RETHUSHENG SPECIAL NEEDS SCHOOL

DESKTOP FLOODLINE ASSESSMENT

PREPARED FOR:
Muteo Consulting

PREPARED BY:
NNB Engineering Consultants

Tel: (082) 559 8111
Email : nilesh@nnbconsulting.co.za

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For NNB Engineering Consultants:

Prepared by	N.Beeputh		26 August 2025
Approved by	S. Dipela		26 August 2025
			Date

For Limpopo Department of Public Works, Roads, and Infrastructure

Project Manager:			
			Date
Director:			
			Date

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1. INTRODUCTION

Muteo Consulting cc has been appointed by the Department of Public Works to provide professional civil and structural engineering services for the construction of Rethusheng Special School.

The scope of services includes the following project stages:

- Scoping
- Preliminary Design
- Detailed Design
- Tender Documentation
- Construction Supervision
- Project Closure

To comply with the National Water Act and the project planning and design stages, floodlines must be determined for any development subject to flooding. NNB Engineering Consultants were appointed by Muteo Consulting to conduct a Flood risk assessment for the proposed school.

1.1 Scope

The scope of this study is to conduct a hydrological and hydraulic analysis of the study area to determine the floodlines and evaluate flood risks that may impact the proposed development.

Figure 1-1 proposed the locaity of the site in relation to the suround in development taken from google earth. Figure 1-2 illustrates the locality of the site boundary and the surrounding watercourse, respectively.

The following portions of watercourses were identified and forms part of the scope of this report.

Watercourse 1 – A small non-perennial Tributary which eventually connect to a large tributary of the Okayamatlala River.

Watercourse 2 – A small non-perennial Tributary which eventually connect to a large tributary of the Okayamatlala River. This tributary passes the built up residential settlement of Mamehlabe.

Watercourse 3 – A large non-perennial Tributary Okayamatlala River.

Watercourse 4 - The non-perennial Nokayamatlala River.

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Figure 1-1 – Locality (Google Earth)

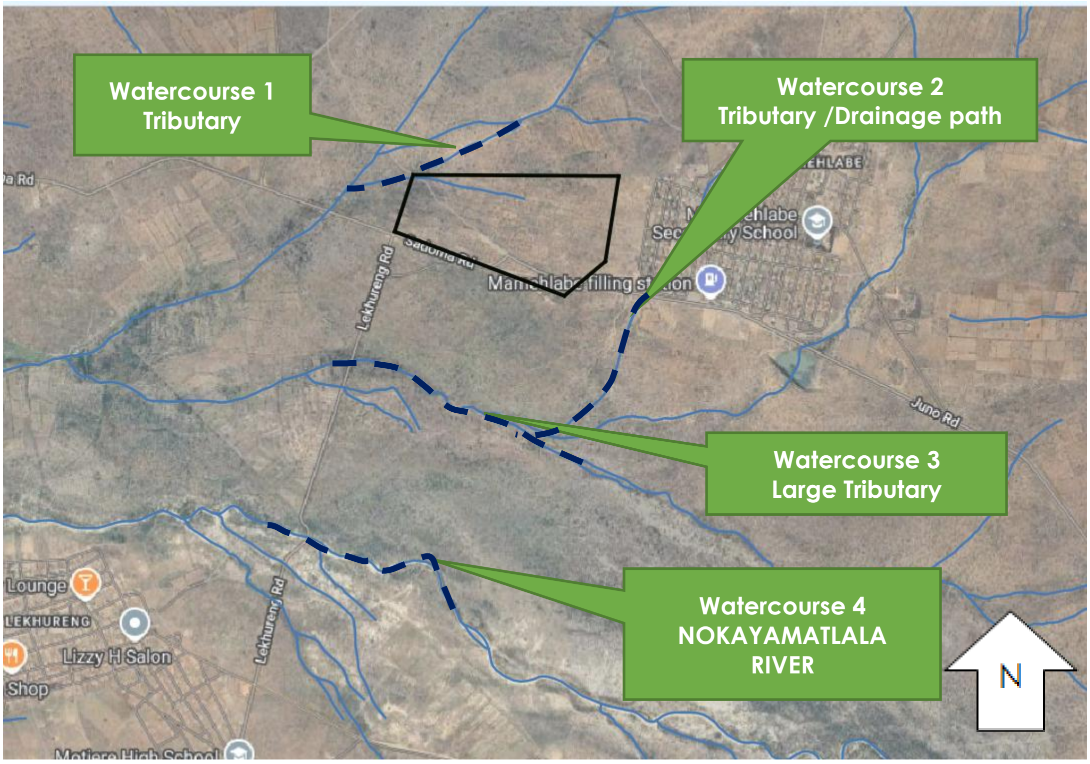

Figure 1-2 - Study watercourse locality (GIS)

2. DATA COLLECTION

The following data was utilised for the assessment:

- Aerial Imagery from QGIS and Google Earth.
- South African National Land Cover (SANLC 2020) data set.
- Generalised SCS soil grouping classification for South Africa. (Schulze and Schutte 2018)
- Advanced Land Observing Satellite (ALOS) Global Digital Surface Model (AW3D30) via the OpenTopography database (Referred to as online data in this report).
- 2m contour intervals data derived from online data.
- The GreenBook online planning support tool for impacts on climate change.
- The 2012 rainfall records from the "Design Rainfall and Flood Estimation in South Africa" by Prof Jeff Smithers from the University of Natal (Pietermaritzburg) were considered in this study.

3. HYDROLOGICAL ASSESSMENT

This section provides details of the catchment characteristics and design flood estimation (peak flows) for the identified watercourses as previously mentioned in Section 1.1. The site and identified watercourses are located within the Quaternary Catchment A62E

3.1 CATCHMENT BOUNDARY DELINEATION

As shown in Figure 1-2, four watercourses of the non-perennial Nokayamatlala River catchment were identified.

The corresponding catchment boundary was delineated using 2m contours from online data and is depicted in Figure 3-1. The contributing catchment areas were estimated for each watercourse as detailed below in Table 1.

Watercourse	**1**	**2**	**3**	**4**
Sub Basin	**1**	**2**	**3**	**4**
Area (km²)	4.425	1.6305	53.0645	477.1502

Table 3-1 Area per Sub Basin

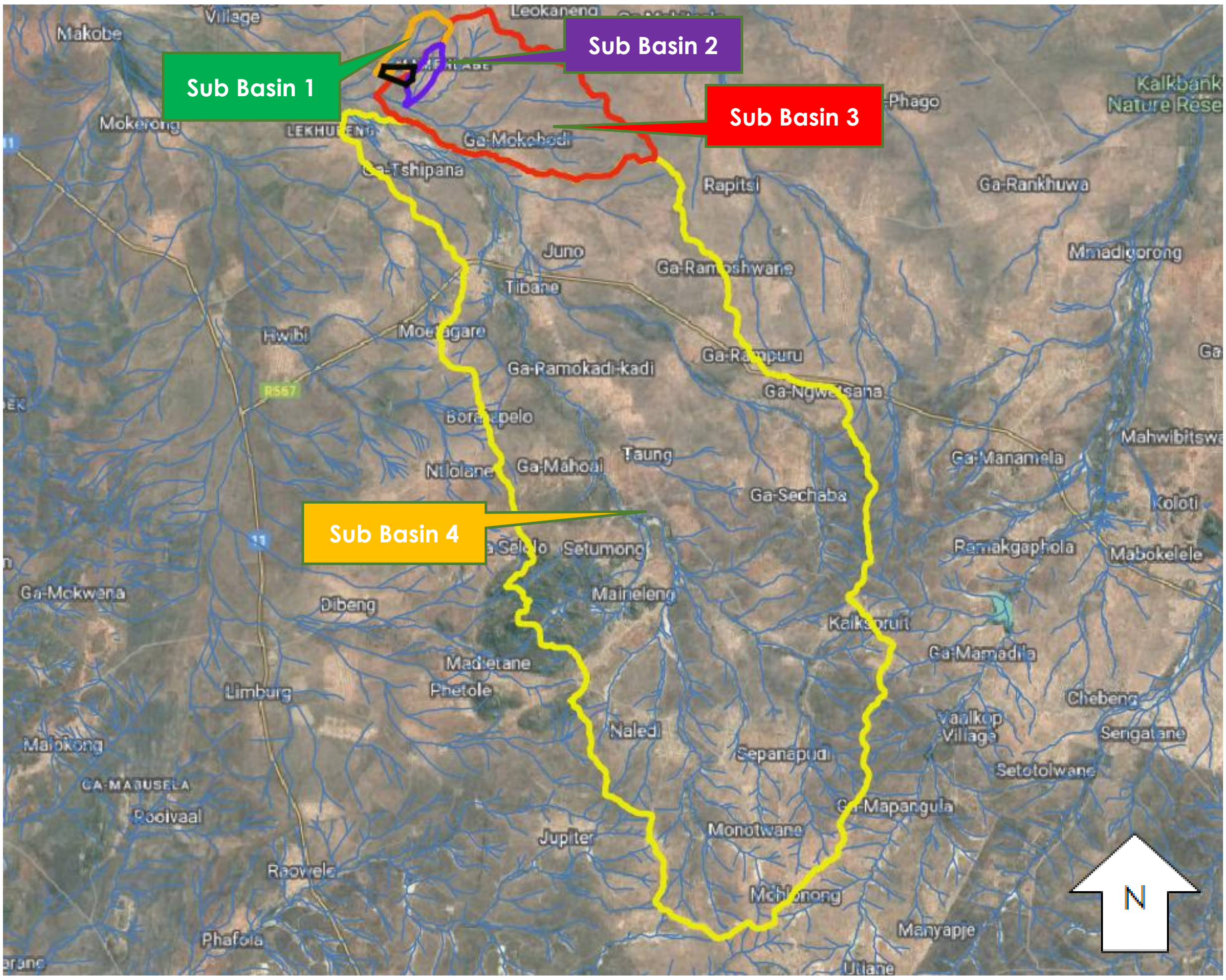

Figure 3-1 - Catchment boundary delineation.

3.2 CLIMATE CHANGE

Studies have shown that climate change is leading to more frequent and intense extreme rainfall events in South Africa. However, currently there are no definitive updated design rainfall figures which account for climate change. This means that current design rainfall estimates should, to some degree, account for these increased intensities.

The GreenBook (an online planning support tool) was utilised to inform the selection of design rainfall data for the purposes of climate change considerations in this stormwater management plan. The Blouberg Municipality in Limpopo was selected to extract related climate change data projected for the year 2050.

3.2.1 About the GreenBook

"The GreenBook is an online planning support tool that provides quantitative scientific evidence on the likely impacts that climate change and urbanisation will have on South Africa's cities and towns, as well as presenting a number of adaptation actions that can be implemented by local government to support climate resilient development. The GreenBook was co-funded by the

CSIR and the International Development Research Centre (IDRC), over the past three years, between 2016 and 2019. The CSIR has partnered with the National Disaster Management Centre (NDMC) and co-developed this product with universities, government departments, NGOs and other peer groups". Further details about the GreenBook can be found at https://greenbook.co.za/index.html

3.2.2 Climate Change Impacts

As depicted in Figure 3-2, Blouberg Local Municipality average rainfall is expected to experience increases of 56mm. Furthermore, as depicted in Figure 3-3, the extreme rainfall days are expected to increase by +-1.

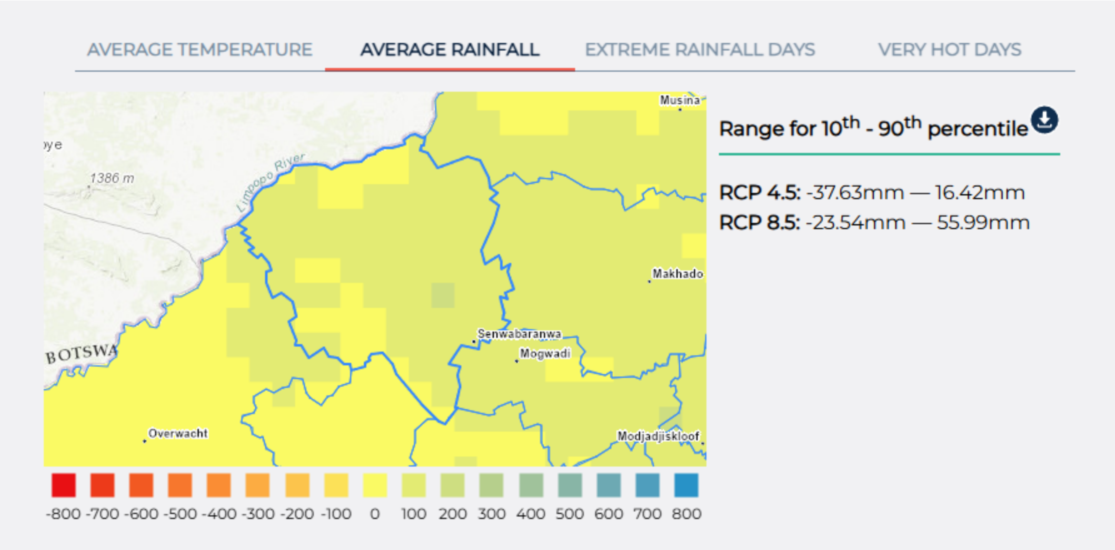

Figure 3-2 – GreenBook – Climate impact on Average rainfall in Blouberg Local Municipality.

