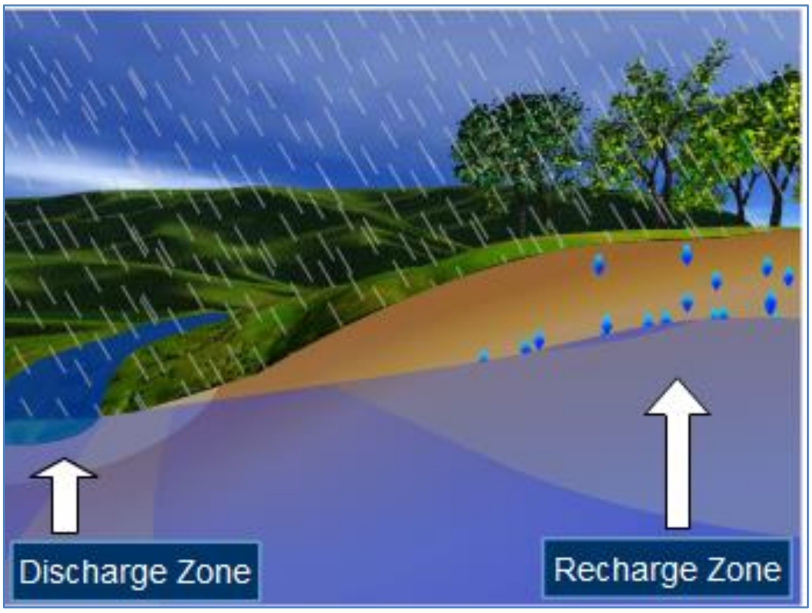


Figure 3-10: Groundwater baseflow concept (DWS, 2011)

3.8 Present ecological state (PES) and environmental sensitivity and ecological importance (EIS) of the Groot Dwars River – Quaternary Scale

Table 3-5 provides a summary of the PES and EIS for the quaternary catchment associated with the project area (WRC, 2015). According to the NBA 2018: SAIIAE Dataset the Groot-Dwars River is largely modified (Class D), poorly protected (Ecosystem Protection Level) and critically endangered (Ecosystem Threat Status) (CSIR, 2018).

Table 3-5: Summary of PES and EIS for the Quaternary Catchment

Quat	PES	EIS
B41G	Class D: Largely Modified	High

3.9 Overview of site hydrological cycle

Based on the information attained for the study area (as presented in this section), existing groundwater and surface water users, climate, runoff and estimated baseflow to wetland areas, a sub-catchment-specific hydrological cycle was developed (refer to Figure 3-11). *The impact of the proposed/existing activities at the site on the cycle was considered in the hydrological impact assessment (refer to Section* Figure 3-11*).*

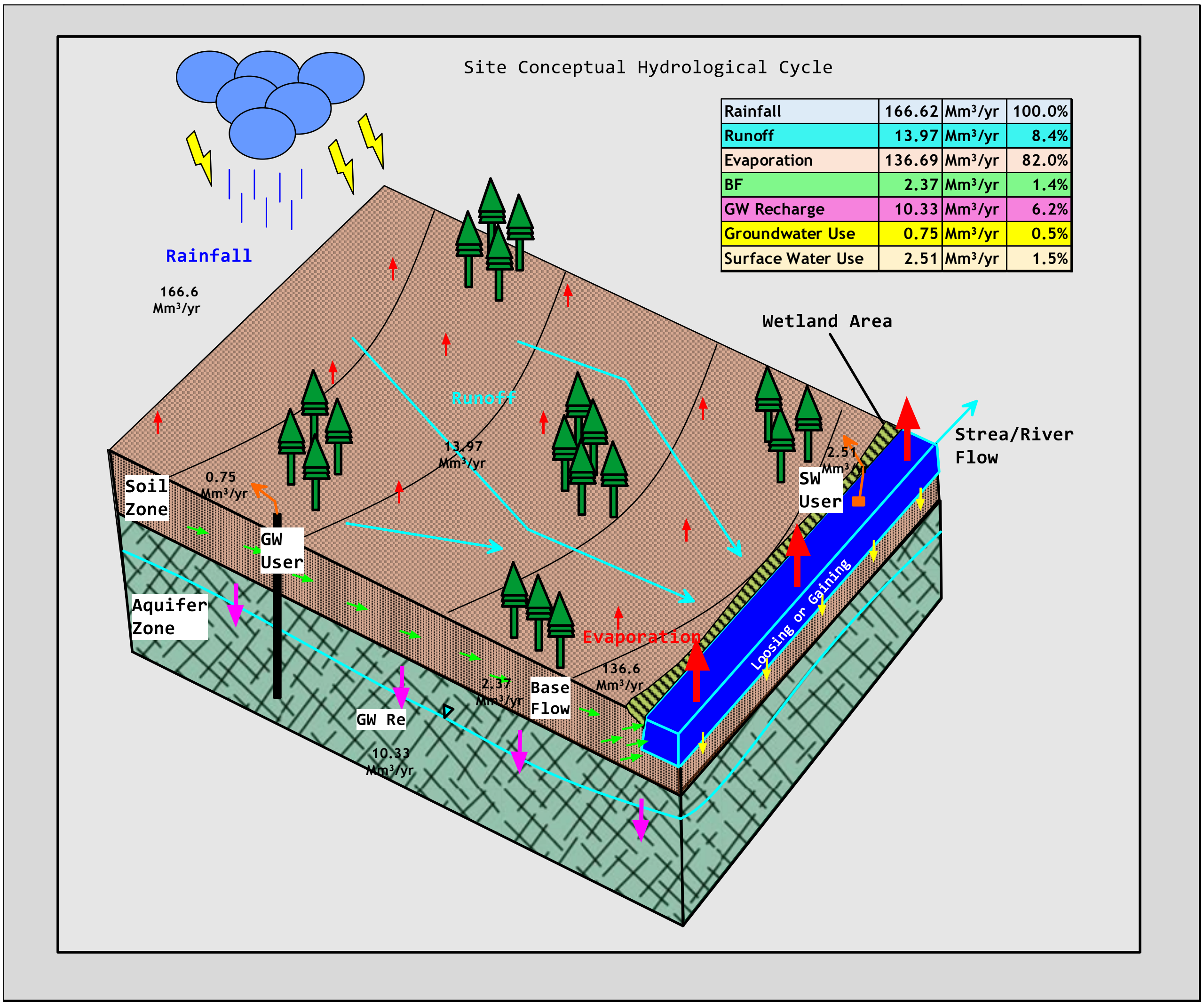


Figure 3-11: Simplified overview of the hydrological cycle at the site and existing allocations/impacts

4 SURFACE AND GROUNDWATER QUALITY

The following section supplies an overview of the expected surface and groundwater quality within the project area. Data were obtained from the DWS IWQS/WMS database and hydrogeology map series for the project area.

4.1 Surface water quality

Surface water quality data for the Groot-Dwars River was obtained from DWS IWQS/WMS, station number B41 192 609 situated at the Groot Dwars River at Bridge on Road to Two Rivers Mine (Lat: -24.92828 Lon: 30.10819), to illustrate water quality of the river and highly likely tributaries associated with it. A Maucha diagram is presented in Figure 4-1. Water quality data at the point is available from 2011 to 2018. From the data obtained the following is noted:

- TDS ranges from 419 to 257 mg/l
- EC ranges from 27 to 57 mS/m;
- pH ranges from 7.8 to 8.7;
- Na ranges from 7 to 11 mg/l;
- K ranges from 0.5 to 1.5 mg/l
- Ca ranges from 25 to 35 mg/l
- Mg ranges from 25 to 52 mg/l
- Cl ranges from 8 to 11 mg/l
- SO_4 ranges from 7 to 32.4 mg/l
- F ranges from 0.08 to 0.2 mg/l; and
- NO_3 ranges from 5 to 45.4 mg/l.

Limited impacts in terms of local mining are observed in the evaluated DWS data for the Groot-Dwars River.

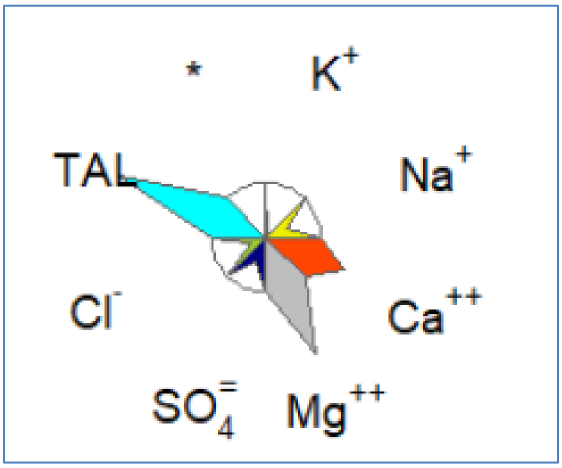


Figure 4-1: Maucga diagram relating to major ions in surface water environment (Groot-Dwars River – DWS, 2022)

4.2 Groundwater quality

Literature suggests that the electrical conductivity (EC) for the underlying aquifer generally ranges between 70– 300 mS/m (milli Siemens/metre) and the pH ranges from 6 to 8 (refer to Figure 4-2). This means that groundwater abstracted from the aquifer can generally be used for domestic and recreational use, however, there may be some scaling issues in appliances and water pipes (King, et al., 1998).

