

PROPOSED TOWNSHIP ESTABLISHMENT ON PORTION OF THE FARM DE PUT 298, MATWABENG, FREE STATE PROVINCE

1:100 RETURN PERIOD FLOODLINE DETERMINATION REPORT

March 2021, Rev 0

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1. INTRODUCTION

1.1 Study Request

Dalimede Projects (PTY) LTD was appointed by Skotane Development Consultants to undertake floodline assessment relating to the proposed township situated on portion of the Farm De Put 298, Matwabeng, Free State Province.

1.2 Locality

The proposed township is situated in Matwabeng, Senekal town, in the Free State Province, South Africa. Senekal town is 85km north from Ficksburg town, along the R70 highway. The area is administered by Setsoto Local Municipality, under the Thabo Mofutsanyana District Municipality. GPS coordinates of site are 28°20'41.85"S 27°38'21.69"E.

The locality map is shown on the figures below.

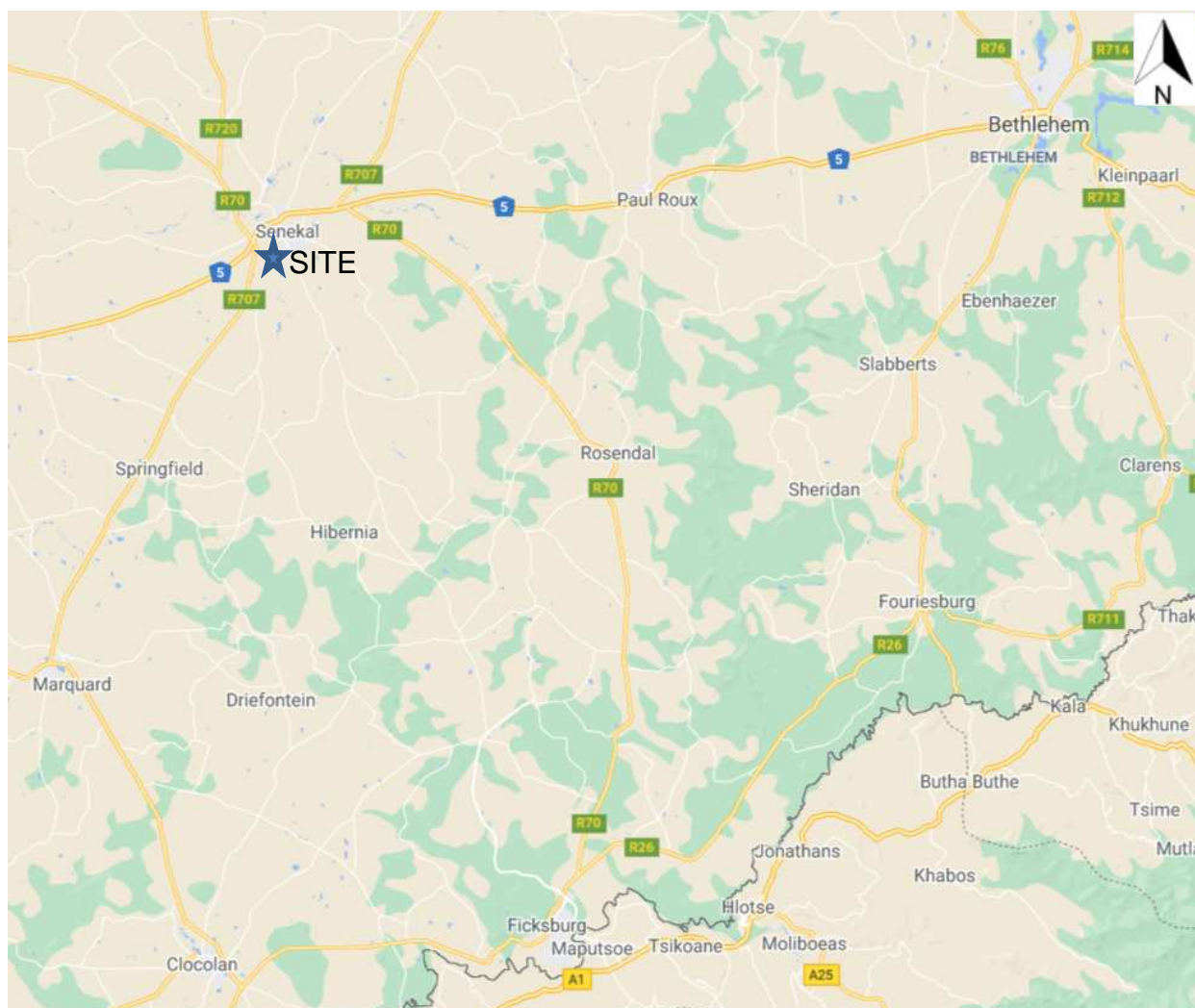


Figure 1 Location of development site

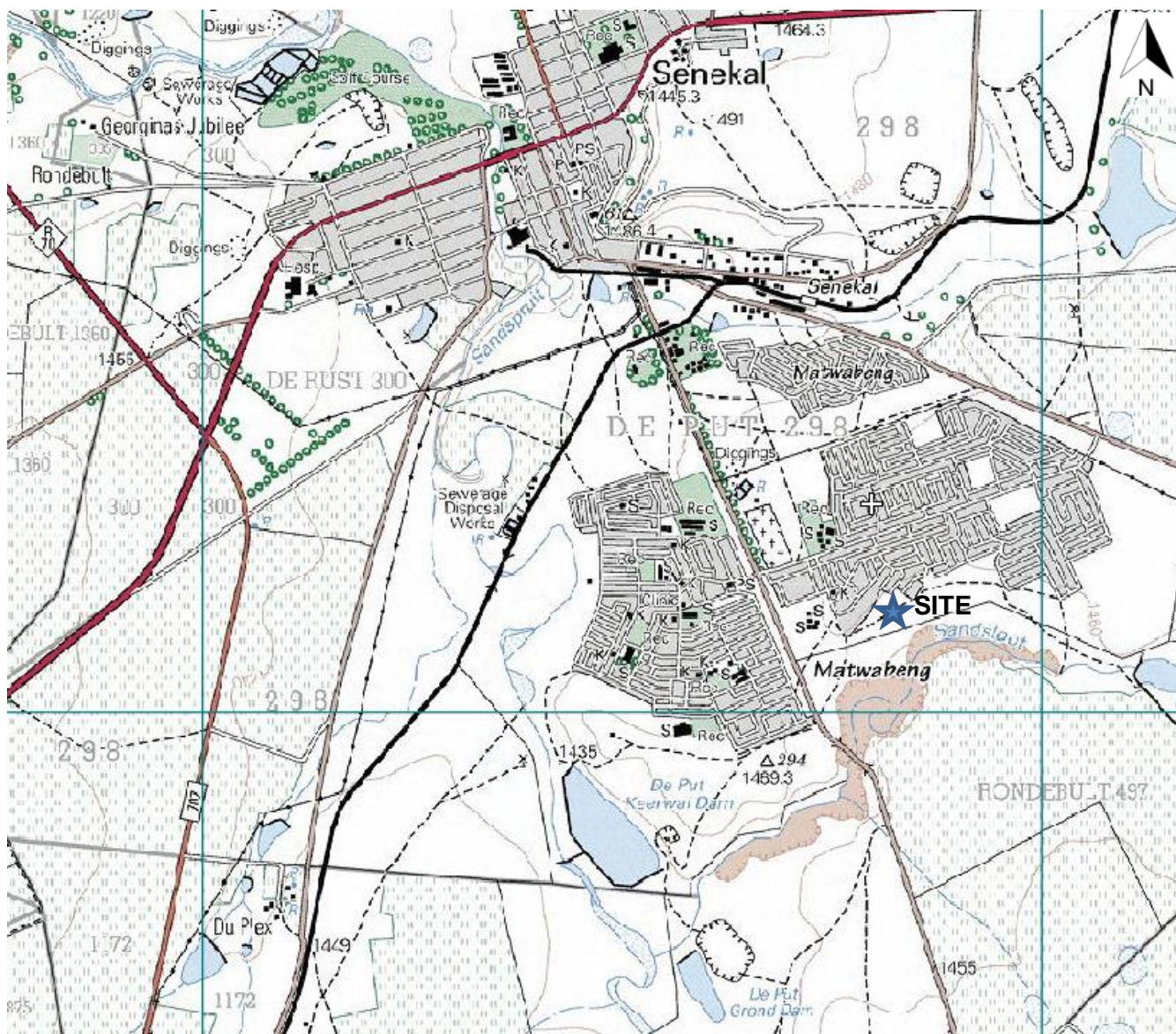


Figure 2 Project site

1.3 Background

A flood line analysis must be conducted along the stream / river traversing or in proximity to the site of proposed development. The stream / river in proximity to the site is the Sandsloot river.