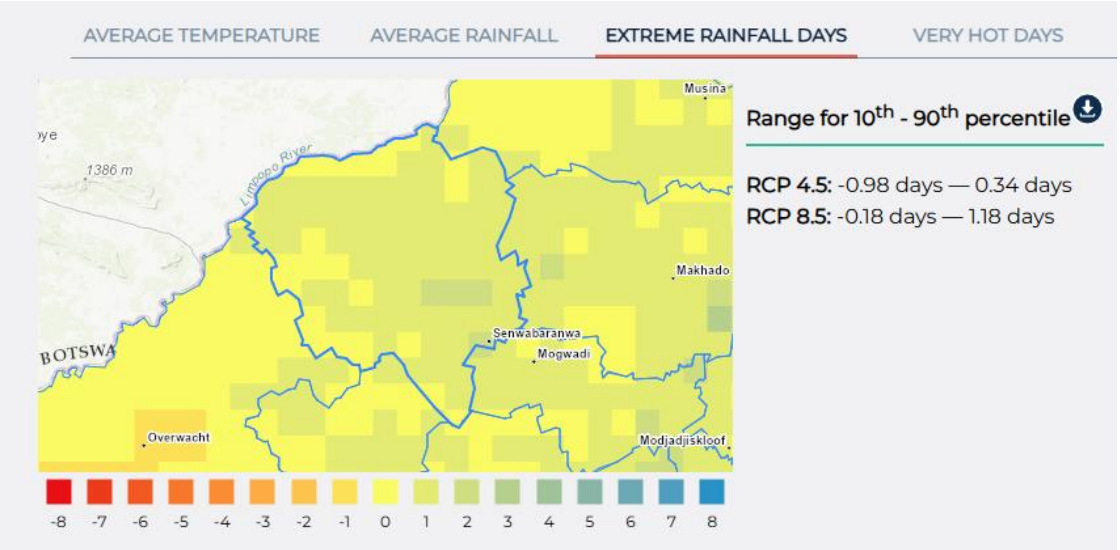

Figure 3-3 - GreenBook – Climate impact on Extreme rainfall days in Blouberg Local Municipality.

3.2.3 Climate Change Considerations

Based on the findings above, it is evident that Blouberg Local Municipality is expected to be impacted by climate change. Therefore, to account for climate change in the hydrological analysis of this Floodline assessment, the upper 90% design rainfall data was adopted as recommended by "A best practice guideline for design flood estimation in municipal areas in South Africa, July 2023."

Furthermore, the selection of peak flows calculated from the various methods should done with the above information taken into consideration.

3.3 RAINFALL DATA

The 2012 rainfall records from the "Design Rainfall and Flood Estimation in South Africa" by Prof Jeff Smithers from The University of Natal (Pietermaritzburg) were considered in this study (The RLMA&SI method). The below Table 3-2 - Rainfall Station Details

2, provides details of the five weather stations applicable to the catchments assessed.

Station Name	CROMFORD	CHLOE	VULCANUS (HOSP)	SWERWERSK RAAL	VAALPENSK RAAL	SALEM
SAWS Number	0676783_W	0677099_W	677188_W	0676705_W	0676523_W	0676363_W
Latitude (S)	23° 32'	23° 38'	23° 38'	23° 44'	23° 42'	23° 32'
Longitude (E)	28° 57'	29° 04'	29° 07'	28° 54'	28° 48'	28° 42'
MAP (mm)	445	434	418	474	506	419
Record (years)	45	51	49	52	43	45
Altitude (m)	1057	1141	1176	1066	1104	929

Table 3-2 - Rainfall Station Details

Error! Reference source not found. below indicates the average adopted design rainfall depths f or different Return Intervals, extracted from the gridded rainfall dataset taken at 1 minute grid intervals within the catchment boundary.

As discussed in the previous section, the impact of climate change on rainfall within the Blouberg Local Municipal is noted to increase annual rainfall and extreme rainfall days by the year 2050. Therefore, as recommended by the best practice guidelines for design flood estimation in municipal areas in South Africa, the upper 90% rainfall values were considered.

Duration	Return Period (Years)						
	2	5	10	20	50	100	200
1hr	35.304	48.072	57.488	67.24	81.164	92.512	104.64
12hr	63.792	86.88	103.872	121.492	146.664	167.188	189.096
16hr	66.656	90.772	108.552	126.956	153.24	174.7	197.584
20hr	68.964	93.924	112.304	131.356	158.552	180.752	204.44
24hr	70.916	96.568	115.468	135.072	163.032	185.848	210.208

Table 3-3 - Design Rainfall Depths.

3.4 CATCHMENT LAND USE

The estimated land cover for the study catchment was derived from the South African National Land Cover (SANLC 2020) dataset, provided by the Department of Forestry, Fisheries and the Environment.

The area of interest was divided into four sub-basins, for which the findings are tabulated with the corresponding maps for reference.

3.3.1 Land Use Characteristics: Sub Basin 1

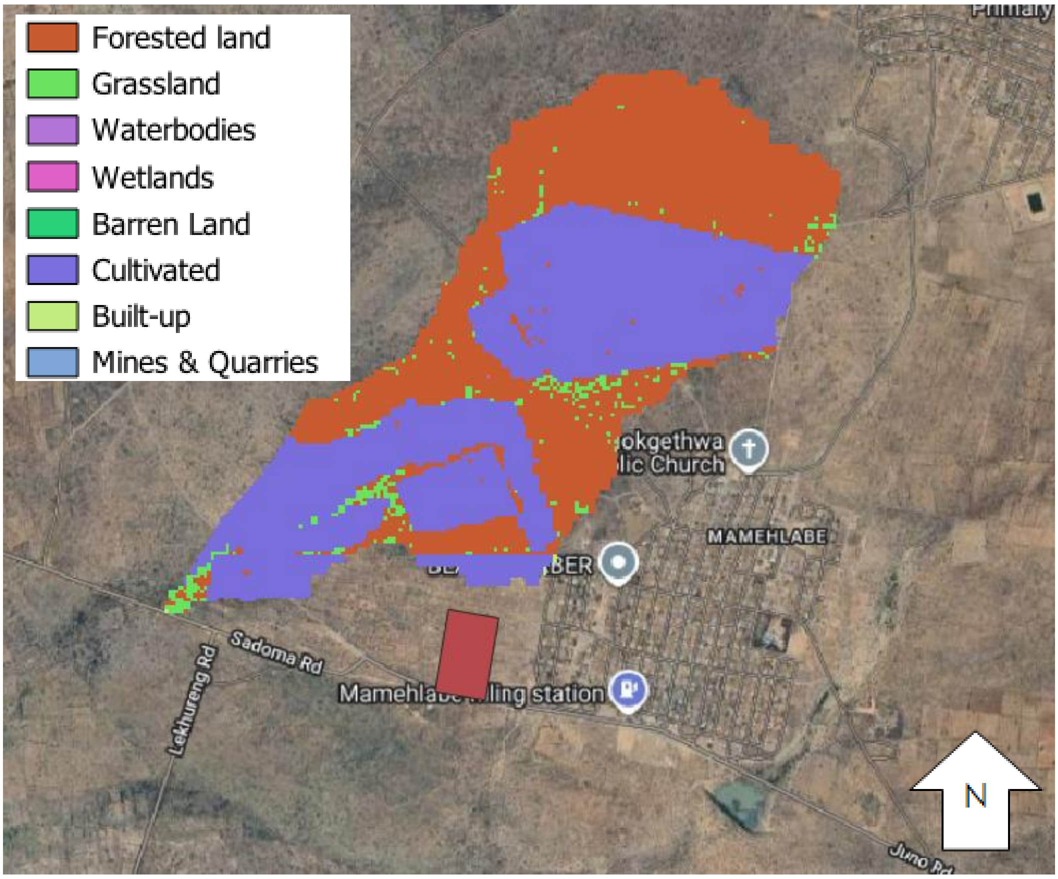

Figure 3-4 – Plan of catchment Land Cover for Sub Basin 1

Land Use	Area (km²)	% of Total
Forested Land	2.0775	46.98
Grassland	0.1347	3.05
Cultivated Land	2.2073	49.92
Water Bodies	0.0004	0.01
Built up	0.0018	0.04

Table 3-4 - Land Use Sub Basin 1

The predominant land use for Sub-basin 1 is forested land, followed by cultivated areas and grasslands. The area of interest is predominantly classified as rural (99.95%), with minimal built-up or urban infrastructure (0.04%).

3.4.1 Land Use Characteristics: Sub Basin 2

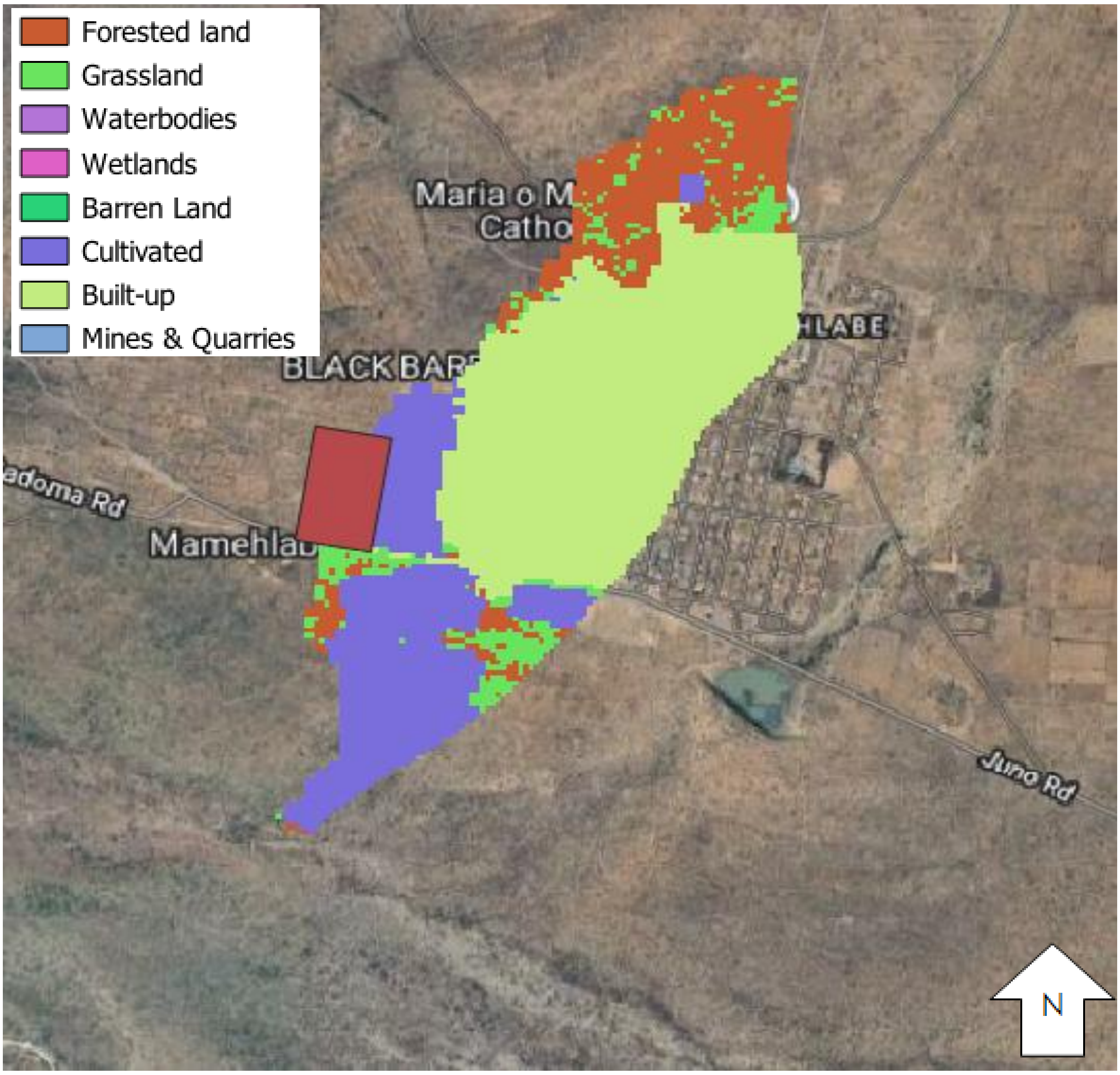

Figure 3-5 – Plan of catchment Land Cover for Sub Basin 2

Land Use	Area (km²)	% of Total
Forested Land	0.3858	17.35%
Grassland	0.1562	7.03%
Cultivated Land	0.6073	27.32%
Built up	1.0738	48.30%

Table 3-5 - Land Use Sub Basin 2

The predominant land use for Sub-basin 2 is Built up, followed by cultivated and forested areas. The area of interest is predominantly classified as rural (51.70%), with built-up or urban infrastructure (48.30%).