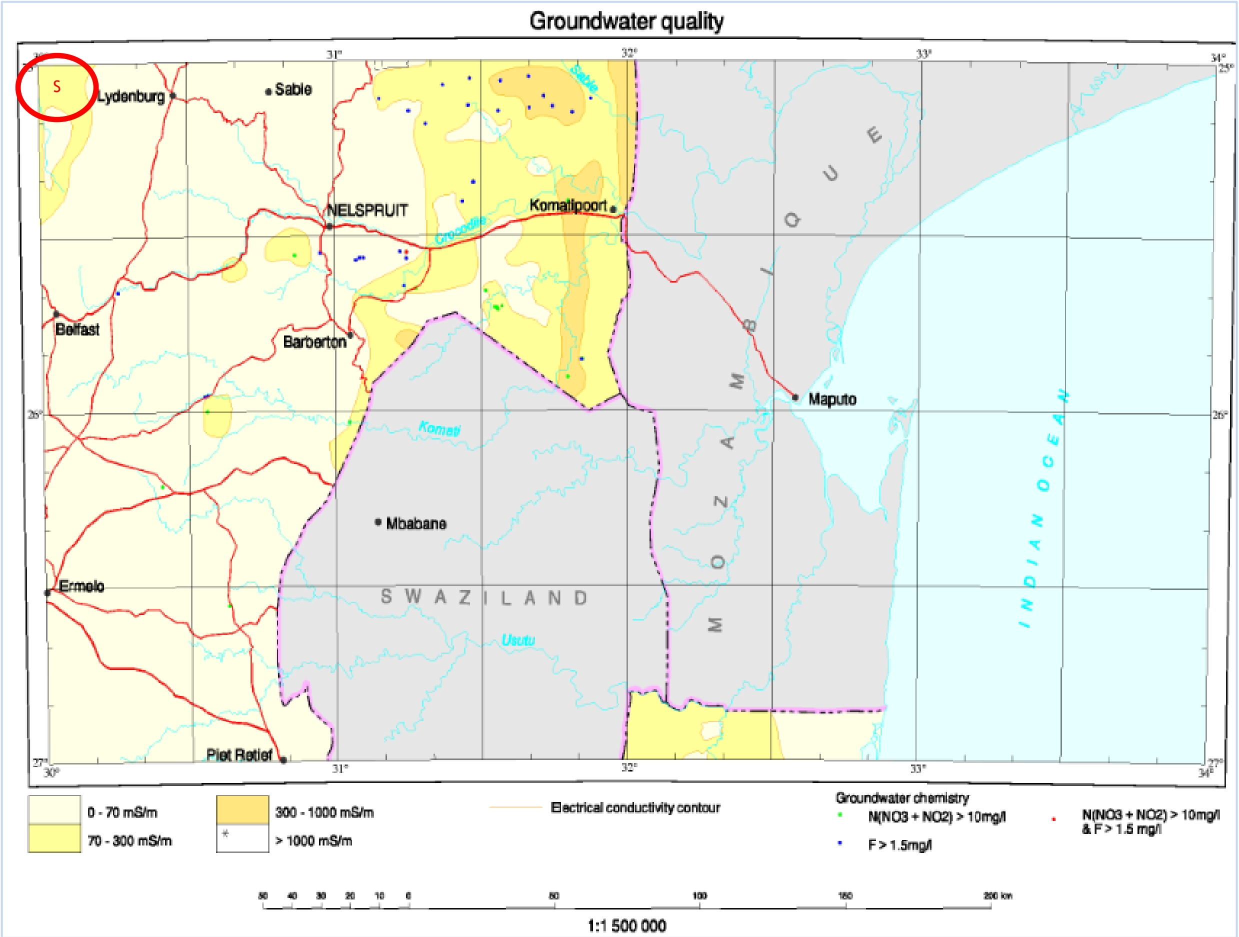


Figure 4-2: Groundwater conductivity for the study area (King, et al., 1998)

5 FLOOD LINE ASSESSMENT

Flood peak flow for the recognised rivers, perennial streams and tributaries thereof associated with the project area were assessed. The Rational Method (3), Standard Design Flood (SDF) and Midgley & Pitman (MIPI) Method (refer to **Appendix A**) were applied. Design rainfall was retrieved from station 0593419W (Martenshoop (pol)) and used to calculate peak flow volumes. Table 5-1 provides a summary of the design rainfall data used to calculate peak flows, and time concentrations were calculated based on the sub-catchment sizes and parameters. The upper limit "U" was used to estimate worst-case peak flows.

Table 5-1: Summary of design rainfall data used for peak flow estimates

Duration	Return Period (years)						
	2U	5U	10U	20U	50U	100U	200U
5 min	10.5	14.4	17.3	20.5	24.9	28.6	32.6
10 min	15.4	21.1	25.3	29.9	36.3	41.8	47.6
15 min	19.2	26.3	31.6	37.3	45.3	52.1	59.4
30 min	24.2	33.2	40	47.2	57.3	65.9	75.1
45 min	27.8	38.1	45.8	54.1	65.8	75.6	86.1
1 hr	30.6	42	50.5	59.7	72.5	83.3	95
1.5 hr	35.1	48.2	58	68.5	83.2	95.6	108.9
2 hr	38.7	53.2	63.9	75.5	91.7	105.4	120.1
4 hr	46.4	63.7	76.6	90.4	109.8	126.2	143.8
6 hr	51.6	70.7	85.1	100.5	122	140.3	159.8
8 hr	55.6	76.2	91.7	108.3	131.5	151.2	172.2
10 hr	58.9	80.8	97.2	114.7	139.4	160.2	182.5
12 hr	61.8	84.7	101.9	120.3	146.1	168	191.4
16 hr	66.6	91.3	109.8	129.7	157.5	181	206.3
20 hr	70.5	96.8	116.4	137.4	166.9	191.9	218.6
24 hr	74	101.5	122	144.1	175	201.2	229.2
1 day	64.1	87.9	105.7	124.8	151.6	174.3	198.6
2 days	74.5	102.2	122.9	145.1	176.2	202.6	230.8
3 days	81.3	111.6	134.1	158.4	192.4	221.2	252
4 days	89.5	122.8	147.7	174.4	211.9	243.5	277.5
5 days	96.5	132.3	159.1	187.9	228.3	262.4	299
6 days	102.5	140.7	169.1	199.7	242.6	278.9	317.8
7 days	107.9	148.1	178.1	210.3	255.5	293.6	334.6

5.1 Estimated floods return periods

Calculated peak flows are summarised in Table 5-2. Due to the large catchment areas, the RM (3) method peak flow estimates are considered inaccurate (RM suitable for catchments <15 km^2) and it was further observed that the MIPI peak flows are in the same order of magnitude as the RM peak flows. As such the SDF peak flows were incorporated into the flood line modelling, as the peak flows more closely relate to that of the DWS (2011) Der Brochen Dam design peak flows. The flood line assessment is aimed at providing a worst-case inundation scenario to evaluate potential flooding risks. The peak flows presented are for the existing project setting.

Table 5-2: Summary of design peak flows for the delineated sub-catchments (m^3/s)

Catchment	Method								
	RM (3)			SDF			MIPI		
	1:20yr	1:50yr	1:100yr	1:20yr	1:50yr	1:100yr	1:20yr	1:50yr	1:100yr
	(m^3/s)								
HRU1	267	402	557	533	787	1002	225	315	398
HRU2	109	164	228	213	315	400	79	111	140
HRU3	180	272	376	267	395	502	90	125	158
HRU4	6	9	12	11	17	22	8	11	14

5.2 Flood line modelling

5.2.1 Software

HEC-RAS 6.1 (September 2021) was used to model the flood elevation profile for the 1:50 and 1:100-year flood events. HEC-RAS is a hydraulic programme designed to perform one-dimensional hydraulic calculations for a range of applications, from a single watercourse to a full network of natural or constructed channels. The software is used worldwide and has consequently been thoroughly tested through numerous case studies.

5.2.2 Topography profile data

A triangulated irregular network (TIN) from the 30m DTM (JAXA, 2022) forms the foundation for the HEC-RAS model and was used to extract elevation data for the river profile together with the river cross-sections. Furthermore, the TIN was used to determine placement positions for the cross-sections along with the river profile, such that the watercourse can be accurately modelled to the resolution of the provided topographical data. The positions of the river sections were further refined, by evaluating Google Earth Imagery and its correlation to the DTM elevations (i.e., does the actual position of a river/stream correlate to the sub-catchment drainage line generated).

5.2.3 Manning's roughness coefficients

Manning's roughness factor (n) is used to describe the channel and adjacent floodplains' resistance to flow. A Manning factor of 0.045 best represents the frictional characteristics of the riverbanks and 0.04 for the channels (river).

5.2.4 Inflow and boundary conditions

Based on the HRUs and the confirmed drainage lines/ streams in the project area, three (3) HEC-RAS rivers were defined, consisting of both normal depth (upstream) and critical depth slope boundary conditions. The normal depth slope was determined based on the ALOS DTM slope rise for the given sub-catchment drainage line.

5.2.5 Hydraulic structures

Hydraulic structures were not incorporated into the HEC-RAS model as the investigation was desktop based. It should however be noted that modelling of hydraulic structures in the project area would have been hampered by the lack of good resolution topographical data (better than 30m ALOS and 5m contours).

5.2.6 Model assumptions

In line with the development of the flood lines, the following assumptions were made:

- The topographic data provided was of sufficient accuracy and coverage to enable hydraulic modelling at a suitable level of detail.
- The Manning's 'n' values used are considered suitable for use in the flooding events modelled, representing all the channels and floodplains.
- No abstractions or discharges into the stream sections were considered during the modelling.
- Hydraulic structures were not entered into the model due to the resolution of available topography data.
- Steady-state hydraulic modelling was undertaken, which assumes the flow is continuous at the peak rate; and
- A mixed flow regime that is tailored to both subcritical and supercritical flows was selected for running the steady-state model.