Figure 3 Streams onsite



Figure 4 Sandsloot river view

2. Methodology

2.1 General

The study consists of 2 major components:

- a flood analysis to determine the flood peak flow and,
- a surface water profile analysis to determine the flood line.

The magnitude of a flood is dependent on many factors, such as catchment size, slope and rainfall intensity. There are several different methods for determining floods and in general, different methods arrive at different estimates of the peak flow rate. The accepted approach is therefore to use several methods and then make a judgment call as to which method is the most applicable to the catchment under consideration. For this study, the Rational, Alternative Rational, Standard Design Flood (SDF) methods were used to determine the peak flow rate for the 1:100 return flood.

The reason for choosing these methods was because they are applicable to the catchment and to show the variance in the flood line between the method that produced the highest flood peak and the method that produced the lowest flood peak. Hence a flood line has been produced to take cognisance of the uncertainty related to estimating floods and flood lines.

The area of the catchment in which the adjacent stream is located was determined using GIS software as were additional properties applicable to the catchment, such as the length of the watercourse and the centroid of the catchment. The flood peak flows provide the flow used in the flood line analysis using the *HEC-RAS* software.

Other input required for *HEC-RAS* is channel geometry and roughness parameters. Channel cross-sections were taken at points along the river / stream course, within the area that contour lines were provided. The stream reaches that were analysed are in a natural state. See the figure below for the streams in catchment area.

2.2 Flood Modelling Methodology

Flood peaks for the catchments selected for flood modelling were estimated by the following methods using the Utility Programs for Drainage (UPD) software with the methods detailed in SANRAL, 2013:

- Rational Method (RM).
- Alternative Rational Method (ARM).
- Standard Design Flood (SDF).

2.3 Rational Method

This method is based on the conservation of mass and is applicable for catchment areas below 15 km². Aerial and time distributions of rainfall in this method are assumed to be uniform throughout the catchment. Flood peaks and empirical hydrographs can be determined by this method.

Where: The peak flow is obtained from the following relationship:

$$Q = \frac{CIA}{3.6}$$

Where: Q = peak flow (m³/s)

C = runoff coefficient (dimensionless)

I = average rainfall intensity over the catchment (mm/hour)

A = effective runoff area of the catchment (km²)

3.6 = conversion factor

2.4 Alternative Rational Method

This method is based on the rational method with the point precipitation being adjusted using the Design Rainfall Estimation Methodology developed by Smithers and Schulze (2003) to consider local South African conditions.

Design rainfall values for the study area were extracted from the database of six closest to site South African Weather Service stations, using the Design Rainfall Utility developed by Smithers and Schulze (2000).

Table 1 Design Rainfall Values for the site

Duration		Return Period (Years) Design Rainfall Depth (mm)						
		1:2	1:5	1:10	1:20	1:50	1:100	1:200
5	m	8.4	11.2	13.2	15.2	17.9	20.1	22.4
10	m	12.3	16.4	19.2	22.2	26.2	29.3	32.6
15	m	15.3	20.4	24	27.6	32.6	36.6	40.7
30	m	19.5	25.9	30.5	35.1	41.4	46.5	51.7
45	m	22.4	29.8	35.1	40.4	47.7	53.5	59.5
1	h	24.8	32.9	38.8	44.6	52.7	59.1	65.7
1.5	h	28.5	37.9	44.6	51.3	60.6	68	75.6
2	h	31.5	41.9	49.3	56.7	66.9	75.1	83.5
4	h	36.9	49.1	57.8	66.6	78.6	88.1	98
6	h	40.6	54	63.5	73.1	86.3	96.8	107.7
8	h	43.4	57.7	67.9	78.1	92.2	103.4	115.1
10	h	45.6	60.7	71.4	82.3	97.1	108.9	121.2
12	h	47.6	63.3	74.5	85.8	101.3	113.6	126.4
16	h	50.9	67.7	79.6	91.7	108.2	121.4	135.1
20	h	53.6	71.3	83.9	96.6	114	127.8	142.2
24	h	55.9	74.4	87.5	100.7	118.9	133.3	148.4
1	h	48.4	64.4	75.8	87.3	103	115.5	128.5
2	h	59.5	79.1	93.1	107.2	126.5	141.9	157.9
3	h	67.1	89.3	105	120.9	142.7	160.1	178.1
4	h	72.6	96.5	113.6	130.8	154.3	173.1	192.6
5	h	77.1	102.6	120.7	138.9	164	183.9	204.7
6	h	81	107.8	126.8	146	172.3	193.3	215.1
7	h	84.5	112.4	132.2	152.2	179.7	201.5	224.3

2.5 Standard Design Flood (SDF) Method

This method is an empirically calibrated version of the Rational method. A major component in the development of the SDF method was the identification of regions with homogeneous flood producing characteristics. The geographic requirement was that the boundaries had to follow catchment watersheds and related to the Department of Water and Sanitation (DWS) drainage region numbering system, formally the Department of Water Affairs and Forestry (DWAF).