The land use dataset (SANLC 2020) was adopted for this study, with adjustments incorporated to account for a projected annual urban increase of 1.5% with the projected determinant as 2025 tabulated below:

Sub Basin	Projected 2025 Increase
Sub Basin 1	8.5%
Sub Basin 2	55.8%

Table 3-7 – Projected Urban Increase

3.4.2 Land Use Characteristics: Sub Basin 3

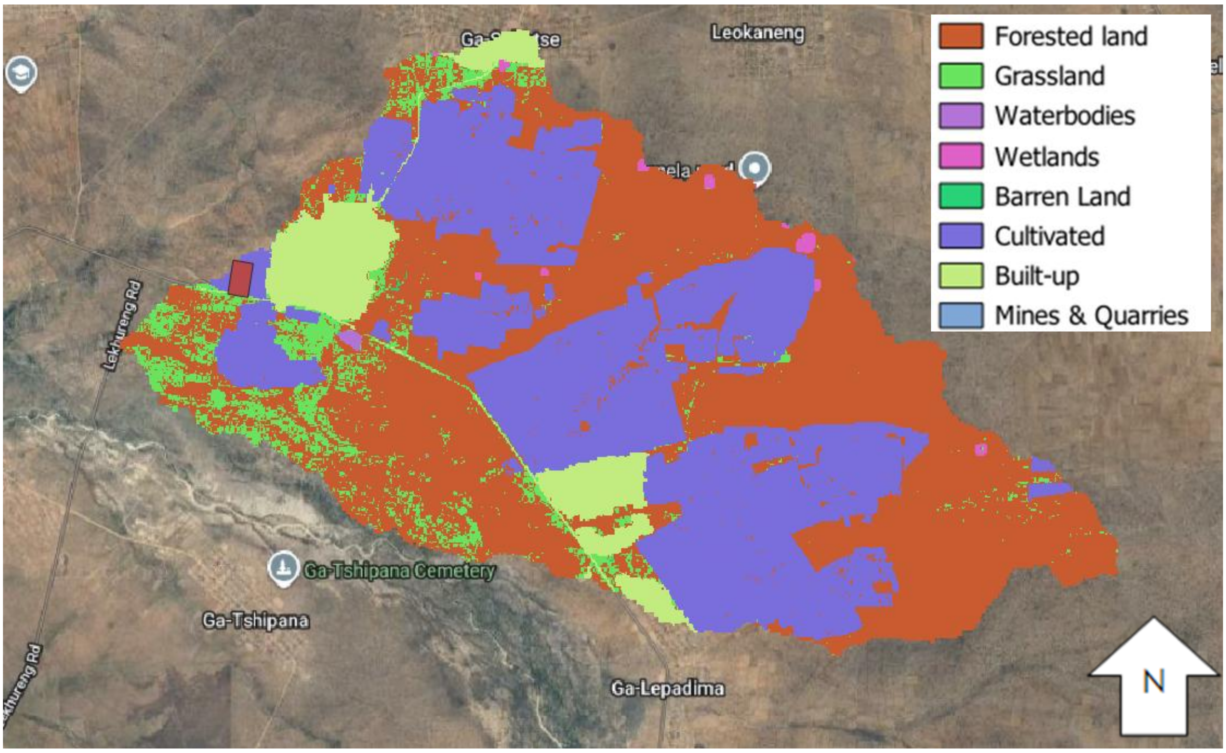

Figure 3-6– Plan of catchment Land Cover for Sub Basin 3

Land Use	Area (km²)	% of Total
Forested Land	25.6256	48.31%
Grassland	3.3683	6.35%
Cultivated Land	20.0229	37.75%
Built-up	3.7874	7.14%
Waterbodies	0.0518	0.10%
Wetlands	0.1683	0.32%
Barren Land	0.0175	0.03%

Table 3-6 - Land Use Sub Basin 3

The predominant land use for Sub-basin 3 is Forested Land, followed by cultivated areas. The area of interest is predominantly classified as rural (92.76%).

3.4.3 Land Use Characteristics: Sub Basin 4

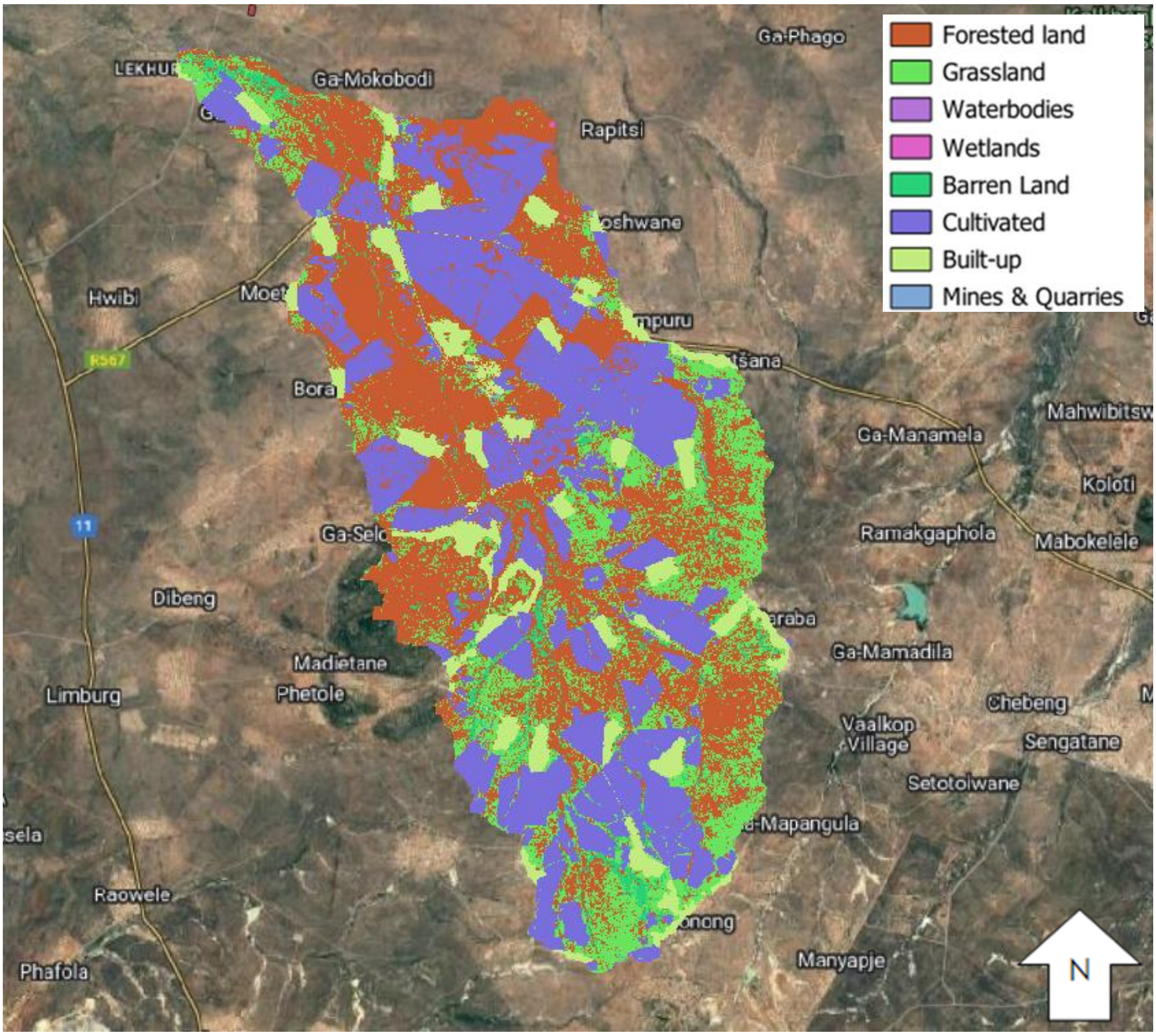

Figure 3-7– Plan of catchment Land Cover for Sub Basin4

Land Use	Area (km²)	% of Total
Forested Land	184.4825	38.66%
Grassland	81.6374	17.11%
Waterbodies	0.2965	0.06%
Barren Land	12.4844	2.62%
Cultivated Land	156.2477	32.74%
Built Up	41.5305	8.70%
Mines and Quarries	0.4933	0.10%
Forested Land	184.4825	38.66%

Table 3-7– Land Use Sub Basin 4

The predominant land use for Sub-basin 4 is Forested Land, followed by cultivated areas. The area of interest is predominantly classified as rural (91.13%).

3.5 CATCHMENT SLOPE

A slope analysis of the catchment was conducted for each Sub Basin for which the findings are tabulated with the corresponding maps for reference.

It is noted that the catchment predominately comprises of slopes ranging from 10%-30% and therefore can be classified as a predominantly hilly catchment.

3.5.1 Sub Basin 1

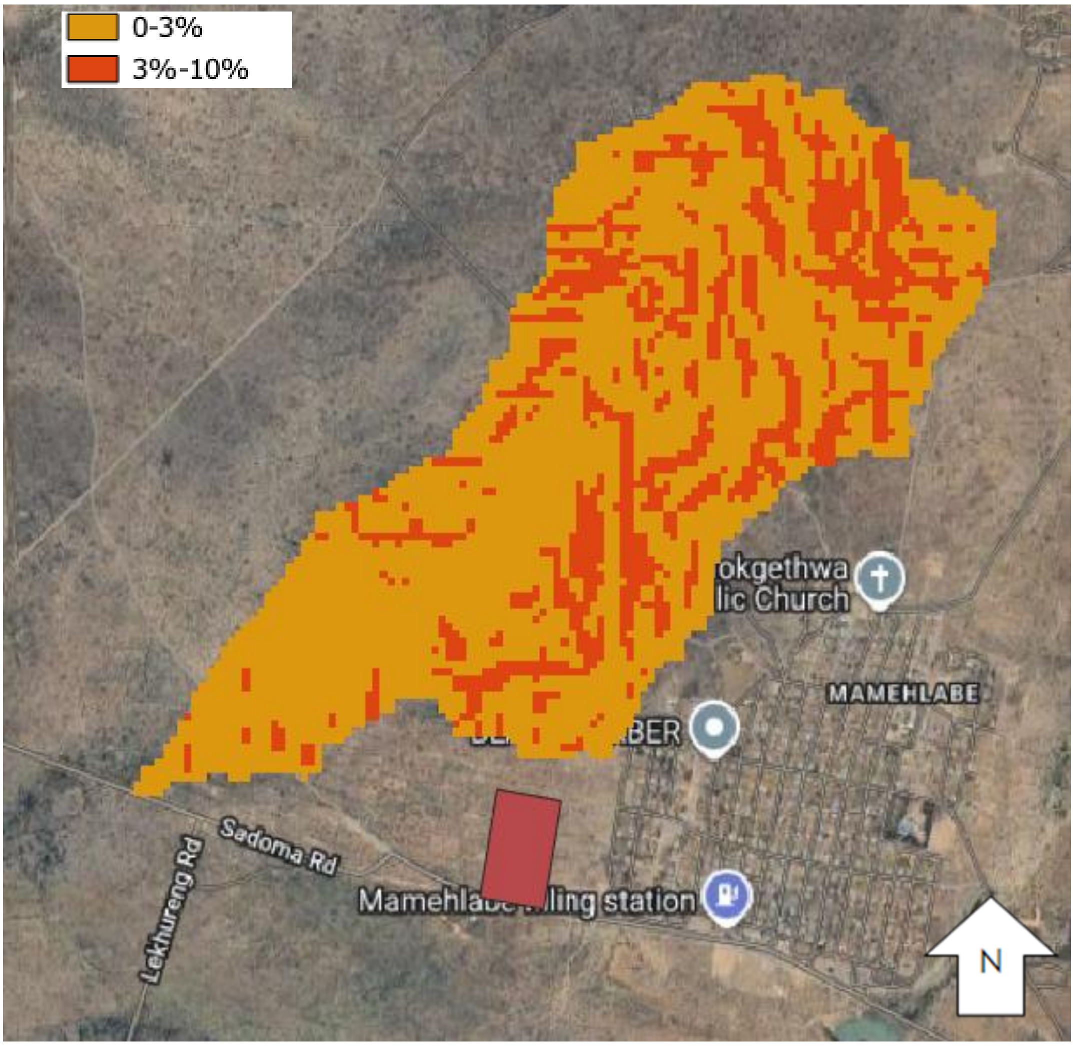

Figure 3-6 - Slope analysis Sub Basin 1

Surface Slope Classification	Range	Actual
Vleis and Pans	0%-3%	74.3%
Flat Areas	3%-10%	25.7%
Hilly	10%-30%	0.0%
Steep Areas	>30%	0.0%
		100.0%

Table 3-8 - Slope Classification Sub Basin 1

A study of the estimated slope distribution within the catchment indicates that the terrain is predominantly gentle, with the majority of the area falling under the Vleis and Pans category (0%–3%), accounting for 74.3% of the surface. The remaining portion is classified as Flat Areas (3%–10%), which represent 25.7% of the total catchment.

No areas were classified as Hilly (10%–30%) or Steep Areas (>30%), indicating the catchment is characterized by low-relief terrain with minimal slope variability.