5.3 Model results

The 1:50-year and 1:100-year flood lines are shown in Figure 5-1. It can be seen that larger flooded areas are expected for the Groot-Dwars River and the perennial tributary of the Groot-Dwars River, as opposed to the non-perennial stream making up the 2nd tributary of the Groot-Dwars River.

As stated previously, due to the nature of this project (non-invasive prospecting), flood lines for the ephemeral drainage lines in the study areas were not modelled.

A ground truthed hydrological survey and lidar survey, with updated flood lines for non-perennial drainage lines (ephemeral streams) would only be required if an invasive prospecting phase is implemented and if prospecting methods and prospecting areas that could change runoff patterns or impact the hydrological cycle take place.

5.4 Site-specific sensitivity & buffers (avoidance areas)

The 1:100-year flood lines associated with the modelled river sections represents site-specific avoidance areas, and section 21 **c** and **i** applies to any activities that will fall in the modelled flooding areas.

As there are several non-perennial (ephemeral) streams in the project area, and these have not been modelled as per the limitations of this investigation and project type, it is proposed that 32m buffers from the streamflow centre be considered, to safeguard against any probable flooding risk associated with these drainage features.

5.5 Limitations

Steady-state flood modelling was undertaken which is a conservative approach as it ignores the effect of storage within the system and therefore produces higher flood levels than would be expected to occur. A steady-state model will result in worst-case (conservative) estimates of flooding, and resultant flood levels and floodplain extents would decrease if unsteady state modelling were undertaken using an inflow hydrograph as opposed to continuous peak flow.

Despite the above mentioned, the manning coefficients for the vegetation observed, and the low-resolution topographic data, the flood risk for major rivers in the project area were adequately assessed. No further flood modelling work is considered necessary and would only be considered necessary when more detailed topographical data is available, and if the prospecting phase changes to invasive.

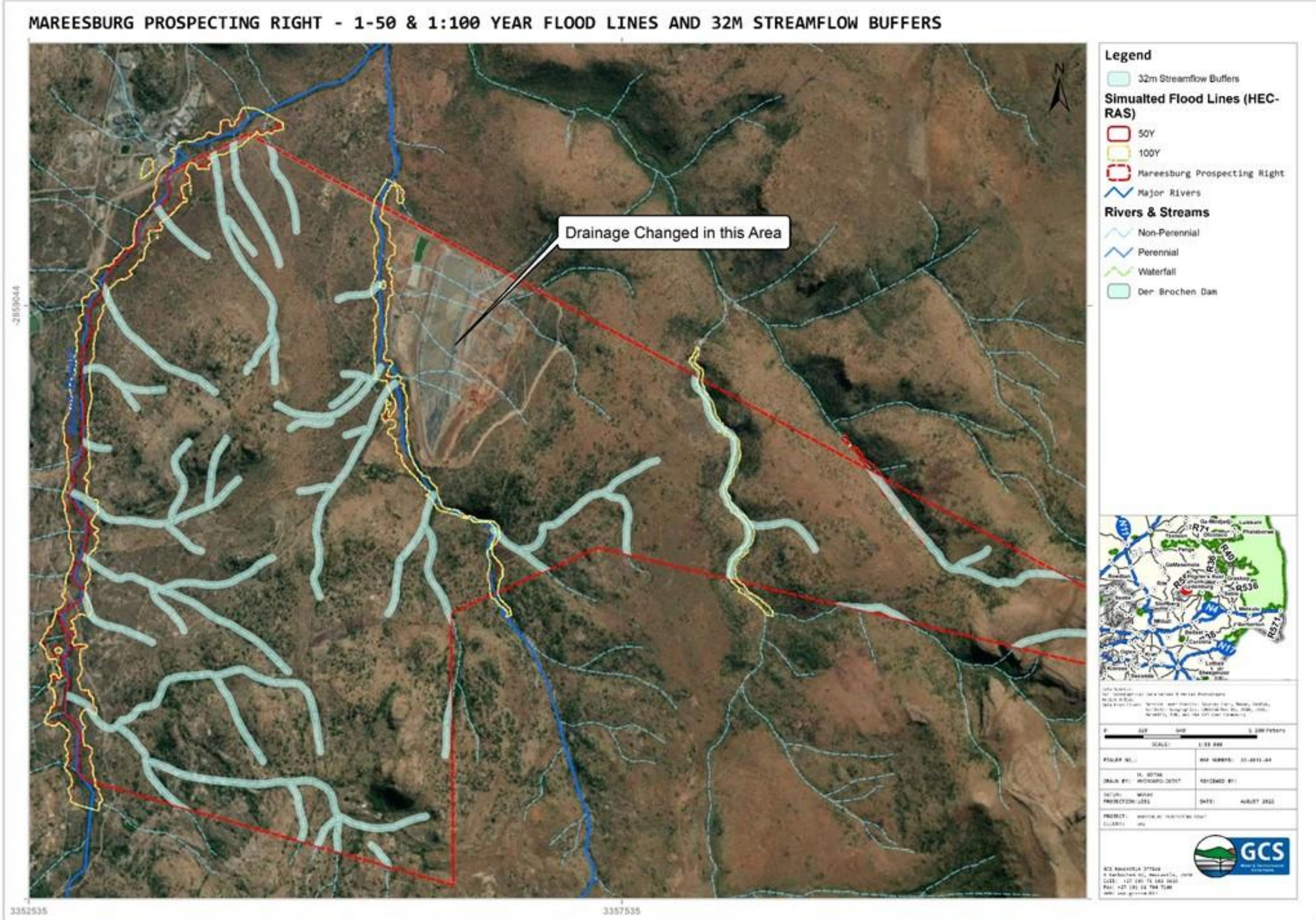


Figure 5-1: **Simulated 1:50 and 1:100 year flood lines & 32m Streamflow Buffers**

6 RISK ASSESSMENT & MITIGATION

Due to the project being a **non-invasive prospecting** process, no hydrological risks are associated with the activity. The current hydrological risk associated with this prospecting process is considered **Zero**. Moreover, no cumulative impacts are likely.

A risk assessment would only be required if the prospecting process is changed to invasive, and if prospecting methodologies and areas are confirmed.

7 SURFACE WATER MONITORING

Currently, no water monitoring is taking place by the applicant in the project area, and as this hydrology assessment is for a **non-invasive prospecting** process, no dedicated surface water monitoring is required. A surface water monitoring network and monitoring would be required if the process changes to an invasive prospecting phase.

Some monitoring requirements to consider **if the process is changed are**:

- Regular visual inspections of areas exposed to high traffic volumes (i.e. trucks or machinery entering the site) need to be undertaken.
- Placement and monitoring of drip trays underneath parked vehicles will help to determine which vehicles need to be repaired/taken off-site to prevent contamination.
- Establishment of dedicated surface water monitoring within perennial and non-perennial streams, upstream and downstream of the prospecting activities, and baseline sampling. Monthly monitoring of the established monitoring points after establishment, and as long as the invasive prospecting takes place upstream of the watercourse.

8 CONCLUSIONS

- The site is situated in Quaternary B41G of the Olifants Water Management (DWS, 2016)
  - The site's mean annual precipitation (MAP) is in the order of 686 mm/yr.
  - Natural runoff was recorded as approximately 57 mm/yr, which represents approximately 8.4% of the MAP.
  - Evaporation is reported > 1 300 mm/annum (S-Pan).
- In terms of the greater hydrological area, the prospecting right area is drained by the Groot-Dwars River (western boundary of the prospecting area) and a perennial tributary of the Groot-Dwars River (middle portion of the prospecting right area). The eastern portion of the prospecting area is drained via a non-perennial tributary of the Groot-Dwars River. Towards the south of the site, and in the Groot-Dwars River the Der Brochen Dam is found. The dam consists of an earth-fill embankment, stand-alone intake and a side-channel spillway. The dam has a maximum height of 30.5 m and is classified as large (DWAF, 2011). The dam was constructed to withstand a designed flow of 886 m^3/sec (RMF was calculated at 715 m^3/s and SEF 1 000 m^3/s) (DWAF, 2011). Drainage from the Dwars River is towards the Steelpoort River, situated approximately 15km downstream of the site.
- Available water quality data for the Groot-Dwars River suggest a limited impact on water quality as a result of the existing mining activities in the project area.
- The 1:50-year and 1:100-year flood lines suggest that larger flooded areas are expected for the Groot-Dwars River and the perennial tributary of the Groot-Dwars River, as opposed to the non-perennial stream making up the 2nd tributary of the Groot-Dwars River.
  - As stated previously, due to the nature of this project (non-invasive prospecting), flood lines for the ephemeral drainage lines in the study areas were not modelled.
  - A ground truthed hydrological survey and lidar survey, with updated flood lines for non-perennial drainage lines (ephemeral streams) would only be required if an invasive prospecting phase is implemented and if prospecting methods and prospecting areas that could change runoff patterns or impact the hydrological cycle take place.
- The hydrological risk associated with the non-invasive prospecting phase is deemed Zero, and no water monitoring would be required. An updated risk assessment would only be required if the prospecting process is changed to invasive, and if prospecting methodologies and areas are confirmed.

8.1 Identification of any areas that should be avoided

The 1:100-year flood lines associated with the modelled river sections represents site-specific avoidance areas, and section 21 **c** and **i** applies to any activities that will fall in the modelled flooding areas.

As there are several non-perennial (ephemeral) streams in the project area, and these have not been modelled as per the limitations of this investigation and project type, it is proposed that 32 m buffers from the streamflow centre be considered, to safeguard against any probable flooding risk associated with these drainage features.

8.2 Recommendations to include in the EMPR

The following can be considered for the EMPR as part of the non-invasive prospecting process:

- Maintain 32 m streamflow buffers for non-perennial streams, and simulated 1:50 and 1:100 year flood lines as exclusion zones.