The regions are called 'basins' to avoid confusion with DWAF's drainage regions and the South African Weather Services' (SAWS) rainfall districts. Each basin must contain at least one flow gauging station from the DWAF published TR102 Catalogue of hydrological catchment parameters. The only information required for its application is the area of the catchment, the length and slope of the main stream / river, and the drainage basin in which it is located.

3. ANALYSIS

3.1 Flood Analysis

To make the analysis possible, properties of the catchments that influence the runoff relating to the 1:100 return flood event need to be determined. These properties are described in the following sections.

3.2 Catchment Properties

The catchment topography is mainly composed of flat areas (92% of catchment) with a small portion of hilly areas (6% of catchment) and steep areas (2% of catchment). The topographic elevation in the catchment ranges from 1440m to 1800m above sea level. The landscape soils are mostly characterised by moderate to slow infiltration rates with effective drainage. The permeability being slightly restricted to restricted (Schulze, 2010). The soils are classified to have a moderate runoff potential.

The Mean Annual Precipitation (MAP) of the catchment was determined from weather stations gridded from in the vicinity of the site. The MAP for the catchment is estimated to be 645mm.

Table 2 Rainfall data

Station Name	SAWS	Distance (km)	Record (Years)	Latitude		Longitude		MAP (mm)
	Number			(°)	(')	(°)	(')	
Senekal (Agr)	0330199_W	15.5	94	28	19	27	37	625
Klipdrift	0296305_W	20.5	27	28	35	27	41	650
Fairfield	0330747_W	20.5	39	28	27	27	55	681
Mignonette	0330403_W	21.7	45	28	12	27	43	544
Rosendal	0330750_W	22.6	68	28	30	27	55	643
Paul Roux (Mun)	0330797_W	26.6	73	28	17	27	57	614

The climate is characterised by hot and rainy summers for a long period as well as cool and dry winters over a short period.

There are no river gauging stations on the catchment.

3.3 Catchment Delineation

The catchment area is within the Middle Vaal Water Management Area.

The catchment in the table below was delineated to cover the streams within or in proximity of the project boundary and was utilised to determine the flood peaks for 1:100 return extreme events. The catchment information is listed in the table below.

Table 3 Catchment area

Catchment Site	Catchment area (km ²)	Remark	Quaternary catchment
C1	126.977	Catchment	C42C