3.5.2 Sub Basin 2

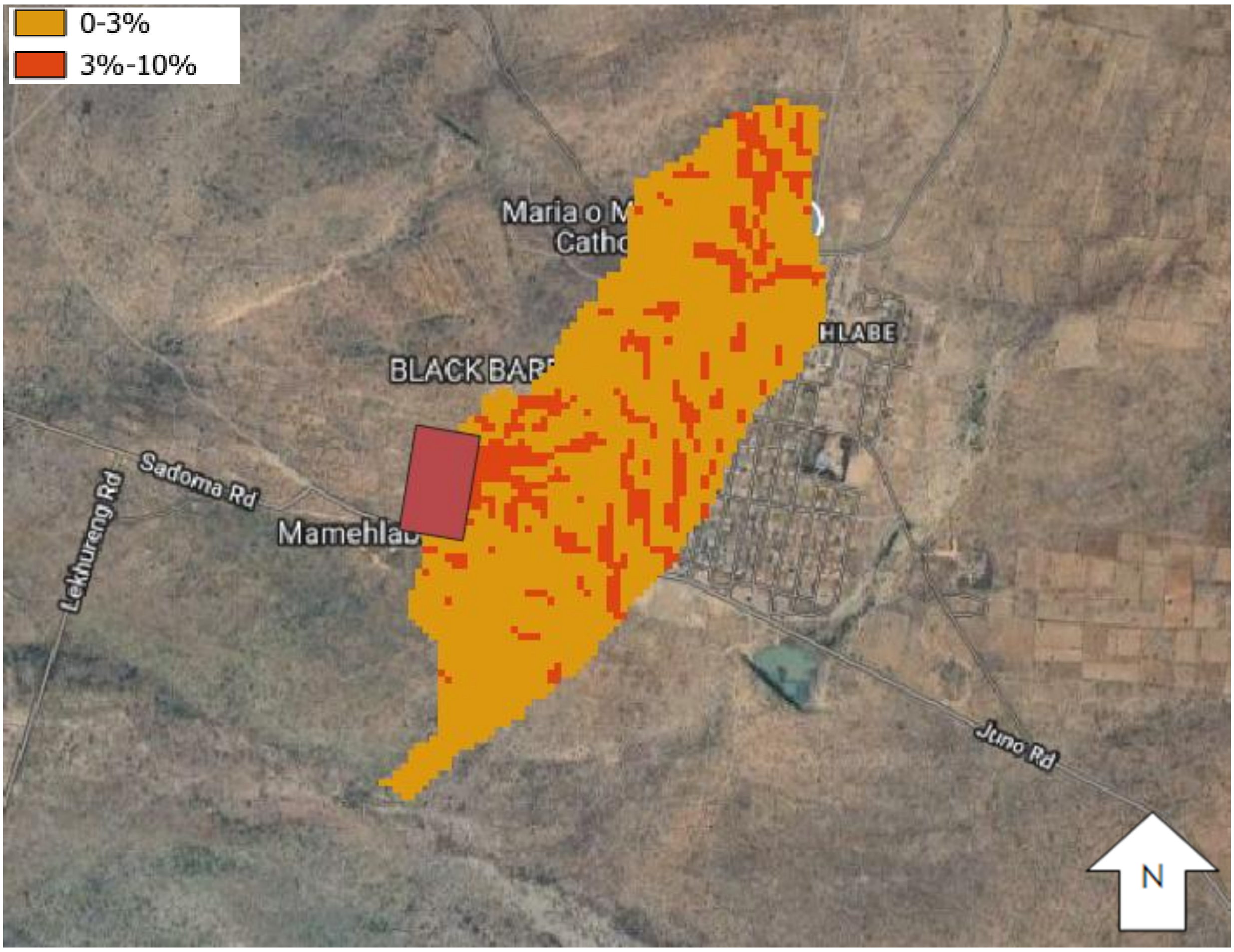

Figure 3-7 - Slope analysis Sub Basin 2

Surface Slope Classification	Range	Actual
Vleis and Pans	0%-3%	79.8%
Flat Areas	3%-10%	20.2%
Hilly	10%-30%	0.0%
Steep Areas	>30%	0.0%
		100.0%

Table 3-9 - Slope Classification Sub Basin 2

The catchment is predominately characterized by gentle slopes, with 79.8% of the area classified as Vleis and Pans (0%–3%). The remaining 20.2% falls into the Flat Areas (3%–10%) category.

No portions of the catchment fall within the Hilly (10%–30%) or Steep Areas (>30%) classes, confirming the overall low-relief nature of the landscape.

3.5.3 Sub Basin 3

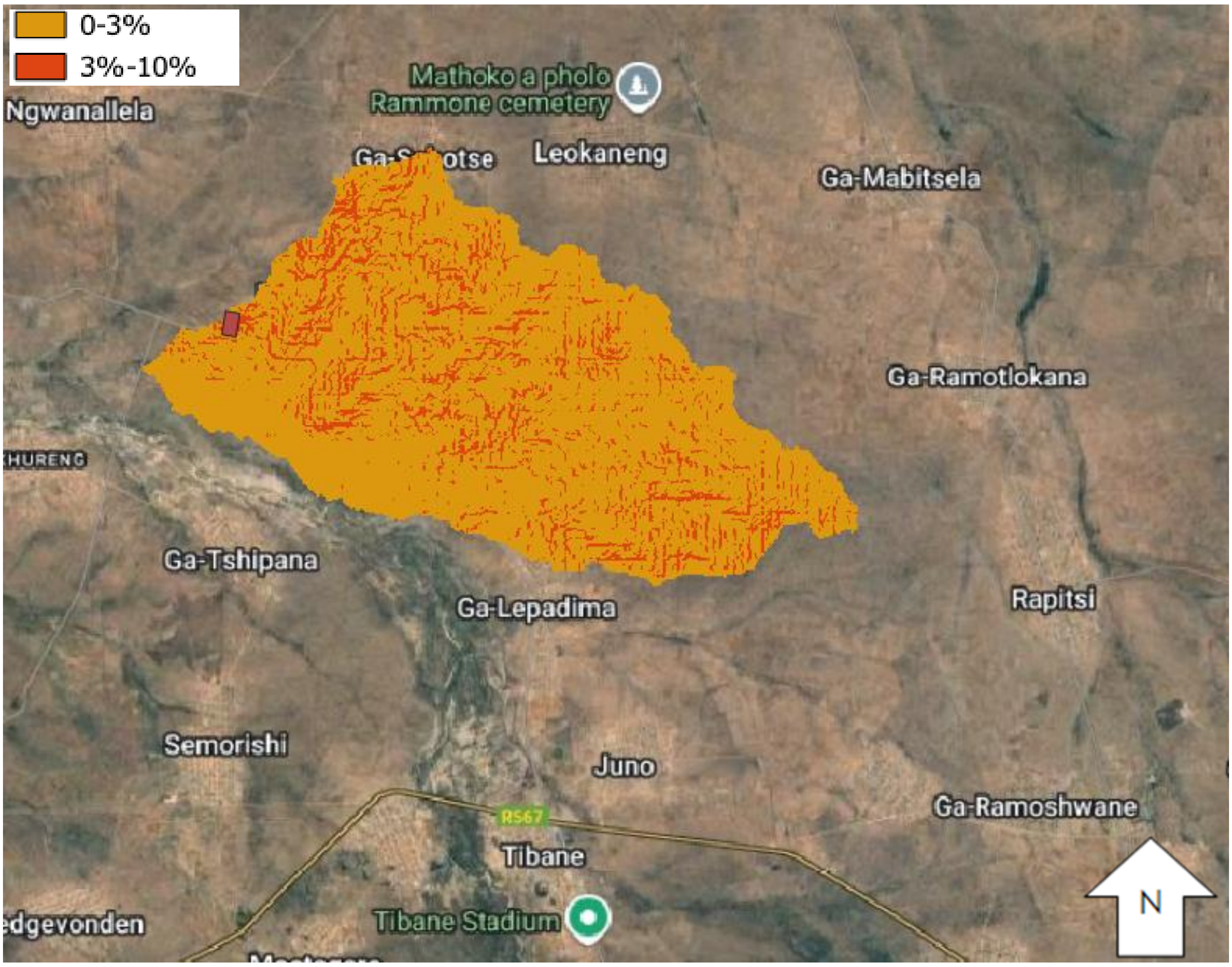

Figure 3-8 - Slope analysis Sub Basin 3

Surface Slope Classification	Range	Actual
Vleis and Pans	0%-3%	79.85%
Flat Areas	3%-10%	20.15%
Hilly	10%-30%	0.00%
Steep Areas	>30%	0.00%
		100.00%

Table 3-10 - Slope Classification Sub Basin 3

The slope classification analysis indicates that the catchment is dominated by very gentle terrain. Approximately 79.85% of the area falls within the Vleis and Pans class (0%–3%), while the remaining 20.15% is categorized as Flat Areas (3%–10%).

There are no areas classified as Hilly (10%–30%) or Steep Areas (>30%), highlighting the absence of significant relief or elevated terrain within the catchment.

3.5.4 Sub Basin 4

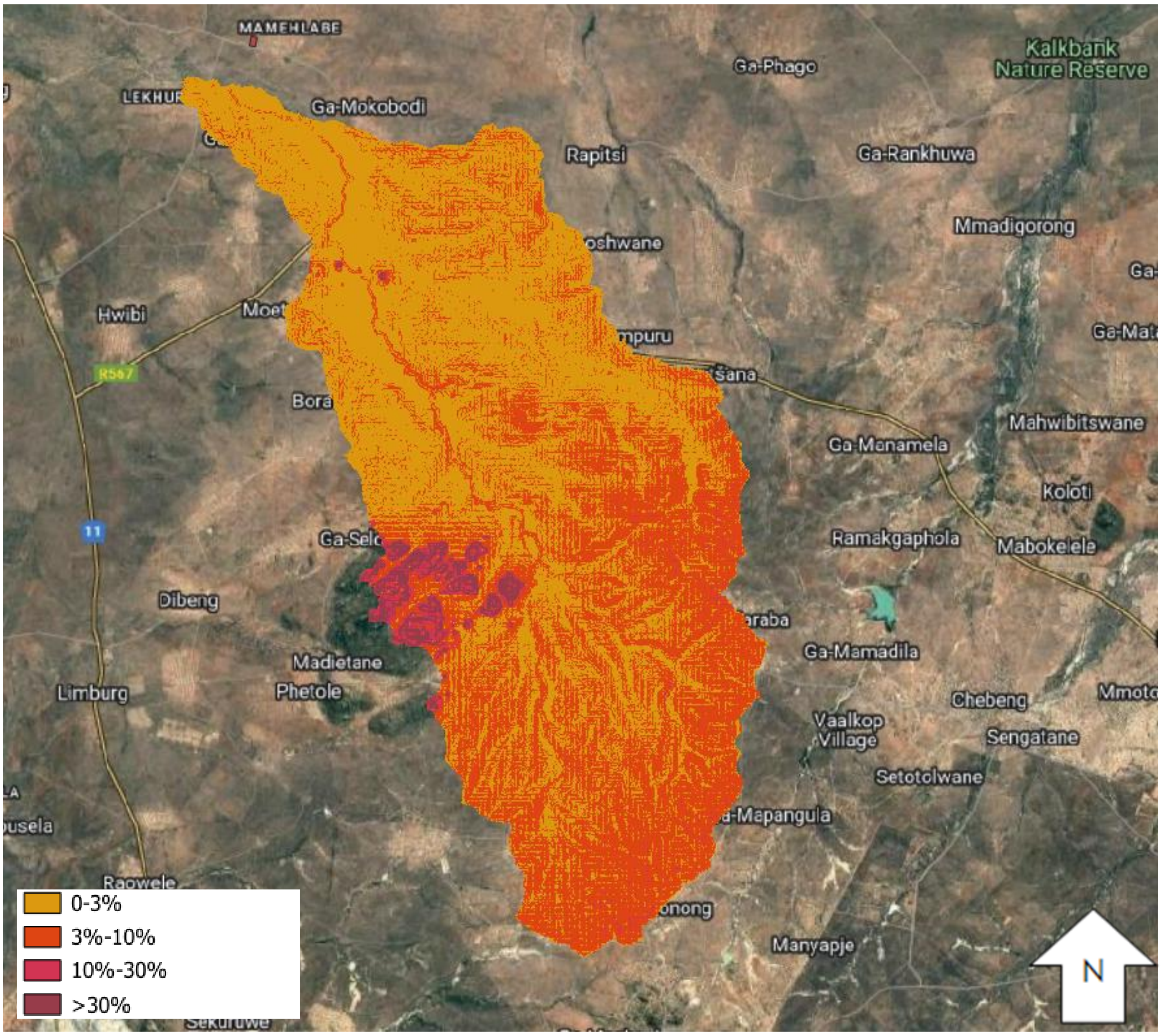

Figure 3-8- Slope analysis Sub Basin 4

Surface Slope Classification	Range	Actual
Vleis and Pans	0%-3%	53.59%
Flat Areas	3%-10%	42.53%
Hilly	10%-30%	1.97%
Steep Areas	>30%	1.92%
		100.00%

Table 3-11 - Slope Classification Sub Basin 4

The slope distribution shows a more diverse terrain**:**

- Vleis and Pans (0%–3%) dominate, covering 53.59% of the catchment.
- Flat Areas (3%–10%) account for a significant 42.53%.
- A small portion is classified as Hilly (10%–30%), comprising 1.97%.
- Steep Areas (>30%) are present but limited, representing 1.92% of the total area.

The catchment is predominantly characterized by gentle terrain, with the majority of the area (54–80%) classified as Vleis and Pans (0–3%) and a further 20–43% as Flat Areas (3–10%). In three datasets, no hilly or steep slopes were observed, confirming the dominance of low-relief terrain. However, one dataset indicated ~4% hilly and steep slopes, suggesting localized zones of higher gradient.

3.6 SUMMARY OF CATCHMENT CHARACTERISTICS

The summary of catchment characteristics that were adopted for the peak flow calculations, are shown Table 3-12 - Catchment Characteristics summary

below:

Detailed descriptions of the characteristics can be found in the calculation sheets of Appendix-A.