Some monitoring requirements to consider **if the process is changed are**:

- Regular visual inspections of areas exposed to high traffic volumes (i.e. trucks or machinery entering the site) need to be undertaken.
- Placement and monitoring of drip trays underneath parked vehicles will help to determine which vehicles need to be repaired/taken off-site to prevent contamination.
- Establishment of dedicated surface water monitoring within perennial and non-perennial streams, upstream and downstream of the prospecting activities, and baseline sampling. Monthly monitoring of the established monitoring points after establishment, and as long as the invasive prospecting takes place upstream of the watercourse.

8.3 Reasoned opinion on whether the activity should be authorized

This assessment cannot find any grounds or identify high hydrological risks to not authorize the non-invasive prospecting phase.

8.4 Verification statement

The verification statement for this assessment is captured in Table 8-1.

Table 8-1: Verification statement

SCREENING TOOL SENSITIVITY	VERIFIED SENSITIVITY	OUTCOME STATEMENT/PLAN OF STUDY
N/A	The 1:100-year flood lines and in 32m buffer areas demarcate high sensitivity areas, and moving away from these features can be considered low sensitivity areas.	Compliance and Mitigation Plan as per Section 8.2.

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APPENDIX A: PEAK FLOW ESTIMATES

HRU1

RATIONAL METHOD 3							
Description of catchment		HRU1					
River detail	Groot Dwars River						
Calculated by	Hendrik Botha				Date	Wednesday, 31 August 2022	
Physical characteristics							
Size of catchment (A)	181.756	km^2		Rainfall region		B4B	
Longest watercourse (L)	25.1	km		Area distribution factors			
Average slope (S_{av})	0.0128	m/m		Rural (α)	Urban (β)	Lakes (γ)	
Dolomite area (D%)	0	%		1	0	0	
Mean annual rainfall(MAR)	686	mm					
Rural				URBAN			
Surface slope	%	Factor	C_s	Description	%	Factor	C2
Vleis and pans (<3%)	2.34	0.03	0.07	Lawns			
Flat areas (3 - 10%)	16.48	0.08	1.32	Sandy,flat<2%	0	0.08	0
Hilly (10 - 30%)	40.19	0.16	6.43	Sandy,steep>7%	0	0.16	0
Steep Areas (>30%)	40.99	0.26	10.66	Heavy s,flat<2%	0	0.15	0
Total	100.00	0.53	18.48	Heavy s,steep>7%	0	0.3	0
Permeability	%	Factor	C_p	Residential Areas			
Very permeable	80	0.04	3.20	Houses	0	0.5	0
Permeable	20	0.08	1.60	Flats	0	0.6	0
Semi-permeable	0	0.16	0.00	Industry			
Impermeable	0	0.26	0.00	Light industry	0	0.6	0
Total	100	0.54	4.80	Heavy industry	0	0.7	0
Vegetation	%	Factor	C_v	Business			
Thick bush & plantation	9.42	0.04	0.38	City centre	0	0.8	0
Light bush & farm-lands	38.88	0.11	4.28	Suburban	0	0.65	0
Grasslands	44.27	0.21	9.30	Streets	0	0.75	0
No vegatation	7.43	0.25	1.86	Max flood	0	1	0
Total	100	0.61	15.81	Total (C2)	0		0
Time of concentration (TC)							
Overland flow	Defined watercourse						
$T_C = 0.604\left(\frac{rL}{\sqrt{S_{av}}}\right)^{0.467}$	$T_c = \left[\frac{0.87 L^2}{1000 S_{AV}}\right]^{0.385}$			Use Defined watercourse			
4.907 hours	4.248	hours					
Run-off coefficient							
Return Period (years)	2	5	10	20	50	100	PMF
Run-off coefficient, C_1	0.391	0.391	0.391	0.391	0.391	0.391	0.900
Adjusted for dolomitic areas, C_{1D}	0.391	0.391	0.391	0.391	0.391	0.391	0.900
dj factor for initial saturation, F	0.5	0.55	0.6	0.67	0.83	1	1.00
Adjusted run - off coefficient, C_{1T}	0.195421	0.2149631	0.2345052	0.262	0.324	0.391	0.900
Combined run - off coefficient, C_T	0.195421	0.2149631	0.2345052	0.262	0.324	0.391	0.900
Rainfall							
Return Period (years)	2	5	10	20	50	100	PMF
Point rainfall (mm), P_T	48.76	66.87	80.45	94.98	115.33	132.59	151.06
Point Intensity (mm/h), P_{it}	11.48	15.74	18.94	22.36	27.15	31.21	35.56
Area reduction factor (%),ARF_T	0.905	0.905	0.905	0.905	0.905	0.905	0.905
Average intensity (mm/hour),I_T	10.385	14.244	17.136	20.230	24.565	28.242	32.174
Return Period (years)	2	5	10	20	50	100	PMF
Peak flow (m3/s)	102.463	154.588	202.887	267.461	402.329	557.28	1461.94

STANDARD DESIGN FLOOD (SDF) METHOD							
Description of catchment		HRU1					
River detail	Groot Dwars River						
Calculated by	Hendrik Botha			Date	31/08/2022		
Physical characteristics							
Size of catchment (A)	181.756	km^2	Days of thunder per year (R)		10	days	
Longest watercourse (L)	25.1	km	Time of concentration, t		254.882	minutes	
Average slope (S_{av})	0.013	m/m	Time of concentration, T_c	$T_c = \left[\frac{0.87\,L^2}{1000\,S_{AV}}\right]^{0.385}$		4.2480	
SDF Basin	5						
2-year return period rainfall (M)	78	mm					
TR102 n-day rainfall data							
Weather Service Station			MAP		686	mm	
Weather Service Station no.			Coordinates				
Duration	Return Period (years)						
	2	5	10	20	50	100	200
Rainfall							
Return Period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**200**
Point precipitation depth (mm) $P_{t,T}$	33.8	57.1	74.6	92.2	115.5	133.0	150.6
Area reduction factor (%),ARF_T	0.905	0.905	0.905	0.905	0.905	0.905	0.905
Average intensity (mm/hour),I_T	7.2	12.2	15.9	19.6	24.6	28.3	32.1
Run-off coefficient							
Calibration factors C_2 (%)	15		C_{100} (%)		70		
Return Period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**200**
Return period factors (Y_T)	0	0.84	1.28	1.64	2.05	2.33	2.58
Run-off coefficient, C_T	0.150	0.348	0.452	0.537	0.634	0.700	0.759
Peak flow (m3/s)	54.57	213.74	362.95	532.71	787.12	1001.52	1229.44

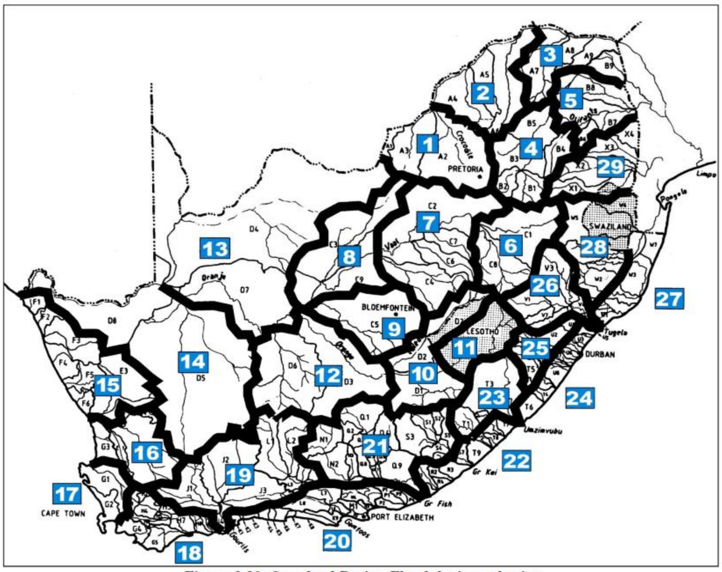


Figure 3.30: Standard Design Flood drainage basins

MIDGLEY & PITMAN (MIPI) METHOD														
River Detail	Catchment Area	MAP	S	L	Lc	Constant K_T				Catchment Parameter	Peak Flows			
	(km^2)	(mm)	m/m	km	km	1:10 year	1:20 Year	1: 50 year	1: 100 year	(Dimensionless)	1:10 year	1:20 Year	1: 50 year	1: 100 year
HRU1	181.756	686	0.0128	25.1	14.27	0.59	0.68	0.95	1.2	0.0574	195.45	225.27	314.71	397.53