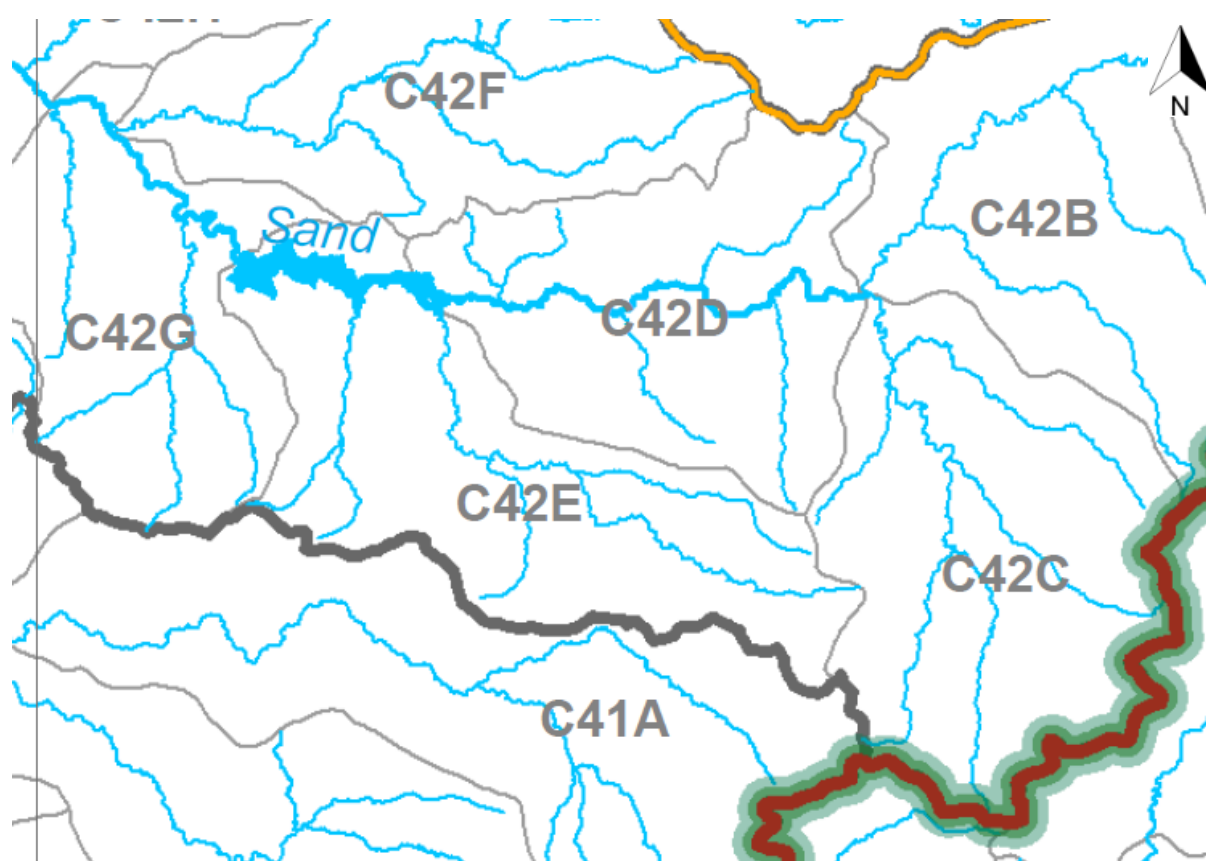


Figure 5 Quaternary catchments

The delineated catchments are shown in the figures below.