CHARACTERISTICS	Sub Basin 1	Sub Basin 2	Sub Basin 3	Sub Basin 4
Area (km²)	4.425	1.6305	53.0645	477.1502
Length of Longest Flow path (km)	5.07141	3.79635	16.99539	56.46091
Distance to Centroid (km)	62.0233	49.0109	121.0072	450.5580
Average Slope of longest flow path (km)	0.01133	0.01229	0.00683	0.00609
Height difference along equal-area slope (m)	62.02	49.01	121.0	450.55
Height difference along 10-85 slope (m)	43.0	34.99	87.05	257.88
Average Basin Slope (%)	0.02531	0.02372	0.02132	0.04608
Tc (h)	1.2995	1.0077	0.032	0.024
Mean Annual Precipitation (mm)	449	449	449	449
SDF Basin No.	2	2	2	2
Kovacs Region (k)	K5(K = 5.0)	K5(K = 5.0)	K5(K = 5.0)	K5(K = 5.0)
Veld Type no.	8	8	8	8

Table 3-12 - Catchment Characteristics summary

3.7 DESIGN FLOOD PEAK FLOW ESTIMATION

The magnitude of the flood peaks is dependent on the catchment characteristics, rainfall data, land use and developments. The magnitude of flood peaks depends on various factors, including catchment characteristics, rainfall data, land use, and developments. Given the varying catchment areas, the following peak flow calculation methods were evaluated, namely:

Small Catchment (<15km2)

- Rational Method - All Alternatives
- Unit Hydrograph Method
- Standard Design Flood Method
- Midgley & Pitman

Large catchments

- Unit Hydrograph Method.
- Standard Design Flood (SDF) Method.
- Midgley & Pitman Method.

The Rational Method was applied to Sub-basins 1 and 2, as their contributing catchment areas are each less than 15 km², making this method appropriate for small catchments. For Sub-basins 3 and 4, which each exceed 15 km² in area, the rational method was excluded in the peak flow calculations.

The 1:2yr, 1:5yr, 1:10yr, 20yr ,1:50yr & 1:100yr peak flows for the various calculation methods are summarized below per Sub Basin:

3.7.1 Sub Basin 1

Peak flow calculation method	Return Period					
	2yr	5yr	10yr	20yr	50yr	100yr
Rational Method 1	2.72	3.92	5.23	6.92	10.38	14.58
Rational Method 2	3.22	5.75	7.94	10.53	15.23	20.07
Rational Method 3	4.51	6.48	8.16	10.23	14.23	18.49
Unit Hydrograph Method	4.19	7.05	10.38	14.57	22.10	30.65
Standard Design Flood Method	1.414	6.684	11.69	17.42	26.06	33.36
Empirical Method Midgley & Pitman			8.859	12.02	16.66	21.09
Regional Maximum Flood	210.40					

Table 3-13- Catchment Flood Peak Flow Table: Sub Basin 1

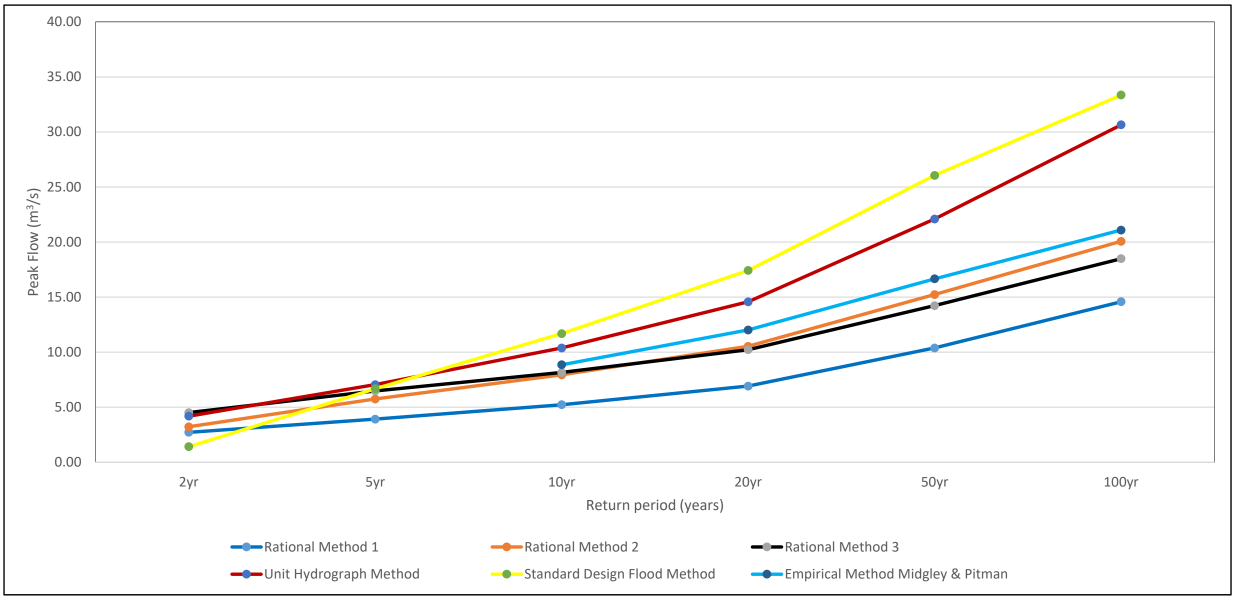

Figure 3-9– Peak flow vs return period for the various applicable flood calculation methods – Sub basin 1

3.7.2 Sub Basin 2

Peak flow calculation method	Return Period					
	2yr	5yr	10yr	20yr	50yr	100yr
Rational Method 1	4.35	5.99	7.67	9.61	12.92	16.46
Rational Method 2	5.16	8.81	11.66	14.63	18.96	22.63
Rational Method 3	6.73	9.27	11.20	13.30	16.63	19.64
Unit Hydrograph Method	2.75	4.63	6.84	9.66	14.72	20.49
Standard Design Flood Method	0.858	4.056	7.094	10.57	15.81	20.25
Empirical Method Midgley & Pitman			5.846	7.934	11	13.92
Regional Maximum Flood	149.20					

Figure 3-10- Catchment Flood Peak Flow Table: Sub Basin 2

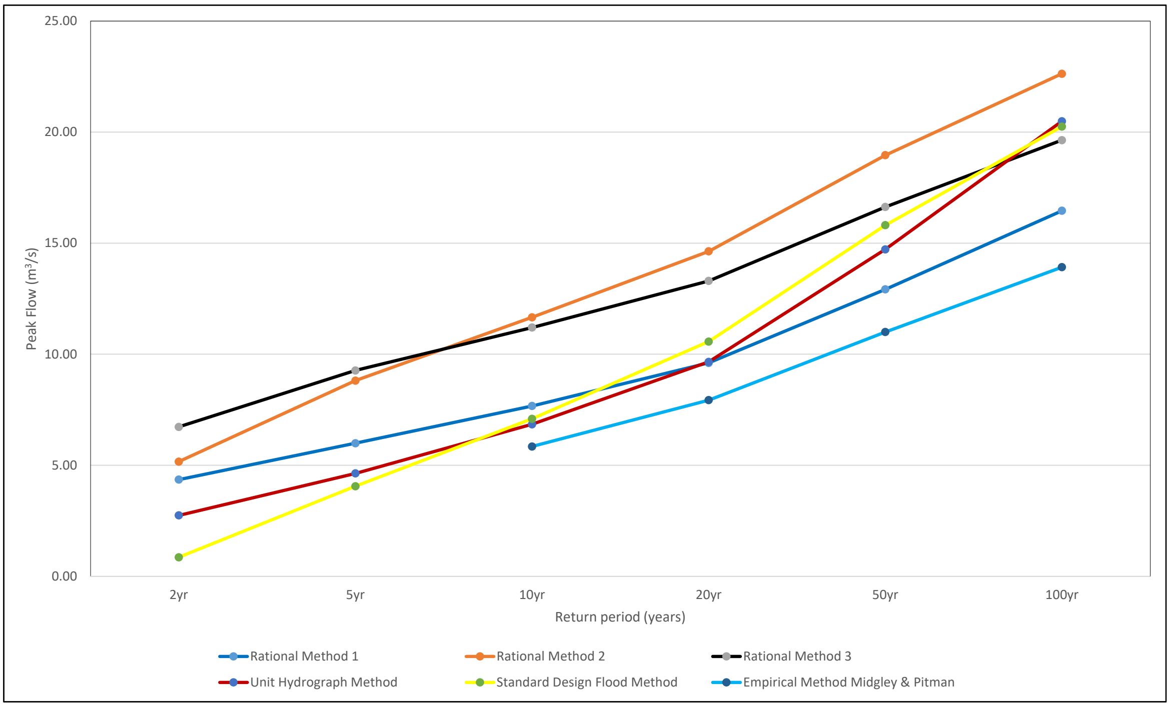

Figure 3-11– Peak flow vs return period for the various applicable flood calculation methods- Sub basin 2

3.7.3 Sub Basin 3

Peak flow calculation method	Return Period					
	2yr	5yr	10yr	20yr	50yr	100yr
Unit Hydrograph Method	15.99	26.03	37.44	51.55	76.23	103.25
Standard Design Flood Method	6.865	32.46	56.76	84.58	126.51	162
Midgley & Pitman	-	-	38.62	52.41	72.64	91.95
Regional Maximum Flood	728.50					

Table 3-14 - Catchment Flood Peak Flow Table: Sub Basin 3

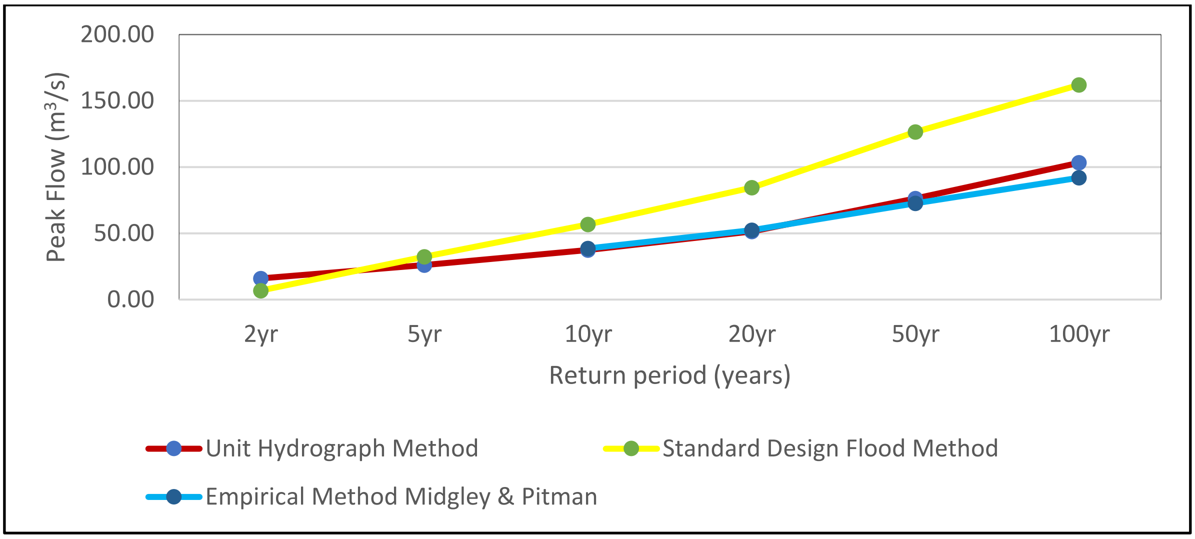

Figure 3-12– Peak flow vs return period for the various applicable flood calculation methods- Sub basin 3

3.7.4 Sub Basin 4

Peak flow calculation method	Return Period					
	2yr	**5yr**	**10yr**	**20yr**	**50yr**	**100yr**
Unit Hydrograph Method	69.65	112.28	160.20	219.11	322.23	434.32
Standard Design Flood Method	25.75	115.82	199.35	297.45	450.3	584.87
Midgley & Pitman	-	-	136.2	184.84	256.18	324.28
Regional Maximum Flood	2184.4					

Table 3-15- Catchment Flood Peak Flow Table: Sub Basin 4

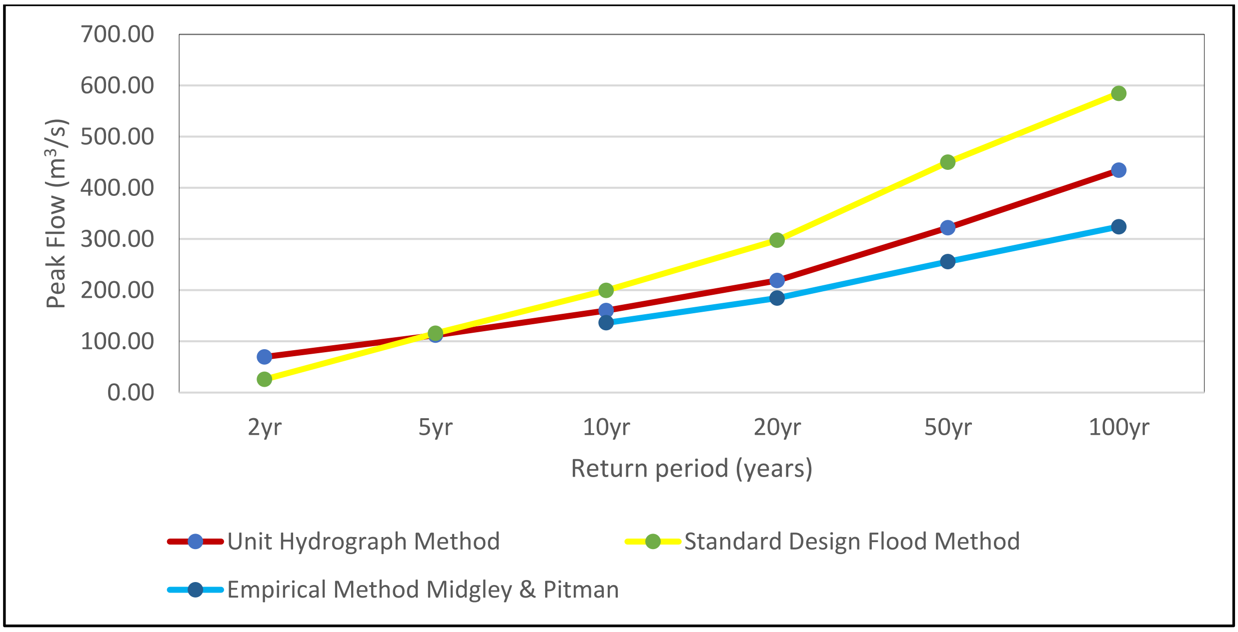

Figure 3-13– Peak flow vs return period for the various applicable flood calculation methods- Sub basin 4

From the methodologies considered above, the results obtained from the **Rational method Alternative** were adopted to represent the peak flows for the sub basin 1 and 2. The selection of this method is proposed due to the following:

- The use of the rational method is suitable for calculating peak flows for catchment areas less than $15km^2$.
- This method considers rainfall data records more specific to the site location as opposed to regional statistic and allows for considering increases to rainfall figures due to climate change.
- The results are noted to be relatively similar to the SDF method for the higher magnitude return periods

From the methodologies considered above, the results obtained from the Standard Design Flood Method (SDF) were adopted to represent the peak flows for sub basins 2 and 3. The selection of this method is proposed due to the following:

- The use of the SDF Method is suitable for calculating peak flows for large catchment areas .
- The peak flow results from the SDF method are noted to be significantly higher than most methods and a conservative approach can therefore be adopted.