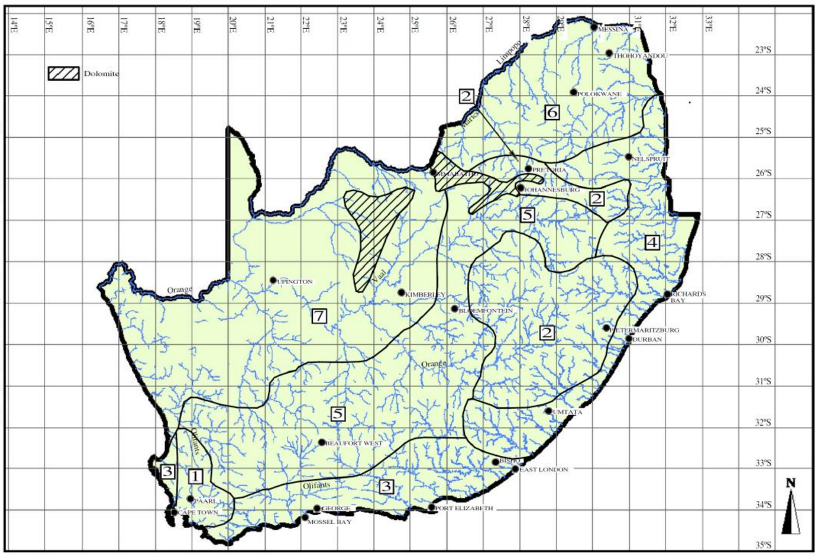


Figure 3.35: Homogeneous flood regions in South Africa

HRU2

RATIONAL METHOD 3							
Description of catchment		HRU2					
River detail	Unnamed						
Calculated by	Hendrik Botha				Date	Wednesday, 31 August 2022	
Physical characteristics							
Size of catchment (A)	31.355	km^2		Rainfall region		B4B	
Longest watercourse (L)	13.21	km		**Area distribution factors**			
Average slope (S_{av})	0.0471	m/m		Rural (α)	Urban (β)	Lakes (γ)	
Dolomite area (D%)	0	%		1	0	0	
Mean annual rainfall(MAR)	686	mm					
Rural				**URBAN**			
Surface slope	**%**	**Factor**	**C_s**	**Description**	**%**	**Factor**	**C2**
Vleis and pans (<3%)	1.78	0.03	0.05	**Lawns**			
Flat areas (3 - 10%)	30.75	0.08	2.46	Sandy,flat<2%	0	0.08	0
Hilly (10 - 30%)	50.01	0.16	8.00	Sandy,steep>7%	0	0.16	0
Steep Areas (>30%)	17.45	0.26	4.54	Heavy s,flat<2%	0	0.15	0
Total	99.99	0.53	15.05	Heavy s,steep>7%	0	0.3	0
Permeability	**%**	**Factor**	**C_p**	**Residential Areas**			
Very permeable	80	0.04	3.20	Houses	0	0.5	0
Permeable	20	0.08	1.60	Flats	0	0.6	0
Semi-permeable	0	0.16	0.00	Industry			
Impermeable	0	0.26	0.00	Light industry	0	0.6	0
Total	100	0.54	4.80	Heavy industry	0	0.7	0
Vegetation	**%**	**Factor**	**C_v**	**Business**			
Thick bush & plantation	5.29	0.04	0.21	City centre	0	0.8	0
Light bush & farm-lands	23.47	0.11	2.58	Suburban	0	0.65	0
Grasslands	60.75	0.21	12.76	Streets	0	0.75	0
No vegatation	10.14	0.25	2.54	Max flood	0	1	0
Total	99.65	0.61	18.09	Total (C2)	0		0
Time of concentration (TC)							
Overland flow	Defined watercourse						
$T_C = 0.604\left(\frac{rL}{\sqrt{S_{av}}}\right)^{0.467}$	$T_c = \left[\frac{0.87\,L^2}{1000\,S_{AV}}\right]^{0.385}$			Use Defined watercourse			
2.682 hours	1.569	hours					
Run-off coefficient							
Return Period (years)	2	5	10	20	50	100	PMF
Run-off coefficient, C_1	0.379	0.379	0.379	0.379	0.379	0.379	0.900
Adjusted for dolomitic areas, C_{1D}	0.379	0.379	0.379	0.379	0.379	0.379	0.900
dj factor for initial saturation, F	0.5	0.55	0.6	0.67	0.83	1	1.00
Adjusted run - off coefficient, C_{1T}	0.189689	0.2086579	0.2276268	0.254	0.315	0.379	0.900
Combined run - off coefficient, C_T	0.189689	0.2086579	0.2276268	0.254	0.315	0.379	0.900
Rainfall							
Return Period (years)	2	5	10	20	50	100	PMF
Point rainfall (mm), P_T	41.33	56.78	68.23	80.58	97.87	112.50	128.19
Point Intensity (mm/h), P_{it}	26.34	36.18	43.48	51.35	62.37	71.69	81.68
Area reduction factor (%),ARF_T	0.961	0.961	0.961	0.961	0.961	0.961	0.961
Average intensity (mm/hour),I_T	25.313	34.779	41.793	49.358	59.949	68.904	78.514
Return Period (years)	2	5	10	20	50	100	PMF
Peak flow (m3/s)	41.820	63.206	82.857	109.271	164.412	227.68	615.45

STANDARD DESIGN FLOOD (SDF) METHOD							
Description of catchment	HRU2						
River detail	Unnamed						
Calculated by	Hendrik Botha				Date	31/08/2022	
Physical characteristics							
Size of catchment (A)	31.355	km^2		Days of thunder per year (R)		10	days
Longest watercourse (L)	13.21	km		Time of concentration, t		94.156	minutes
Average slope (S_{av})	0.047	m/m		Time of concentration, T_c	$T_c = \left[\frac{0.87 L^2}{1000 S_{AV}}\right]^{0.385}$		1.5693
SDF Basin	5						
2-year return period rainfall (M)	78	mm					
TR102 n-day rainfall data							
Weather Service Station				MAP		686	mm
Weather Service Station no.				Coordinates			
Duration	**Return Period (years)**						
	2	**5**	**10**	**20**	**50**	**100**	**200**
Rainfall							
Return Period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**200**
Point precipitation depth (mm) $P_{t,T}$	27.3	46.0	60.2	74.3	93.1	107.2	121.4
Area reduction factor (%), ARF_T	0.961	0.961	0.961	0.961	0.961	0.961	0.961
Average intensity (mm/hour), I_T	16.7	28.2	36.9	45.5	57.0	65.7	74.4
Run-off coefficient							
Calibration factors — C_2 (%)	15		C_{100} (%)		70		
Return Period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**200**
Return period factors (Y_T)	0	0.84	1.28	1.64	2.05	2.33	2.58
Run-off coefficient, C_T	0.150	0.348	0.452	0.537	0.634	0.700	0.759
Peak flow (m3/s)	21.82	85.46	145.13	213.01	314.73	400.46	491.60

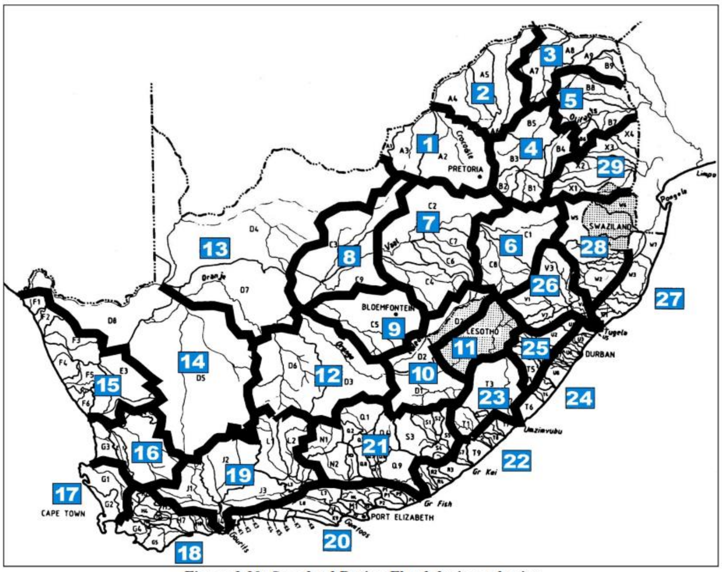


Figure 3.30: Standard Design Flood drainage basins

MIDGLEY & PITMAN (MIPI) METHOD														
River Detail	Catchment Area	MAP	S	L	Lc	Constant K_T				Catchment Parameter	Peak Flows			
	(km^2)	(mm)	m/m	km	km	1:10 year	1:20 Year	1: 50 year	1: 100 year	(Dimensionless)	1:10 year	1:20 Year	1: 50 year	1: 100 year
HRU2	31.355	686	0.0471	13.2	8.57	0.59	0.68	0.95	1.2	0.0601	68.72	79.20	110.65	139.77