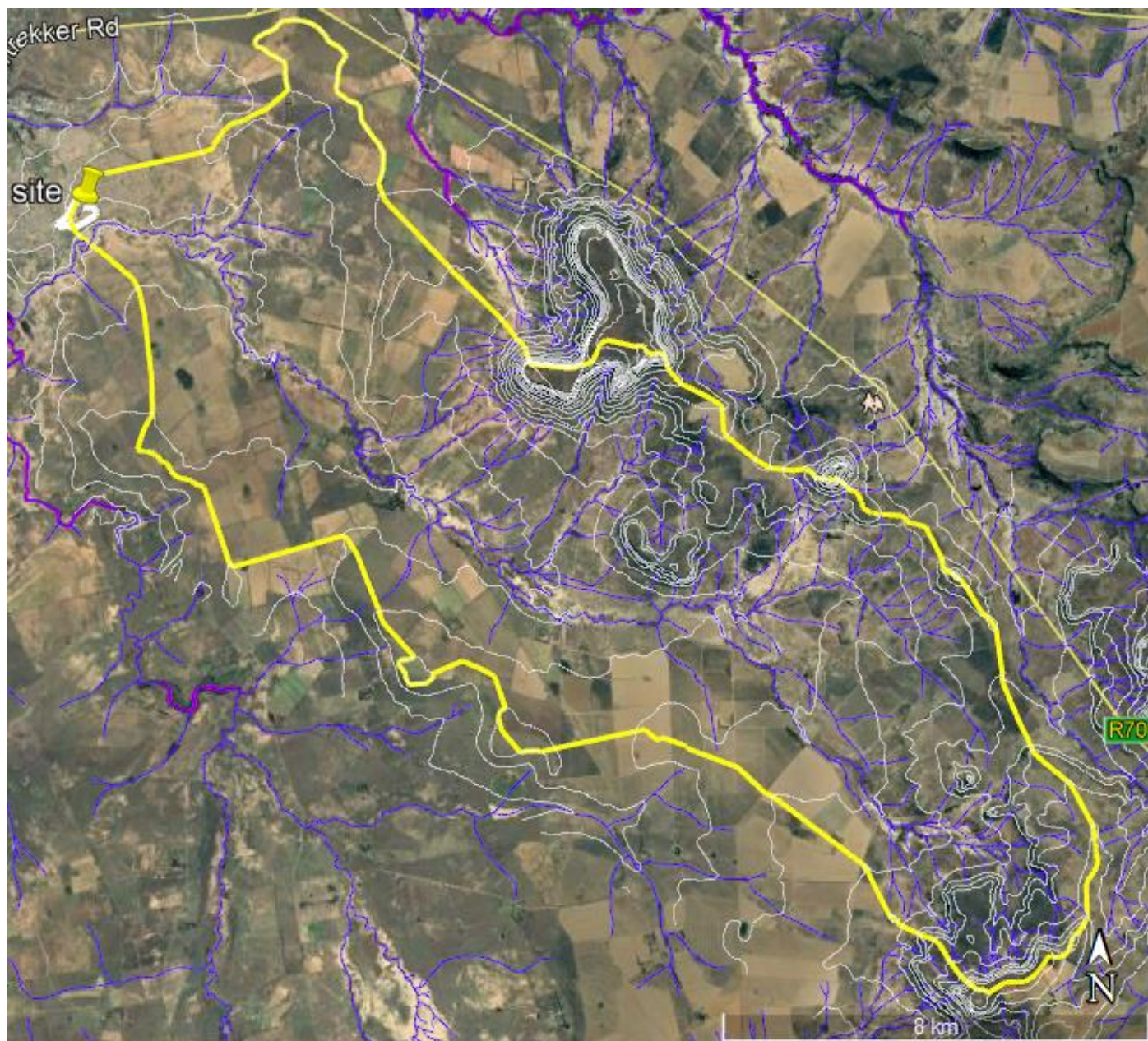


Figure 6 Catchment 1 delineation (yellow line boundary)