3.8 SUMMARY OF ADOPTED FLOOD PEAK FLOWS

Table 3-16 below provides a summary of the estimated peaks flow per return period adopted for the hydraulic assessment.

	Peak Flows (m3/s)			
Catchment Name	**Selected Method**	**20YR**	**50YR**	**100YR**
Sub basin 1	Rational Method Alternative 3	10.23	14.23	18.49
Sub basin 2	Rational Method Alternative 3	13.30	16.63	19.64
Sub basin 3	Standard Design Flood	84.58	126.51	162
Sub basin 4	Standard Design Flood	297.45	450.3	584.87

Table 3-16 - Summary of adopted peak flows

4. HYDRAULIC MODELING

A digital elevation model (DEM) was created from online data, and thereafter the cross-sectional data was derived and imported into the HECRAS model. The HECRAS (version 6.6) model employs standard backwater techniques to compute the High-Water Level (HWL) for various steady flow conditions along the watercourse. The following parameters were assumed and adopted for the analysis.

- Manning's n values are as follows: River Embankments – 0.065
  River Channel – 0.045
- Normal depth upstream and downstream boundary conditions were assumed by the average river channel slope.

Flood level analysis for the various return periods was conducted using the peak flow previously calculated. The river sections were analysed to evaluate the flood water levels that impact the water abstraction site.

5. RESULTS OF HYDRAULIC ANALYSIS

The hydraulic analysis for this desktop floodline assessment was conducted utilising online elevation data sourced from the Advanced Land Observing Satellite (ALOS) Global Digital Surface Model (AW3D30) via the OpenTopography database. The use of online data was selected to perform the study due to limited extent of detailed topographical survey.

A comparison was made between the site-specific topographical survey data conducted by THOTHOME GEOMATICS cc and the online elevation data. The results indicate significant discrepancies in elevation values, with differences of up to +-2.5 meters indicated by the below Figure 5-1.

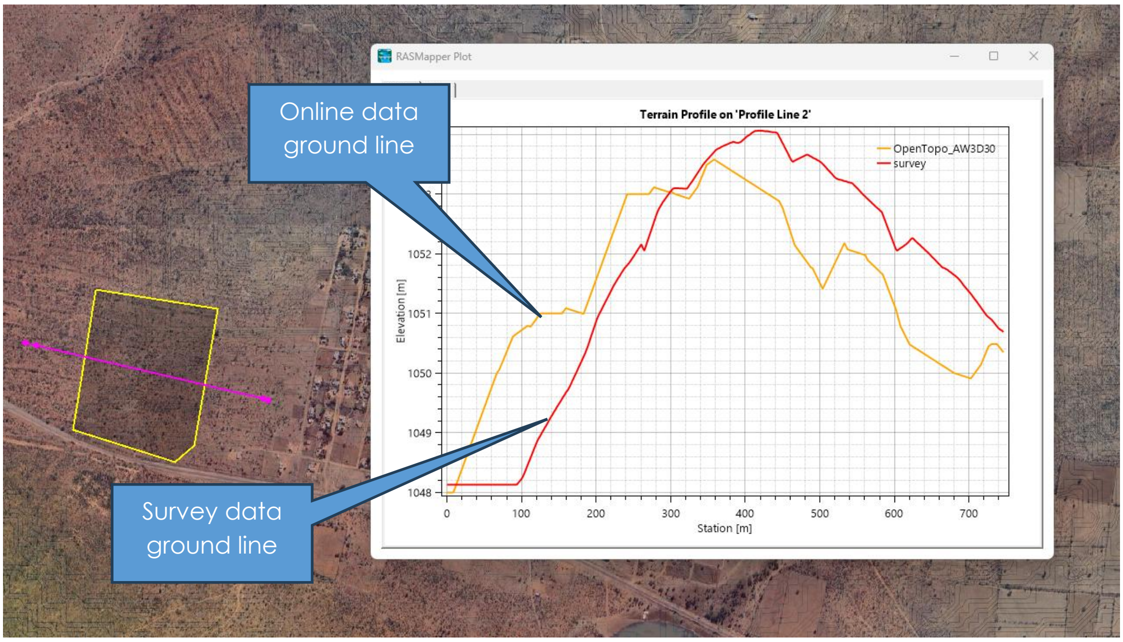

Figure 5-1 - Online Data (open topography) vs Survey Data

As depicted in Figure 5-2, The 100-year flood map generated from online data suggests that the proposed site is at low risk of inundation from adjacent watercourses. However, the accuracy and confidence of this assessment is deemed very low due to the elevation discrepancies and coarse resolution of the online data, which fails to adequately define the watercourse channels and floodplain areas, resulting in unrealistic flood map delineation.

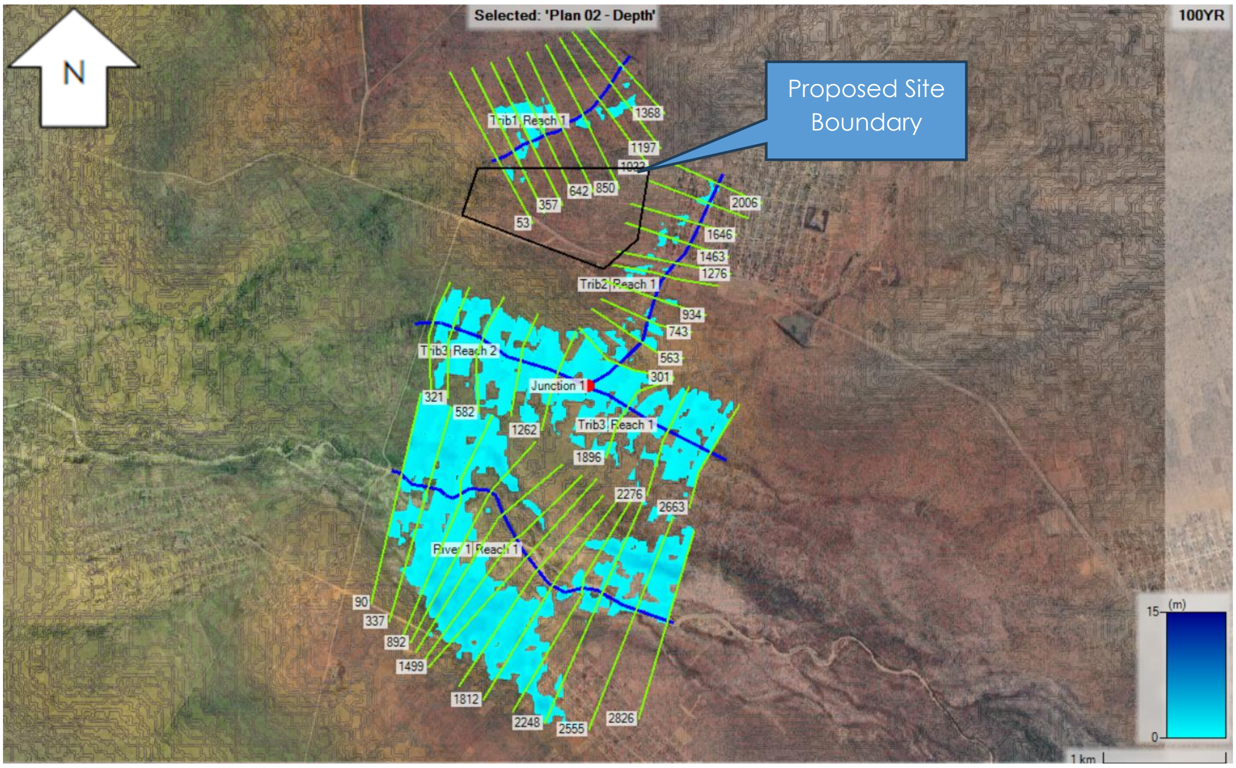

Figure 5-2 -Resulting 100yr flood map with online data.

5.1 CONCLUSION AND RECOMMENDATION

Given the limitations of the online data, the results of this desktop floodline assessment are deemed inconclusive. To ensure a reliable and high-confidence conclusion to the floodline assessment, it is highly recommended that a detailed survey be conducted for the study area and watercourses.

6. FLOODLINE MAPPING

To be completed upon receiving detailed survey for the study area and watercourses.

7. REFERENCES

The South African National Roads Agency SOC Limited (SANRAL). (2013). Drainage Manual 6th Edition.

A best practice guideline for design flood estimation in municipal areas in South Africa (C.J CJ Brooker, JA du Plessis, SJ Dunsmore, CS James, OJ Gericke, JC Smithers.)

JC Smithers and RE Schulze, Design Rainfall and Flood Estimation in South Africa. (2012).

US Army Corps of Engineers, HEC-GeoRAS version 10.2. (n.d.).

US Army Corps of Engineers, HEC-RAS version 6.6. (n.d.).

APPENDIX A

PEAKFLOW CALCULATIONS

PEAKFLOW CALCULATIONS – SUB BASIN 1 – RATIONAL METHOD ALTERNATIVE 3

Description of Catchment	Subbasin-1		
River detail	Trib1		
Calculated by	NB	**Date**	11 August 2025

Physical characteristics

Size of catchment (A)	4.425	km²	Rainfall Region		
Longest Watercourse	5.07141	km	**Area Distribution Factors**		
Average slope (S_{av})	0.01133	m/m	Rural (α)	Urban (β)	Lakes(γ)
Dolomite Area ($D_{\%}$)	0	%	91.5%	8.5%	0
Mean Annual Rainfall (MAR)	449	mm			
Catchment Characteristics	Flat/permeable	%			
r - look up from Table 3C.3	Medium grass cover	0.4			

Rural (1)				**Urban** (2)			
Surface Slope	**%**	**Factor**	**C_s**	**Description**	**%**	**Factor**	**C_2**
Vleis and Pans	74	0.01	0.007	**Lawns**			
Flat Areas	26	0.06	0.016	Sandy, flat (<2%)	0	0.10	-
Hilly	0	0.12	-	Sandy, steep (>7%)	0	0.20	-
Steep Areas	0	0.22	-	Heavy soil, flat (<2%)	5	0.17	0.009
Total	100	-	0.023	Heavy soil, steep (>7%)	5	0.35	0.018
Permeability	**%**	**Factor**	**C_p**	**Residential Areas**			
Very Permeable	0	0.03	-	Houses	60	0.50	0.300
Permeable	80	0.06	0.048	Flats	0	0.70	-
Semi-permeable	20	0.12	0.024	**Industry**			
Impermeable	0	0.21	-	Light industry	0	0.80	-
Total	100	-	0.072	Heavy Industry	0	0.90	-
Vegetation	**%**	**Factor**	**C_v**	**Business**			
Thick bush and plantation	47.0	0.03	0.014	City Centre	0	0.95	-
Light bush and farm-lands	50.0	0.07	0.035	Suburban	0	0.70	-
Grasslands	3.0	0.17	0.005	Streets and Roofs	30	0.95	0.285
No Vegetation	0.0	0.26	-	Maximum flood	0	1.00	-
Total	100	-	0.054	Total	100	-	0.611

Time of concentration (T_c)	Defined Watercourse	Notes:
Overland flow	Defined watercourse	
$T_c = 0.604\left(\frac{rL}{\sqrt{S_{av}}}\right)^{0.467}$	$T_c = \left(\frac{0,87L^2}{1000S_{av}}\right)^{0,385}$	
2.4 Hours	1.2995 Hours	77.97165703 Minutes

Run-off coefficient

Return period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**200**
Run-off coefficient, C_1 ($C_1 = C_s + C_p + C_v$)	0.149	0.149	0.149	0.149	0.149	0.149	0.149
Adjusted for dolomitic areas, C_{1D} ($= C_1(1-D_{\%})+C_1D_{\%}(\Sigma(D_{factor} \times C_{s\%}))$)	0.149	0.149	0.149	0.149	0.149	0.149	0.149
Adjustment factor for initial saturation, F_t	0.5	0.55	0.6	0.67	0.83	1	1
Adjusted run-off coefficient, C_{1T} ($= C_{1D} \times F_t$)	0.075	0.082	0.090	0.100	0.124	0.149	0.149
Combined run-off coeffiecient C_T ($= \alpha C_{1T} + \beta C_2 + \gamma C_3$)	0.120	0.127	0.134	0.143	0.165	0.188	0.188