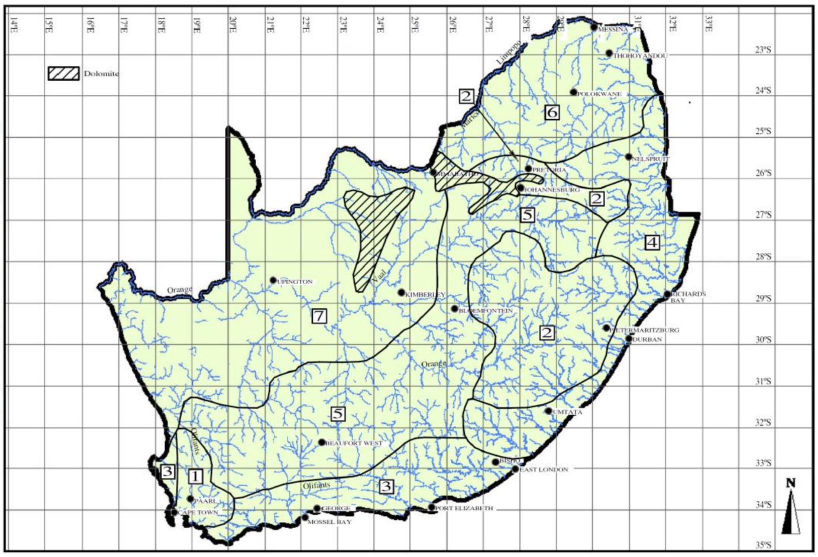


Figure 3.35: Homogeneous flood regions in South Africa

HRU3

RATIONAL METHOD 3							
Description of catchment		HRU3					
River detail	Unnamed						
Calculated by	Hendrik Botha				Date	Wednesday, 31 August 2022	
Physical characteristics							
Size of catchment (A)	28.993	km^2		Rainfall region		B4B	
Longest watercourse (L)	8.41	km		Area distribution factors			
Average slope (S_{av})	0.0582	m/m		Rural (α)	Urban (β)	Lakes (γ)	
Dolomite area (D%)	0	%		1	0	0	
Mean annual rainfall(MAR)	686	mm					
Rural				URBAN			
Surface slope	%	Factor	C_s	Description	%	Factor	C2
Vleis and pans (<3%)	1.72	0.03	0.05	**Lawns**			
Flat areas (3 - 10%)	18.46	0.08	1.48	Sandy,flat<2%	0	0.08	0
Hilly (10 - 30%)	43.96	0.16	7.03	Sandy,steep>7%	0	0.16	0
Steep Areas (>30%)	35.86	0.26	9.32	Heavy s,flat<2%	0	0.15	0
Total	100.00	0.53	17.89	Heavy s,steep>7%	0	0.3	0
Permeability	%	Factor	C_p	**Residential Areas**			
Very permeable	80	0.04	3.20	Houses	0	0.5	0
Permeable	20	0.08	1.60	Flats	0	0.6	0
Semi-permeable	0	0.16	0.00	Industry			
Impermeable	0	0.26	0.00	Light industry	0	0.6	0
Total	100	0.54	4.80	Heavy industry	0	0.7	0
Vegetation	%	Factor	C_v	**Business**			
Thick bush & plantation	5.35	0.04	0.21	City centre	0	0.8	0
Light bush & farm-lands	31.81	0.11	3.50	Suburban	0	0.65	0
Grasslands	58.57	0.21	12.30	Streets	0	0.75	0
No vegatation	4.2	0.25	1.05	Max flood	0	1	0
Total	99.93	0.61	17.06	Total (C2)	0		0
Time of concentration (TC)							
Overland flow	Defined watercourse						
$T_C = 0.604\left(\frac{rL}{\sqrt{S_{av}}}\right)^{0.467}$	$T_c = \left[\frac{0.87 L^2}{1000 S_{AV}}\right]^{0.385}$			Use Defined watercourse			
2.068 hours	1.022	hours					
Run-off coefficient							
Return Period (years)	2	5	10	20	50	100	PMF
Run-off coefficient, C_1	0.397	0.397	0.397	0.397	0.397	0.397	0.900
Adjusted for dolomitic areas, C_{1D}	0.397	0.397	0.397	0.397	0.397	0.397	0.900
dj factor for initial saturation, F	0.5	0.55	0.6	0.67	0.83	1	1.00
Adjusted run - off coefficient, C_{1T}	0.198742	0.2186162	0.2384904	0.266	0.330	0.397	0.900
Combined run - off coefficient, C_T	0.198742	0.2186162	0.2384904	0.266	0.330	0.397	0.900
Rainfall							
Return Period (years)	2	5	10	20	50	100	PMF
Point rainfall (mm), P_T	46.77	63.93	76.37	90.47	110.60	126.72	144.07
Point Intensity (mm/h), P_{it}	45.78	62.57	74.75	88.55	108.25	124.03	141.02
Area reduction factor (%),ARF_T	0.947	0.947	0.947	0.947	0.947	0.947	0.947
Average intensity (mm/hour),I_T	43.372	59.277	70.815	83.888	102.556	117.508	133.598
Return Period (years)	2	5	10	20	50	100	PMF
Peak flow (m3/s)	69.421	104.366	136.016	179.922	272.490	376.17	968.35

STANDARD DESIGN FLOOD (SDF) METHOD							
Description of catchment		HRU3					
River detail	Unnamed						
Calculated by	Hendrik Botha				Date	31/08/2022	
Physical characteristics							
Size of catchment (A)	28.993	km^2		Days of thunder per year (R)		10	days
Longest watercourse (L)	8.41	km		Time of concentration, t		61.300	minutes
Average slope (S_{av})	0.058	m/m		Time of concentration, T_c	$T_c = \left[\frac{0.87 L^2}{1000 S_{AV}}\right]^{0.385}$		1.0217
SDF Basin	5						
2-year return period rainfall (M)	78	mm					
TR102 n-day rainfall data							
Weather Service Station				MAP		686	mm
Weather Service Station no.				Coordinates			
Duration	Return Period (years)						
	2	5	10	20	50	100	200
Rainfall							
Return Period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**200**
Point precipitation depth (mm) $P_{t,T}$	24.4	41.2	53.9	66.6	83.4	96.1	108.8
Area reduction factor (%),ARF_T	0.947	0.947	0.947	0.947	0.947	0.947	0.947
Average intensity (mm/hour),I_T	22.7	38.2	50.0	61.8	77.3	89.1	100.9
Run-off coefficient							
Calibration factors C_2 (%)	15		C_{100} (%)		70		
Return Period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**200**
Return period factors (Y_T)	0	0.84	1.28	1.64	2.05	2.33	2.58
Run-off coefficient, C_T	0.150	0.348	0.452	0.537	0.634	0.700	0.759
Peak flow (m3/s)	27.38	107.23	182.09	267.25	394.88	502.45	616.79

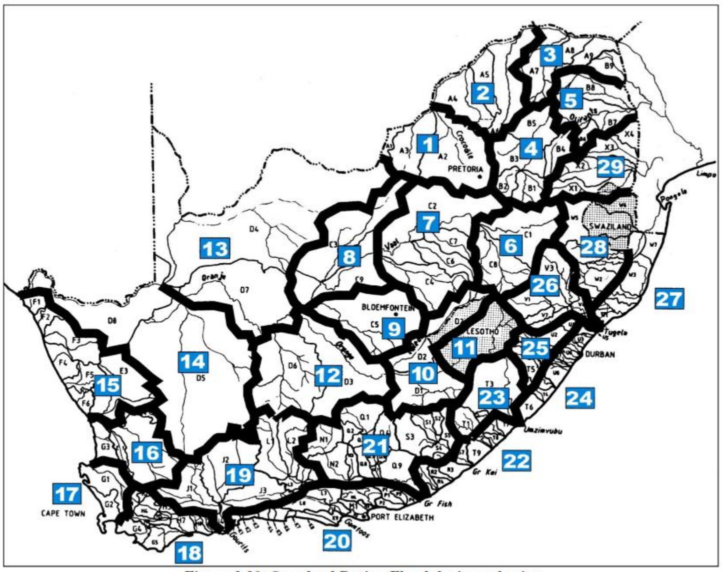
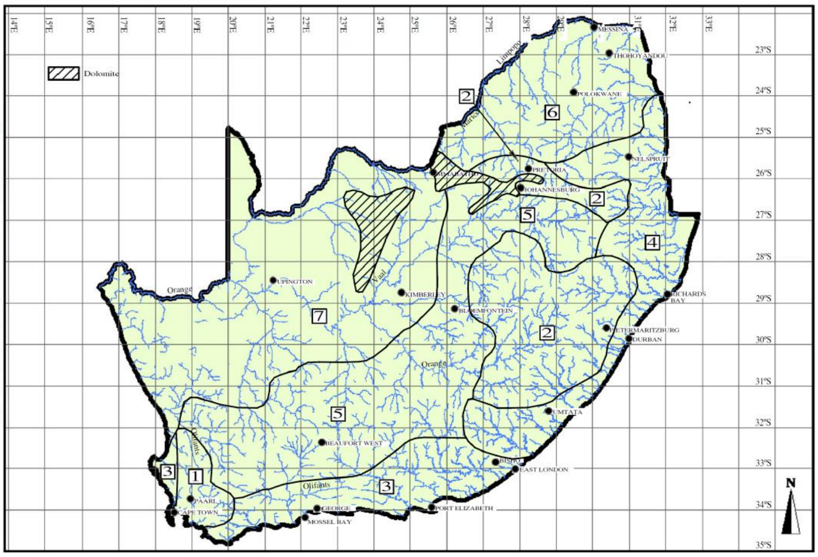


Figure 3.30: Standard Design Flood drainage basins

MIDGLEY & PITMAN (MIPI) METHOD														
River Detail	Catchment Area	MAP	S	L	Lc	Constant K_T				Catchment Parameter	Peak Flows			
	(km^2)	(mm)	m/m	km	km	1:10 year	1:20 Year	1: 50 year	1: 100 year	(Dimensionless)	1:10 year	1:20 Year	1: 50 year	1: 100 year
HRU3	28.993	686	0.0582	8.41	5.89	0.59	0.68	0.95	1.2	0.1412	77.78	89.64	125.24	158.19