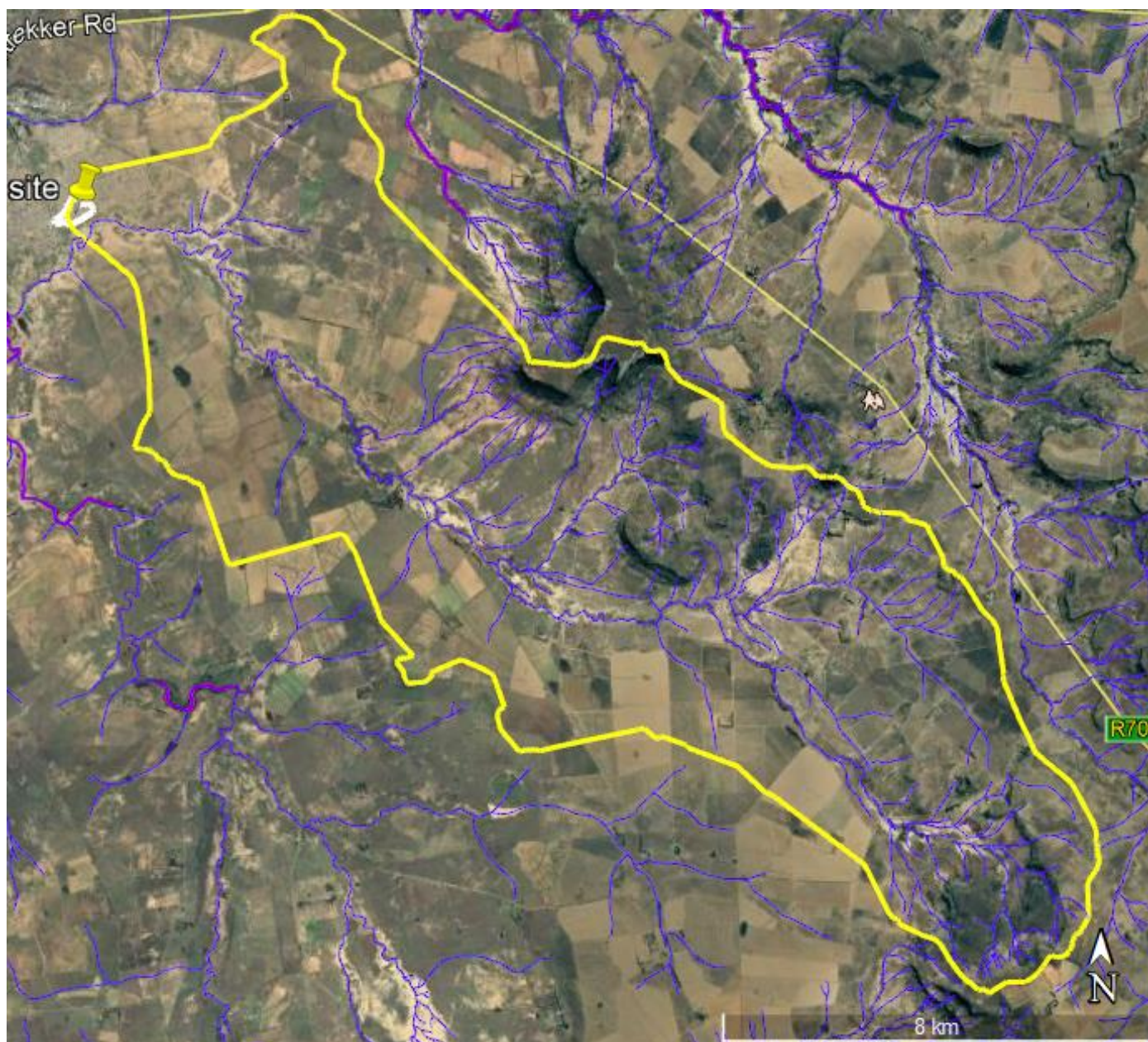


Figure 7 Catchment 1

3.4 Catchment Characteristics

The catchment characteristics are shown the following tables below.

Table 4 Catchment Characteristic

Characteristic	Rural	Urban	Lakes	Total
	Distribution	Distribution	Distribution	
Catchment	%	%	%	(%)
C1	99%	1%	0%	100%

Table 5 Rural area - Surface slope

Rural area - Surface slope	Lakes and pans (<3%)	Flat area (3 to 10%)	Hilly (10 to 30%)	Steep areas (>30%)	Total
	Distribution	Distribution	Distribution	Distribution	
Catchment	(%)	(%)	(%)	(%)	(%)
C1	68%	24%	6%	2%	100%

Table 6 Rural area – Permeability

Rural area - Permeability	Very permeable	Permeable	Semi-permeable	Impermeable	Total
	Distribution	Distribution	Distribution	Distribution	
Catchment	(%)	(%)	(%)	(%)	(%)
C1	4%	52%	40%	4%	100%

Table 7 Rural area - Vegetation

Rural area - Vegetation	Thick bush & forests	Light bush & cultivated land	Grasslands	Bare	Total
	Distribution	Distribution	Distribution	Distribution	
Catchment					(%)
C1	6%	69%	16%	9%	100.0%

Table 8 Run-off factors

Catchment	Run-off factor			
	Rural (C _R)	Urban (C _U)	Lakes (C _L)	Combined (C)
C1	0.309	0.547	0	0.311

Table 9 Hydrological input data

Catchment	Catchment Area (km ²)	Longest water course (km)	Height difference 1085 method (m)	Days thunder was heard (No.)	Area Dolomite (%)	Mean Annual Precipitation (mm)	SDF Basin no. (No.)
C1	126.977	27.444	114.0	75	0	645	7

Table 10 Catchment characteristics

Catchment Site	Catchment area (km ²)	Longest water course, L (km)	Height difference along 10-85 slope (m)	Average slope S_{av} (m/m)	Time of concentration, T_c (hours)	% Slope	MAP (mm)	Run-off factor C
C1	126.977	27.444	114.0	0.00553750	6.282731516	0.55%	645	0.311

3.5 Flood magnitudes

The flood magnitudes from the 1:2 return up to 1:100 return floods are presented in the Tables below.

Table 11 Estimated stormwater flow (m³/s)

	Rational method						Alternative rational method					
Return	1:2	1:5	1:10	1:20	1:50	1:100	1:2	1:5	1:10	1:20	1:50	1:100
Catchment												
C1	58.08	83.74	111.82	145.04	196.77	252.02	45.06	80.79	106.84	130.84	166.18	199.5

Table 12 Estimated stormwater flow (m³/s)

	Unit Hydrograph method						Standard design flood method					
Return	1:2	1:5	1:10	1:20	1:50	1:100	1:2	1:5	1:10	1:20	1:50	1:100
Catchment												
C1	47.28	76.39	109.17	149.39	219.67	296.58	27.56	96.77	161.04	233.79	342.36	433.56

Table 13 Estimated stormwater flow (m³/s)

	Empirical method			
Return	1:10	1:20	1:50	1:100
Catchment				
C1	127.95	147.47	206.03	260.25

The applications and limitation of flood calculation methods are shown in the table below.