Rainfall

Return period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**200**
Point Rainfall (mm), P_T	39.63	53.97	64.53	75.48	91.11	103.86	117.46
Point Intensity (mm/hour), P_{iT} ($=P_T/T_C$)	30.5	41.5	49.7	58.1	70.1	79.9	90.4
Area Reduction Factor (%), ARF_T	100	100	99.9	99.9	99.9	99.9	99.9
Average Intensity (mm/hour), I_T ($= P_{iT} \times ARF_T$)	30.5	41.5	49.6	58.0	70.0	79.8	90.3

Return period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**200**
Peak flow (m³/s), $Q_T = \frac{C_T I_T A}{3.6}$	4.51	6.48	8.16	10.23	14.23	18.49	20.92

PEAKFLOW CALCULATIONS – SUB BASIN 1 – UNIT HYDROGRAPH METHOD

```
Flood Frequency Analysis: Unit Hydrograph Method

Project                                   = Rethusheng SNS
Analysed by                               = NNB
Name of river                             = S1 Trib 1
Description of site                       =
Date                                      = 11/08/2025
Area of catchment                         = 4.425 km²
Length of longest watercourse             = 5.071 km
Height difference along equal area slope  = 62.023 m
Distance to catchment centroid            = 2.783 km
Veld type                                 = Region 8
Duration interval                         = 5 minutes
-------------------------------------------------------------------

Slope of longest stream                   = 0.0122 m/m
Catchment index                           = 127.6
Catchment lag                             = 1.091
Coefficient (Ku)                          = 0.367 m³/s - hours/km²
Peak discharge of unit hydrograph (Qp)    = 1.488 m³/s
-------------------------------------------------------------------

    Return          Storm              Peak
period          duration           discharge
                (minutes)          (m³/s)
-------------------------------------------------------------------
 1:2 year       20                 4.185
 1:5 year       20                 7.051
 1:10 year      20                 10.38
 1:20 year      20                 14.57
 1:50 year      20                 22.10
 1:100 year     20                 30.65
```

PEAKFLOW CALCULATIONS – SUB BASIN 1 – STANDARD DESIGN FLOOD METHOD

```
Flood frequency analysis : Standard Design Flood method

Project name                             = Rethusheng SNS
Analysed by                              = NNB
Name of river                            = S1 Trib 1
Description of site                      =
Date                                     = 11/08/2025
Catchment characteristics:
Area of catchment                        = 4.425 km²
Length of longest watercourse            = 5.07141 km
1085 height difference                   = 43.094 m
Average slope                            = 0.0113 m/m
Drainage basin characteristics:
Drainage basin number                    = 2
Mean annual daily max rain               = 62 mm
Days on which thunder was heard          = 44 days
Runoff coefficient C2                    = 5 %
Runoff coefficient C100                  = 30 %
Basin mean annual precipitation          = 450 mm
Basin mean annual evaporation            = 1900 mm
Basin evaporation index MAE/MAP          = 4.22

RAINFALL DATA
The rainfall data in the table below are derived from two sources. The daily rainfall
is from the Department of Water Affair's publication TR102 for the representative site.
The modified Hershfield equation is used for durations up to four hours. Linear
interpolation is used for values between 4 hours and one day.

Weather Services station ex TR102 = 675125 @ AUTORITEIT
Point mean annual precipitation =  450   mm
```

Dur:	RP =2	5	10	20	50	100	200
.25 h	17	29	38	47	59	68	77
.50 h	23	38	50	62	77	89	101
1 h	28	47	62	76	95	110	124
2 h	33	56	73	90	113	130	148
4 h	38	65	85	105	131	151	171
1 day	62	93	117	145	187	223	264
2 days	74	111	140	173	222	265	313
3 days	80	122	156	193	250	300	355
7 days	94	144	183	225	289	344	405

Runoff coefficients C2 = 5 %   C100 = 30 %

Return period (years)	Time of concentration (hours)	Point precipitation (mm)	ARF (%)	Catchment precipitation (mm)	Runoff coefficient (%)	Peak flow (m³/s)
1:2	1.30	29.9	100.0	29.9	5.0	1.414
1:5	1.30	50.4	100.0	50.4	14.0	6.684
1:10	1.30	65.9	100.0	65.9	18.7	11.69
1:20	1.30	81.4	100.0	81.4	22.6	17.42
1:50	1.30	102.0	100.0	102.0	27.0	26.06
1:100	1.30	117.5	100.0	117.5	30.0	33.36
1:200	1.30	133.0	100.0	133.0	32.7	41.15

PEAKFLOW CALCULATIONS – SUB BASIN 1 – MIDGLEY AND PITMAN

```
Flood Frequency Analysis: Empirical methods

Project                                   = Rethusheng SNS
Analysed by                               = NNB
Name of river                             = S1 Trib 1
Description of site                       =
Date                                      = 11/08/2025
----------------------------------------------------------------------------------------------
Area of catchment                         = 4.425 km²
Length of longest watercourse             = 5.071 km
Height difference along equal-area slope  = 62.023 m
Distance to catchment centroid            = 2.783 km
Dolomitic area                            = 0.0 %
Mean annual rainfall                      = 449.0 mm
Veld type                                 = 8
Kovács region                             = K5(K = 5.0)
Catchment parameter with regard to
reaction time                             = 0.035
----------------------------------------------------------------------------------------------
Peak discharges by means of an empirical method developed by Midgley and Pitman
------------------------------------
Return        KT           Peak
period      constant       flow
(years)                    (m³/s)
------------------------------------
 1:10          0.42         8.859
 1:20          0.57         12.02
 1:50          0.79         16.66
 1:100         1.00         21.09

----------------------------------------------------------------------------------------------
This RMF calculation includes a transition zone adjustment in the case of small catchments.

Regional maximum flood:         210.4  m³/s

Q50(RMF):                       111.70 m³/s (based on QT/QRMF relationship for Kovács regions)
Q100(RMF):                      137.57 m³/s (based on QT/QRMF relationship for Kovács regions)
Q200(RMF):                      163.45 m³/s (based on QT/QRMF relationship for Kovács regions)
----------------------------------------------------------------------------------------------
The following equivalent maxima make no transition zone adjustments for small catchments.

Equivalent southern African maximum
K-factor 5.6:                    581   m³/s

Equivalent world maxima
K-factor 6.0:                    1144  m³/s
K-factor 6.3:                    1901  m³/s
```

PEAKFLOW CALCULATIONS – SUB BASIN 2 – RATIONAL METHOD ALTERNATIVE 3

Description of Catchment	Subbasin-2		
River detail	Trib2		
Calculated by	NB	**Date**	11 August 2025

Physical characteristics

Size of catchment (A)	2.2257	km²	Rainfall Region		
Longest Watercourse	3.79635	km	**Area Distribution Factors**		
Average slope (S_{av})	0.01229	m/m	Rural (α)	Urban (β)	Lakes(γ)
Dolomite Area ($D_{\%}$)	0	%	44.2%	55.8%	0
Mean Annual Rainfall (MAR)	449	mm			
Catchment Characteristics	Flat/permeable	%			
r - look up from Table 3C.3	Medium grass cover	0.4			

Rural (1)				**Urban** (2)			
Surface Slope	**%**	**Factor**	**C_s**	**Description**	**%**	**Factor**	**C_2**
Vleis and Pans	80	0.01	0.008	**Lawns**			
Flat Areas	20	0.06	0.012	Sandy, flat (<2%)	0	0.10	-
Hilly	0	0.12	-	Sandy, steep (>7%)	0	0.20	-
Steep Areas	0	0.22	-	Heavy soil, flat (<2%)	30	0.17	0.051
Total	100	-	0.020	Heavy soil, steep (>7%)	0	0.35	-
Permeability	**%**	**Factor**	**C_p**	**Residential Areas**			
Very Permeable	0	0.03	-	Houses	50	0.50	0.250
Permeable	80	0.06	0.048	Flats	0	0.70	-
Semi-permeable	20	0.12	0.024	**Industry**			
Impermeable	0	0.21	-	Light industry	0	0.80	-
Total	100	-	0.072	Heavy Industry	0	0.90	-
Vegetation	**%**	**Factor**	**C_v**	**Business**			
Thick bush and plantation	34.0	0.03	0.010	City Centre	0	0.95	-
Light bush and farm-lands	53.0	0.07	0.037	Suburban	0	0.70	-
Grasslands	13.0	0.17	0.022	Streets and Roofs	20	0.95	0.190
No Vegetation	0.0	0.26	-	Maximum flood	0	1.00	-
Total	100.000	-	0.069	Total	100	-	0.491

Time of concentration (T_c)	Defined Watercourse	Notes:
Overland flow	Defined watercourse	
$T_c = 0.604\left(\frac{rL}{\sqrt{S_{av}}}\right)^{0.467}$	$T_c = \left(\frac{0,87L^2}{1000S_{av}}\right)^{0,385}$	
2.1 Hours	1.0077 Hours	60.46453207 Minutes

Run-off coefficient

Return period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**200**
Run-off coefficient, C_1 ($C_1 = C_s + C_p + C_v$)	0.161	0.161	0.161	0.161	0.161	0.161	0.161
Adjusted for dolomitic areas, C_{1D} ($= C_1(1-D_{\%})+C_1D_{\%}(\Sigma(D_{factor} \times C_{s\%}))$)	0.161	0.161	0.161	0.161	0.161	0.161	0.161
Adjustment factor for initial saturation, F_t	0.5	0.55	0.6	0.67	0.83	1	1
Adjusted run-off coefficient, C_{1T} ($= C_{1D} \times F_t$)	0.081	0.089	0.097	0.108	0.134	0.161	0.161
Combined run-off coeffiecient C_T ($= \alpha C_{1T} + \beta C_2 + \gamma C_3$)	0.310	0.313	0.317	0.322	0.333	0.345	0.345

Rainfall

Return period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**200**
Point Rainfall (mm), P_T	35.42	48.22	57.67	67.45	81.42	92.81	104.97
Point Intensity (mm/hour), P_{iT} ($=P_T/T_C$)	35.1	47.9	57.2	66.9	80.8	92.1	104.2
Area Reduction Factor (%), ARF_T	100	100	99.9	99.9	99.9	99.9	99.9
Average Intensity (mm/hour), I_T ($= P_{iT} \times ARF_T$)	35.1	47.9	57.2	66.9	80.7	92.0	104.1
Return period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**200**
Peak flow (m³/s), $Q_T = \frac{C_T I_T A}{3,6}$	6.73	9.27	11.20	13.30	16.63	19.64	22.22

PEAKFLOW CALCULATIONS – SUB BASIN 2 – UNIT HYDROGRAPH METHOD

```
Flood Frequency Analysis: Unit Hydrograph Method

Project                                   = Rethusheng SNS
Analysed by                               = NNB
Name of river                             = S2 Trib 2
Description of site                       =
Date                                      = 11/08/2025
Area of catchment                         = 2.226 km²
Length of longest watercourse             = 3.796 km
Height difference along equal area slope  = 49.01 m
Distance to catchment centroid            = 1.953 km
Veld type                                 = Region 8
Duration interval                         = 5 minutes
--------------------------------------------------------------------

Slope of longest stream                   = 0.0129 m/m
Catchment index                           = 65.3
Catchment lag                             = 0.855
Coefficient (Ku)                          = 0.367 m³/s - hours/km²
Peak discharge of unit hydrograph (Qp)    = 0.955 m³/s
--------------------------------------------------------------------

    Return          Storm            Peak
period          duration         discharge
                (minutes)        (m³/s)
--------------------------------------------------------------------
 1:2 year       20               2.745
 1:5 year       20               4.632
 1:10 year      15               6.844
 1:20 year      15               9.657
 1:50 year      15               14.72
 1:100 year     15               20.49
```

PEAKFLOW CALCULATIONS – SUB BASIN 2– STANDARD DESIGN FLOOD METHOD

```
Flood frequency analysis : Standard Design Flood method

Project name                             = Rethusheng SNS
Analysed by                              = NNB
Name of river                            = S2 Trib 2
Description of site                      =
Date                                     = 11/08/2025
Catchment characteristics:
Area of catchment                        = 2.2257 km²
Length of longest watercourse            = 3.79635 km
1085 height difference                   = 34.992 m
Average slope                            = 0.0123 m/m
Drainage basin characteristics:
Drainage basin number                    = 2
Mean annual daily max rain               = 62 mm
Days on which thunder was heard          = 44 days
Runoff coefficient C2                    = 5 %
Runoff coefficient C100                  = 30 %
Basin mean annual precipitation          = 450 mm
Basin mean annual evaporation            = 1900 mm
Basin evaporation index MAE/MAP          = 4.22

RAINFALL DATA
The rainfall data in the table below are derived from two sources. The daily rainfall
is from the Department of Water Affair's publication TR102 for the representative site.
The modified Hershfield equation is used for durations up to four hours. Linear
interpolation is used for values between 4 hours and one day.

Weather Services station ex TR102 = 675125 @ AUTORITEIT
Point mean annual precipitation =  450  mm
```

Dur:	RP =2	5	10	20	50	100	200
.25 h	17	29	38	47	59	68	77
.50 h	23	38	50	62	77	89	101
1 h	28	47	62	76	95	110	124
2 h	33	56	73	90	113	130	148
4 h	38	65	85	105	131	151	171
1 day	62	93	117	145	187	223	264
2 days	74	111	140	173	222	265	313
3 days	80	122	156	193	250	300	355
7 days	94	144	183	225	289	344	405