Figure 3.35: Homogeneous flood regions in South Africa



HRU4

RATIONAL METHOD 3							
Description of catchment			HRU4				
River detail	Groot Dwars River						
Calculated by	Hendrik Botha				Date	Wednesday, 31 August 2022	
Physical characteristics							
Size of catchment (A)	0.54	km^2		Rainfall region		B4B	
Longest watercourse (L)	0.84	km		Area distribution factors			
Average slope (S_{av})	0.0077	m/m		Rural (α)	Urban (β)	Lakes (γ)	
Dolomite area (D%)	0	%		1	0	0	
Mean annual rainfall(MAR)	686	mm					
Rural				URBAN			
Surface slope	%	Factor	C_s	Description	%	Factor	C2
Vleis and pans (<3%)	5.52	0.03	0.17	Lawns			
Flat areas (3 - 10%)	53.99	0.08	4.32	Sandy,flat<2%	0	0.08	0
Hilly (10 - 30%)	32.37	0.16	5.18	Sandy,steep>7%	0	0.16	0
Steep Areas (>30%)	8.13	0.26	2.11	Heavy s,flat<2%	0	0.15	0
Total	100.01	0.53	11.78	Heavy s,steep>7%	0	0.3	0
Permeability	%	Factor	C_p	Residential Areas			
Very permeable	80	0.04	3.20	Houses	0	0.5	0
Permeable	20	0.08	1.60	Flats	0	0.6	0
Semi-permeable	0	0.16	0.00	Industry			
Impermeable	0	0.26	0.00	Light industry	0	0.6	0
Total	100	0.54	4.80	Heavy industry	0	0.7	0
Vegetation	%	Factor	C_v	Business			
Thick bush & plantation	3.85	0.04	0.15	City centre	0	0.8	0
Light bush & farm-lands	53.28	0.11	5.86	Suburban	0	0.65	0
Grasslands	42.39	0.21	8.90	Streets	0	0.75	0
No vegetation	0.14	0.25	0.04	Max flood	0	1	0
Total	99.66	0.61	14.95	Total (C2)	0		0
Time of concentration (TC)							
Overland flow	Defined watercourse						
$T_C = 0.604 \left(\frac{rL}{\sqrt{S_{av}}}\right)^{0.467}$	$T_c = \left[\frac{0.87 L^2}{1000 S_{AV}}\right]^{0.385}$			Use Defined watercourse			
1.131 hours	0.378	hours					
Run-off coefficient							
Return Period (years)	2	5	10	20	50	100	PMF
Run-off coefficient, C_1	0.315	0.315	0.315	0.315	0.315	0.315	0.900
Adjusted for dolomitic areas, C_{1D}	0.315	0.315	0.315	0.315	0.315	0.315	0.900
dj factor for initial saturation, F	0.5	0.55	0.6	0.67	0.83	1	1.00
Adjusted run - off coefficient, C_{1T}	0.1576475	0.17341225	0.189177	0.211	0.262	0.315	0.900
Combined run - off coefficient, C_T	0.1576475	0.17341225	0.189177	0.211	0.262	0.315	0.900
Rainfall							
Return Period (years)	2	5	10	20	50	100	PMF
Point rainfall (mm), P_T	31.78	43.62	52.46	62.00	75.30	86.51	98.63
Point Intensity (mm/h), P_{it}	84.14	115.50	138.91	164.17	199.37	229.08	261.16
Area reduction factor (%),ARF_T	1.106	1.106	1.106	1.106	1.106	1.106	1.106
Average intensity (mm/hour),I_T	93.033	127.710	153.591	181.521	220.450	253.294	288.774
Return Period (years)	2	5	10	20	50	100	PMF
Peak flow (m3/s)	2.200	3.322	4.358	5.752	8.654	11.98	38.98

STANDARD DESIGN FLOOD (SDF) METHOD							
Description of catchment		HRU4					
River detail	Groot Dwars River						
Calculated by	Hendrik Botha			Date	31/08/2022		
Physical characteristics							
Size of catchment (A)	0.54	km^2		Days of thunder per year (R)		10	days
Longest watercourse (L)	0.84	km		Time of concentration, t		22.660	minutes
Average slope (S_{av})	0.008	m/m		Time of concentration, T_c	$T_c = \left[\frac{0.87 L^2}{1000 S_{AV}}\right]^{0.385}$		0.3777
SDF Basin	5						
2-year return period rainfall (M)	78	mm					
TR102 n-day rainfall data							
Weather Service Station				MAP		686	mm
Weather Service Station no.				Coordinates			
Duration	**Return Period (years)**						
	2	**5**	**10**	**20**	**50**	**100**	**200**
Rainfall							
Return Period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**200**
Point precipitation depth (mm) $P_{t,T}$	17.9	30.2	39.5	48.7	61.0	70.3	79.6
Area reduction factor (%), ARF_T	1.106	1.106	1.106	1.106	1.106	1.106	1.106
Average intensity (mm/hour), I_T	52.3	88.3	115.5	142.7	178.7	205.9	233.1
Run-off coefficient							
Calibration factors — C_2 (%)	15		C_{100} (%)	70			
Return Period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**200**
Return period factors (Y_T)	0	0.84	1.28	1.64	2.05	2.33	2.58
Run-off coefficient, C_T	0.150	0.348	0.452	0.537	0.634	0.700	0.759
Peak flow (m3/s)	1.18	4.61	7.83	11.50	16.99	21.62	26.54

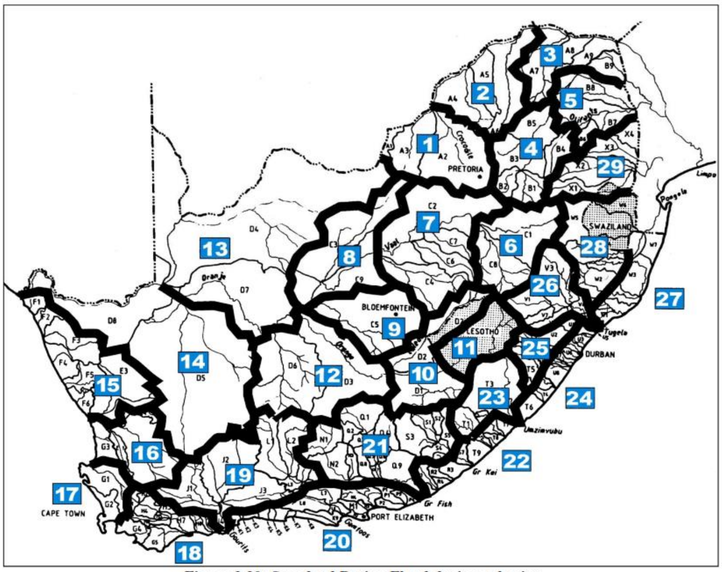


Figure 3.30: Standard Design Flood drainage basins

MIDGLEY & PITMAN (MIPI) METHOD														
River Detail	Catchment Area	MAP	S	L	Lc	Constant K_T				Catchment Parameter	Peak Flows			
	(km^2)	(mm)	m/m	km	km	1:10 year	1:20 Year	1: 50 year	1: 100 year	(Dimensionless)	1:10 year	1:20 Year	1: 50 year	1: 100 year
HRU4	0.54	686	0.0077	0.84	0.4	0.59	0.68	0.95	1.2	0.1410	7.13	8.21	11.47	14.49

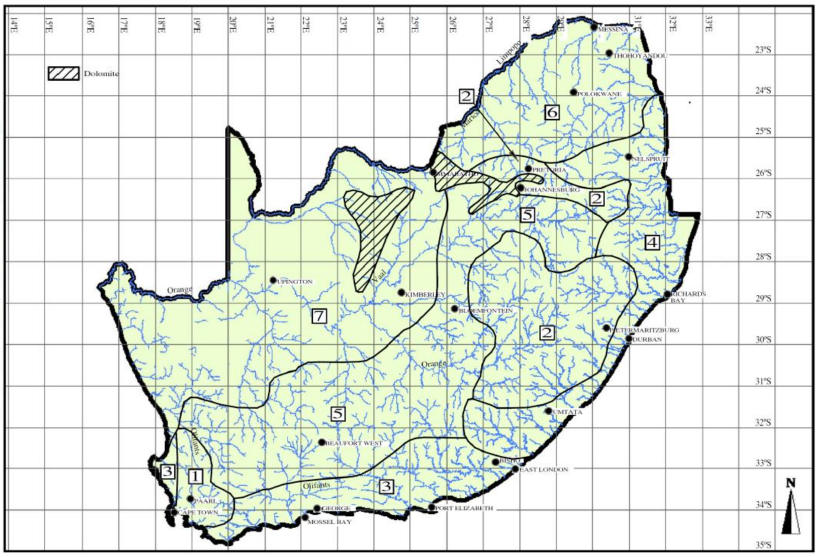


Figure 3.35: Homogeneous flood regions in South Africa

APPENDIX B: RISK ASSESSMENT METHODOLOGY

Due to the assessment forming part of a larger risk assessment for the study area, the potential impacts and the determination of impact significance were assessed. The process of assessing the potential impacts of the project encompasses the following four activities:

1. Identification and assessment of potential impacts.
2. Prediction of the nature, magnitude, extent, and duration of potentially significant impacts.
3. Identification of mitigation measures that could be implemented to reduce the severity or significance of the impacts of the activity; and
4. Evaluation of the significance of the impact after the mitigation measures have been implemented i.e., the significance of the residual impact.

Per GNR 982 of the EIA Regulations (2014), the significance of potential impacts was assessed in terms of the following criteria:

I. Cumulative impacts.
II. Nature of the impact.
III. The extent of the impact.
IV. Probability of the impact occurring.
V. The degree to which the impact can be reversed.
VI. The degree to which the impact may cause irreplaceable loss of resources; and
VII. The degree to which the impact can be mitigated.

Table 9-1 provides a summary of the criteria used to assess the significance of the potential impacts identified. An explanation of these impact criteria is provided in Table 9-2.

Consequence = (Duration + Extent + Irreplaceability of resource) x Severity

And the environmental significance of an impact was determined by multiplying consequence by probability.

Table 9-1: Proposed Criteria and Rating Scales to be used in the Assessment of the Potential Impacts

Criteria	Rating Scales	Notes
Nature	Positive (+)	An evaluation of the effect of the impact related to the proposed development.
	Negative (-)	
Extent	Footprint (1)	The impact only affects the area in which the proposed activity will occur.
	Site (2)	The impact will affect only the development area.
	Local (3)	The impact affects the development area and adjacent properties.
	Regional (4)	The effect of the impact extends beyond municipal boundaries.
	National (5)	The effect of the impact extends beyond more than 2 regional/ provincial boundaries.
	International (6)	The effect of the impact extends beyond country borders.
Duration	Temporary (1)	The duration of the activity associated with the impact will last 0-6 months.
	Short-term (2)	The duration of the activity associated with the impact will last 6-18 months.