Runoff coefficients C2 = 5 %   C100 = 30 %

Return period (years)	Time of concentration (hours)	Point precipitation (mm)	ARF (%)	Catchment precipitation (mm)	Runoff coefficient (%)	Peak flow (m³/s)
1:2	1.01	27.9	100.0	27.9	5.0	0.858
1:5	1.01	47.1	100.0	47.1	14.0	4.056
1:10	1.01	61.7	100.0	61.7	18.7	7.094
1:20	1.01	76.2	100.0	76.2	22.6	10.57
1:50	1.01	95.4	100.0	95.4	27.0	15.81
1:100	1.01	109.9	100.0	109.9	30.0	20.25
1:200	1.01	124.4	100.0	124.4	32.7	24.97

PEAKFLOW CALCULATIONS – SUB BASIN 2 – MIDGLEY AND PITMAN

```
Flood Frequency Analysis: Empirical methods

Project                                   = Rethusheng SNS
Analysed by                               = NNB
Name of river                             = S2 Trib 2
Description of site                       =
Date                                      = 11/08/2025
----------------------------------------------------------------------------------------------
Area of catchment                         = 2.226 km²
Length of longest watercourse             = 3.796 km
Height difference along equal-area slope  = 49.01 m
Distance to catchment centroid            = 1.953 km
Dolomitic area                            = 0.0 %
Mean annual rainfall                      = 449.0 mm
Veld type                                 = 8
Kovács region                             = K5(K = 5.0)
Catchment parameter with regard to
reaction time                             = 0.034
----------------------------------------------------------------------------------------------
Peak discharges by means of an empirical method developed by Midgley and Pitman
------------------------------------
Return        KT          Peak
period        constant    flow
(years)                   (m³/s)
------------------------------------
 1:10          0.42        5.846
 1:20          0.57        7.934
 1:50          0.79        11.00
 1:100         1.00        13.92

----------------------------------------------------------------------------------------------
This RMF calculation includes a transition zone adjustment in the case of small catchments.

Regional maximum flood:         149.2  m³/s

Q50(RMF):                       79.22  m³/s (based on QT/QRMF relationship for Kovács regions)
Q100(RMF):                      97.57  m³/s (based on QT/QRMF relationship for Kovács regions)
Q200(RMF):                      115.92 m³/s (based on QT/QRMF relationship for Kovács regions)
----------------------------------------------------------------------------------------------
The following equivalent maxima make no transition zone adjustments for small catchments.

Equivalent southern African maximum
K-factor 5.6:                    429   m³/s

Equivalent world maxima
K-factor 6.0:                    869   m³/s
K-factor 6.3:                    1474  m³/s
```

PEAKFLOW CALCULATIONS – SUB BASIN 3 – UNIT HYDROGRAPH METHOD

```
Flood Frequency Analysis: Unit Hydrograph Method

Project                                    = Rethusheng SNS
Analysed by                                = NNB
Name of river                              = S3 Trib3
Description of site                        =
Date                                       = 12/08/2025
Area of catchment                          = 53.065 km²
Length of longest watercourse              = 16.995 km
Height difference along equal area slope   = 121.007 m
Distance to catchment centroid             = 8.326 km
Veld type                                  = Region 8
Duration interval                          = 5 minutes
---------------------------------------------------------------------

Slope of longest stream                    = 0.0071 m/m
Catchment index                            = 1677.0
Catchment lag                              = 2.787
Coefficient (Ku)                           = 0.367 m³/s - hours/km²
Peak discharge of unit hydrograph (Qp)     = 6.988 m³/s
---------------------------------------------------------------------

  Return          Storm             Peak
period          duration          discharge
                (minutes)         (m³/s)
---------------------------------------------------------------------
 1:2 year       85                16.13
 1:5 year       85                26.25
 1:10 year      85                37.74
 1:20 year      85                51.93
 1:50 year      85                76.69
 1:100 year     85                103.73
```

PEAKFLOW CALCULATIONS – SUB BASIN 3 – STANDARD DESIGN FLOOD METHOD

```
Flood frequency analysis : Standard Design Flood method

Project name                                 = Rethusheng SNS
Analysed by                                  = NNB
Name of river                                = S3 Trib3
Description of site                          =
Date                                         = 12/08/2025
Catchment characteristics:
Area of catchment                            = 53.065 km²
Length of longest watercourse                = 16.99539 km
1085 height difference                       = 87.058 m
Average slope                                = 0.0068 m/m
Drainage basin characteristics:
Drainage basin number                        = 2
Mean annual daily max rain                   = 62 mm
Days on which thunder was heard              = 44 days
Runoff coefficient C2                        = 5 %
Runoff coefficient C100                      = 30 %
Basin mean annual precipitation              = 450 mm
Basin mean annual evaporation                = 1900 mm
Basin evaporation index MAE/MAP              = 4.22

RAINFALL DATA
The rainfall data in the table below are derived from two sources. The daily rainfall
is from the Department of Water Affair's publication TR102 for the representative site.
The modified Hershfield equation is used for durations up to four hours. Linear
interpolation is used for values between 4 hours and one day.

Weather Services station ex TR102 = 675125 @ AUTORITEIT
Point mean annual precipitation =  450  mm
```

Dur:	RP =2	5	10	20	50	100	200
.25 h	17	29	38	47	59	68	77
.50 h	23	38	50	62	77	89	101
1 h	28	47	62	76	95	110	124
2 h	33	56	73	90	113	130	148
4 h	38	65	85	105	131	151	171
1 day	62	93	117	145	187	223	264
2 days	74	111	140	173	222	265	313
3 days	80	122	156	193	250	300	355
7 days	94	144	183	225	289	344	405

Runoff coefficients C2 = 5 % C100 = 30 %

Return period (years)	Time of concentration (hours)	Point precipitation (mm)	ARF (%)	Catchment precipitation (mm)	Runoff coefficient (%)	Peak flow (m³/s)
1:2	4.01	38.4	97.2	37.3	5.0	6.865
1:5	4.01	64.7	97.2	62.9	14.0	32.46
1:10	4.01	84.7	97.2	82.3	18.7	56.76
1:20	4.01	104.6	97.2	101.7	22.6	84.58
1:50	4.01	131.0	97.2	127.3	27.0	126.51
1:100	4.01	151.0	97.2	146.7	30.0	162.00
1:200	4.01	170.9	97.2	166.1	32.7	199.81

PEAKFLOW CALCULATIONS – SUB BASIN 3 – MIDGLEY AND PITMAN

```
Flood Frequency Analysis: Empirical methods

Project                                    = Rethusheng SNS
Analysed by                                = NNB
Name of river                              = S3 Trib3
Description of site                        =
Date                                       = 12/08/2025
----------------------------------------------------------------------------------------------
Area of catchment                          = 53.065 km²
Length of longest watercourse              = 16.995 km
Height difference along equal-area slope   = 121.007 m
Distance to catchment centroid             = 8.326 km
Dolomitic area                             = 0.0 %
Mean annual rainfall                       = 449.0 mm
Veld type                                  = 8
Kovács region                              = K5(K = 5.0)
Catchment parameter with regard to
reaction time                              = 0.032
----------------------------------------------------------------------------------------------
Peak discharges by means of an empirical method developed by Midgley and Pitman
------------------------------------
Return        KT          Peak
period        constant    flow
(years)                   (m³/s)
------------------------------------
 1:10          0.42        38.62
 1:20          0.57        52.41
 1:50          0.79        72.64
 1:100         1.00        91.95

----------------------------------------------------------------------------------------------
This RMF calculation includes a transition zone adjustment in the case of small catchments.

Regional maximum flood:         728.5  m³/s

Q50(RMF):                       357.52 m³/s (based on QT/QRMF relationship for Kovács regions)
Q100(RMF):                      451.24 m³/s (based on QT/QRMF relationship for Kovács regions)
Q200(RMF):                      547.37 m³/s (based on QT/QRMF relationship for Kovács regions)
----------------------------------------------------------------------------------------------
The following equivalent maxima make no transition zone adjustments for small catchments.

Equivalent southern African maximum
K-factor 5.6:                    1733  m³/s

Equivalent world maxima
K-factor 6.0:                    3090  m³/s
K-factor 6.3:                    4766  m³/s
```

PEAKFLOW CALCULATIONS – SUB BASIN 4– UNIT HYDROGRAPH METHOD

```
Flood Frequency Analysis: Unit Hydrograph Method

Project                                   = Rethusheng SNS
Analysed by                               = NNB
Name of river                             = S4 Trib4
Description of site                       =
Date                                      = 12/08/2025
Area of catchment                         = 477.15 km²
Length of longest watercourse             = 56.46 km
Height difference along equal area slope  = 450.558 m
Distance to catchment centroid            = 31.784 km
Veld type                                 = Region 8
Duration interval                         = 5 minutes
-------------------------------------------------------------------

Slope of longest stream                   = 0.0080 m/m
Catchment index                           = 20088.4
Catchment lag                             = 6.882
Coefficient (Ku)                          = 0.367 m³/s - hours/km²
Peak discharge of unit hydrograph (Qp)    = 25.447 m³/s
-------------------------------------------------------------------


Return          Storm             Peak
period          duration          discharge
                (minutes)         (m³/s)
-------------------------------------------------------------------
 1:2 year       160               69.65
 1:5 year       160               112.28
 1:10 year      160               160.20
 1:20 year      200               219.11
 1:50 year      205               322.23
 1:100 year     205               434.32
```

PEAKFLOW CALCULATIONS – SUB BASIN 4 – STANDARD DESIGN FLOOD METHOD

```
Flood frequency analysis : Standard Design Flood method

Project name                            = Rethusheng SNS
Analysed by                             = NNB
Name of river                           = S4 Trib4
Description of site                     =
Date                                    = 12/08/2025
Catchment characteristics:
Area of catchment                       = 477.15 km²
Length of longest watercourse           = 56.46 km
1085 height difference                  = 257.885 m
Average slope                           = 0.0061 m/m
Drainage basin characteristics:
Drainage basin number                   = 2
Mean annual daily max rain              = 62 mm
Days on which thunder was heard         = 44 days
Runoff coefficient C2                   = 5 %
Runoff coefficient C100                 = 30 %
Basin mean annual precipitation         = 450 mm
Basin mean annual evaporation           = 1900 mm
Basin evaporation index MAE/MAP         = 4.22

RAINFALL DATA
The rainfall data in the table below are derived from two sources. The daily rainfall
is from the Department of Water Affair's publication TR102 for the representative site.
The modified Hershfield equation is used for durations up to four hours. Linear
interpolation is used for values between 4 hours and one day.

Weather Services station ex TR102 = 675125 @ AUTORITEIT
Point mean annual precipitation =  450  mm
```

Dur:	RP =2	5	10	20	50	100	200
.25 h	17	29	38	47	59	68	77
.50 h	23	38	50	62	77	89	101
1 h	28	47	62	76	95	110	124
2 h	33	56	73	90	113	130	148
4 h	38	65	85	105	131	151	171
1 day	62	93	117	145	187	223	264
2 days	74	111	140	173	222	265	313
3 days	80	122	156	193	250	300	355
7 days	94	144	183	225	289	344	405

Runoff coefficients C2 = 5 %   C100 = 30 %

Return period (years)	Time of concentration (hours)	Point precipitation (mm)	ARF (%)	Catchment precipitation (mm)	Runoff coefficient (%)	Peak flow (m³/s)
1:2	10.56	46.1	88.9	41.0	5.0	25.75
1:5	10.56	74.0	88.9	65.8	14.0	115.82
1:10	10.56	95.3	88.9	84.7	18.7	199.35
1:20	10.56	117.9	88.9	104.7	22.6	297.45
1:50	10.56	149.3	88.9	132.7	27.0	450.30
1:100	10.56	174.6	88.9	155.1	30.0	584.87
1:200	10.56	201.4	88.9	179.0	32.7	735.15

PEAKFLOW CALCULATIONS – SUB BASIN 4 – MIDGLEY AND PITMAN

```
Flood Frequency Analysis: Empirical methods

Project                                  = Rethusheng SNS
Analysed by                              = NNB
Name of river                            = S4 Trib4
Description of site                      =
Date                                     = 12/08/2025
----------------------------------------------------------------------------------------------
Area of catchment                        = 477.15 km²
Length of longest watercourse            = 56.46 km
Height difference along equal-area slope = 450.558 m
Distance to catchment centroid           = 31.784 km
Dolomitic area                           = 0.0 %
Mean annual rainfall                     = 449.0 mm
Veld type                                = 8
Kovács region                            = K5(K = 5.0)
Catchment parameter with regard to
reaction time                            = 0.024
----------------------------------------------------------------------------------------------
Peak discharges by means of an empirical method developed by Midgley and Pitman
------------------------------------
Return          KT          Peak
period       constant       flow
(years)                     (m³/s)
------------------------------------
 1:10          0.42        136.20
 1:20          0.57        184.84
 1:50          0.79        256.18
 1:100         1.00        324.28

----------------------------------------------------------------------------------------------
This RMF calculation includes a transition zone adjustment in the case of small catchments.

Regional maximum flood:         2184.4 m³/s

Q50(RMF):                       1104.43m³/s (based on QT/QRMF relationship for Kovács regions)
Q100(RMF):                      1381.27m³/s (based on QT/QRMF relationship for Kovács regions)
Q200(RMF):                      1664.63m³/s (based on QT/QRMF relationship for Kovács regions)
----------------------------------------------------------------------------------------------
The following equivalent maxima make no transition zone adjustments for small catchments.

Equivalent southern African maximum
K-factor 5.6:                    4556  m³/s

Equivalent world maxima
K-factor 6.0:                    7438  m³/s
K-factor 6.3:                    10742 m³/s
```

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