Criteria	Rating Scales	Notes
	Medium-term (3)	The duration of the activity associated with the impact will last 18 months-5 or years.
	Long-term (4)	The duration of the activity associated with the impact will last more than 5 years.
Severity	Low (1)	Where the impact affects the environment in such a way that natural, cultural and social functions and processes are minimally affected.
	Moderate (2)	Where the affected environment is altered but natural, cultural and social functions and processes continue albeit in a modified way; and valued, important, sensitive, or vulnerable systems or communities are negatively affected.
	High (3)	Where natural, cultural, or social functions and processes are altered to the extent that the natural process will temporarily or permanently cease; and valued, important, sensitive, or vulnerable systems or communities are substantially affected.
Potential for impact on irreplaceable resources	No (0)	No irreplaceable resources will be impacted.
	Yes (1)	Irreplaceable resources will be impacted.
Consequence	Extremely detrimental (-25 to -33)	A combination of extent, duration, intensity, and the potential for impact on irreplaceable resources.
	Highly detrimental (-19 to -24)	
	Moderately detrimental (-13 to -18)	
	Slightly detrimental (-7 to -12)	
	Negligible (-6 to 0)	
	Slightly beneficial (0 to 6)	
	Moderately beneficial (13 to 18)	
	Highly beneficial (19 to 24)	
	Extremely beneficial (25 to 33)	
Probability (the likelihood of the impact occurring)	Improbable (0)	It is highly unlikely or less than 50 % likely that an impact will occur.
	Probable (1)	It is between 50 and 70 % certain that the impact will occur.
	Definite (2)	It is more than 75 % certain that the impact will occur, or the impact will occur.
Significance	Very high - negative (-49 to -66)	A function of Consequence and Probability.
	High - negative (-37 to -48)	
	Moderate - negative (-25 to -36)	
	Low - negative (-13 to -24)	
	Neutral - Very low (0 to -12)	
	Low - positive (0 to 12)	
	Moderate - positive (13 to 24)	
	High-positive (37 to 48)	
	Very high - positive (49 to 66)	

Table 9-2: Explanation of Assessment Criteria

Criteria	Explanation
Nature	This is an evaluation of the type of effect the construction, operation, and management of the proposed development would have on the affected environment. Will the impact of change on the environment be positive, negative, or neutral?
Extent or Scale	This refers to the spatial scale at which the impact will occur. The extent of the impact is described as footprint (affecting only the footprint of the development), site (limited to the site), and regional (limited to the immediate surroundings and closest towns to the site). The extent of scale refers to the actual physical footprint of the impact, not to the spatial significance. It is acknowledged that some impacts, even though they may be of a small extent, are of very high importance, e.g., impacts on species of very restricted range. To avoid "double counting, specialists have been requested to indicate spatial significance under "intensity" or "impact on irreplaceable resources" but not under "extent" as well.
Duration	The lifespan of the impact is indicated as temporary, short, medium, and long-term.
Severity	This is a relative evaluation within the context of all the activities and the other impacts within the framework of the project. Does the activity destroy the impacted environment, alter its functioning, or render it slightly altered?
Impact on irreplaceable resources	This refers to the potential for an environmental resource to be replaced, should it be impacted. A resource could be replaced by natural processes (e.g., by natural colonization from surrounding areas), through artificial means (e.g., by reseeding disturbed areas or replanting rescued species) or by providing a substitute resource, in certain cases. In natural systems, providing substitute resources is usually not possible, but in social systems, substitutes are often possible (e.g., by constructing new social facilities for those that are lost). Should it not be possible to replace a resource, the resource is essentially irreplaceable e.g., red data species that are restricted to a particular site or habitat to a very limited extent.
Consequence	The consequence of the potential impacts is a summation of the above criteria, namely the extent, duration, intensity, and impact on irreplaceable resources.
Probability of occurrence	The probability of the impact occurring is based on the professional experience of the specialist with environments of a similar nature to the site and/or with similar projects. It is important to distinguish between the probability of the impact occurring and the probability that the activity

Criteria	Explanation
	causing a potential impact will occur. Probability is defined as the probability of the impact occurring, not as the probability of the activities that may result in the impact.
Significance	Impact significance is defined to be a combination of the consequence (as described below) and the probability of the impact occurring. The relationship between consequence and probability highlights that the risk (or impact significance) must be evaluated in terms of the seriousness (consequence) of the impact, weighted by the probability of the impact occurring. In simple terms, if the consequence and probability of an impact are high, then the impact will have a high significance. The significance defines the level to which the impact will influence the proposed development and/or environment. It determines whether mitigation measures need to be identified and implemented and whether the impact is important for decision-making.
Degree of confidence in predictions	Specialists and the EIR team were required to indicate the degree of confidence (low, medium, or high) that there is in the predictions made for each impact, based on the available information and their level of knowledge and expertise. The degree of confidence is not taken into account in the determination of consequence or probability.
Mitigation measures	Mitigation measures are designed to reduce the consequence or probability of an impact or to reduce both consequence and probability. The significance of impacts has been assessed both with mitigation and without mitigation.

APPENDIX C: DISCLAIMER AND DECELERATION OF INDEPENDENCE

The opinions expressed in this Report have been based on site /project information supplied to GCS (Pty) Ltd by EMA and are based on public domain data, field data and data supplied to GCS by the client. GCS has acted and undertaken this assessment objectively and independently.

GCS has exercised all due care in reviewing the supplied information. Whilst GCS has compared key supplied data with expected values, the accuracy of the results and conclusions are entirely reliant on the accuracy and completeness of the supplied data. GCS does not accept responsibility for any errors or omissions in the supplied information and does not accept any consequential liability arising from commercial decisions or actions resulting from them.

Opinions presented in this report, apply to the site conditions, and features as they existed at the time of GCS's investigations, and those reasonably foreseeable. These opinions do not necessarily apply to conditions and features that may arise after the date of this report, about which GCS had no prior knowledge nor had the opportunity to evaluate.

APPENDIX D: DETAILS OF THE SPECIALIST, DECLARATION OF INTEREST AND UNDERTAKING UNDER OATH

Application for authorisation in terms of the National Environmental Management Act, Act No. 107 of 1998, as amended and the Environmental Impact Assessment (EIA) Regulations, 2014, as amended (the Regulations)

PROJECT TITLE

Desktop Hydrological Assessment for the Nomamix (Pty) Ltd - Mareesburg Non-Invasive Prospecting Right Application

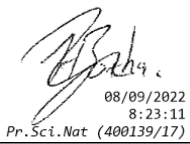
SPECIALIST INFORMATION

Specialist Company Name:	GCS Environmental SA			
B-BBEE	Contribution level (indicate 1 to 8 or non-compliant)	2	Percentage Procurement Recognition	
Specialist name:	Hendrik Botha			
Specialist Qualifications:	MSc Environmental Sciences (Geohydrology & Geochemistry) BSc Hons. Environmental Sciences (Hydrology) BSc. Geology and Chemistry			
Professional affiliation/registration:	PR SCI NAT 400139/17			
Physical address:	1 Karbochem Road, Newcastle, KZN			
Postal address:				
Postal code:	2940	Cell:		
Telephone:	071 102 3819	Fax:		
E-mail:	hendrikb@gcs-sa.biz			

DECLARATION BY THE SPECIALIST

I, Hendrik Botha, declare that –

- I act as the independent specialist in this application.
- I will perform the work relating to the application objectively, even if this results in views and findings that are not favourable to the applicant.
- I declare that there are no circumstances that may compromise my objectivity in performing such work.
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity.
- I will comply with the Act, Regulations and all other applicable legislation.
- I have no, and will not engage in, conflicting interests in the undertaking of the activity.
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken concerning the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority.
- all the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.



Signature of the Specialist

GCS

Name of Company:

08 September 2022

Date

CV OF SPECIALIST

GCS Water & Environmental Consultants

Hendrik Botha

Technical Director

CORE SKILLS

- Project management
- Analytical and numerical groundwater modelling
- Geochemical assessments and geochemical modelling
- Hydropedology and hydrological assessments
- Hydrology, floodline modelling & storm water management
- Groundwater vulnerability, impact, and risk assessments
- Technical report writing
- GIS and mapping

DETAILS

Qualifications

- BSc Chemistry and Geology (Environmental Sciences) (2012)
- BSc Hons Hydrology (Environmental Sciences) (2013)
- MSc Geohydrology and Hydrology (Environmental Sciences) (2014-2016)

Membership

- Groundwater Division of GSSA
- Groundwater Association of KwaZulu Natal Member
- International Mine Water Association (IMWA)

Languages

- Afrikaans - Speak, read, write.
- English - Speak, read, write.

Projects undertaken in

- South Africa
- Nigeria
- Namibia
- Liberia

PROFILE

Hendrik (Henri) Botha is currently the manager of the GCS Newcastle Office and occupies the role of principal hydrogeologist. Groundwater, geochemistry and surface hydrology, as well as knowledge of water chemistry together with GIS, analytical and numerical modelling skills, is some of his sought-after expertise. General and applied logical knowledge are his key elements in problem-solving.

Professional Affiliations:

SACNASP Professional Natural Scientist (400139/17)

Areas of Expertise:

- Waste classification and Impact Assessments
- Aquifer vulnerability assessments
- Geochemical sampling, data interpretation and modelling
- Geophysical surveys and data interpretation
- GIS
- Water quality sampling and data interpretation
- Groundwater impact and risk assessments
- Numerical and Conceptual Visual Modelling (Visual Modflow, ModflowFLEX, Voxler, RockWorks, Surfer and Excel)
- Hydropedology (Hydrological Soil Types) & Soils Assessments
- Floodline Modelling (HEC-RAS)
- Stormwater Management Systems and Modelling
- Surface Water Yield Assessments
- Water and Salt Balances

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