Table 14 Applications and limitation of flood calculation methods

Method	Recommended maximum area (km ²)	Return period of floods that could be determined
Statistical method	No limitation (larger areas)	1:2 to 1:200
Rational method	Usually less than 15km ²	1:2 to 1:200
Unit Hydrograph method	15km ² to 5,000km ²	1:2 to 1:100
Standard Design Flood method	No limitation	1:2 to 1:200
SCS-SA method	Less than 30km ²	1:2 to 1:100
Empirical methods	No limitation (larger areas)	1:10 to 1:100

3.6 Flood magnitudes for the 1:100-year floods

The Rational, Alternative Rational (AR), and Standard Design Flood (SDF) methods were used to select the flood peak.

As the SDF results were observed as having been outlying, the Rational and Alternative Rational method with the highest magnitude of the peak flow was used for the 1:100 return flood for a sub-catchment.

The selected maximum peak flows are shown in the table below.

Table 15 Catchment generated estimated 1:100 peak flow

C1	Catchment, estimated 100year peak flow =	433.56	m ³ /s

The estimated 1:100 stream flow is listed in the table below.

Table 16 Stream Peak flows estimates

Stream - Reach	Flow (m³/s)
Stream 1	433.56

3.7 Flood line Modelling

The HEC-RAS model was used to determine the flood line during the event of a flood for any return period, and in this case the 1:100-year floods were modelled.

3.8 Cross section profile

Cross sectional data was generated using GIS and CAD software, as well as the 5m contour lines that were obtained from the National Geo-Spatial Information (NGI). Sections shown in Annexure 5 were used to approximate the geometry for the river.

3.9 Flood profiles

Annexure 4 shows the longitudinal profile for the 1:100 return peak flow.

4. CONCLUSION

The determination of the 1:100 return period floodlines was undertaken for the site of the proposed development. The results of this determination provide an indication as to the extent of the areas that will be inundated by the 1:100 return design flood.

It is recommended that a buffer zone of 20m should be provided between the 1:100 flood line and any proposed development.

The lateral extent of the 1:100 return flood line is shown in Annexure 2. These flood lines have also been provided as Gauss Conform WGS84 LO27 coordinated CAD dwg softcopy files.

5. REFERENCES

- Smithers J.C. and Schulze R.E. (2002): Drainage rainfall and flood estimation in South Africa, WRC project KS/1060.
- The South African National Roads Agency Limited (2013): Drainage manual, 6th Edition.

ANNEXURE 1: FLOODLINE CERTIFICATE



Branch Offices
Polokwane, Limpopo

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Reg. No: 2014 / 233383 / 07

FLOOD LINE CERTIFICATE

Dalimede Projects (PTY) LTD was appointed by Skotane Development Consultants to undertake floodline assessment relating to the proposed township situated on portion of the Farm De Put 298, Matwabeng, Free State Province.

This will entail to delineate the 1:100 return flood line.

Site: *Thabo Section / Alexandra, Matwabeng, Senekal town*
Township Name: *Farm De Put 298, Matwabeng*
Co-ordinates: *28°20'41.85"S 27°38'21.69"E*
Municipality: *Setsoto Local Municipality, in Thabo Mofutsanyana District*

In terms of section 114 of the National Water Act, Act 36 of 1998 the above-mentioned property is not affected by flood water within the 1:100 period from the stream / river as indicated in the floodline report. Development must be done outside of the floodline.

It is recommended that a buffer zone of 20m should be provided between the 1:100 flood line and any proposed development.

Thus, done and signed in on this day.....

Signature:




Engineer: Litmos Mthunzi
Pr Tech Eng

Pr no.:

ANNEXURE 2: FLOODLINE DELINEATION

NOTES

KEY

-  FLOODLINE 1:100
-  CROSS SECTION
-  STREAM / RIVER

REVISIONS

REV	DATE	SIGN	DESCRIPTION
0

CLIENT



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DRAWING STATUS

FOR INFORMATION

PROJECT TITLE

Proposed township situated on portion of the Farm De Put 298,
Matwabeng, Free State Province.

PROJECT LOCATION

The proposed township is situated in Matwabeng, Senekal town,
in the Free State Province. Senekal town is 85km north from
Fickburg town, along the R70 highway. GPS coordinates
28°20'41.85"S 27°38'21.69"E

DRAWING DESCRIPTION

FLOODLINE DELINEATION 1:100 RETURN PERIOD

SCALE	DATE	DESIGNED	DRAWN	CHECKED
As Shown	Mar 2021	LM	HM	BM

DRAWING No. MATWABENG/FL/01	REVISION A
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SCALE 1:2,000

A1

ANNEXURE 3: HEC-RAS PROGRAMME MODELLING RESULTS

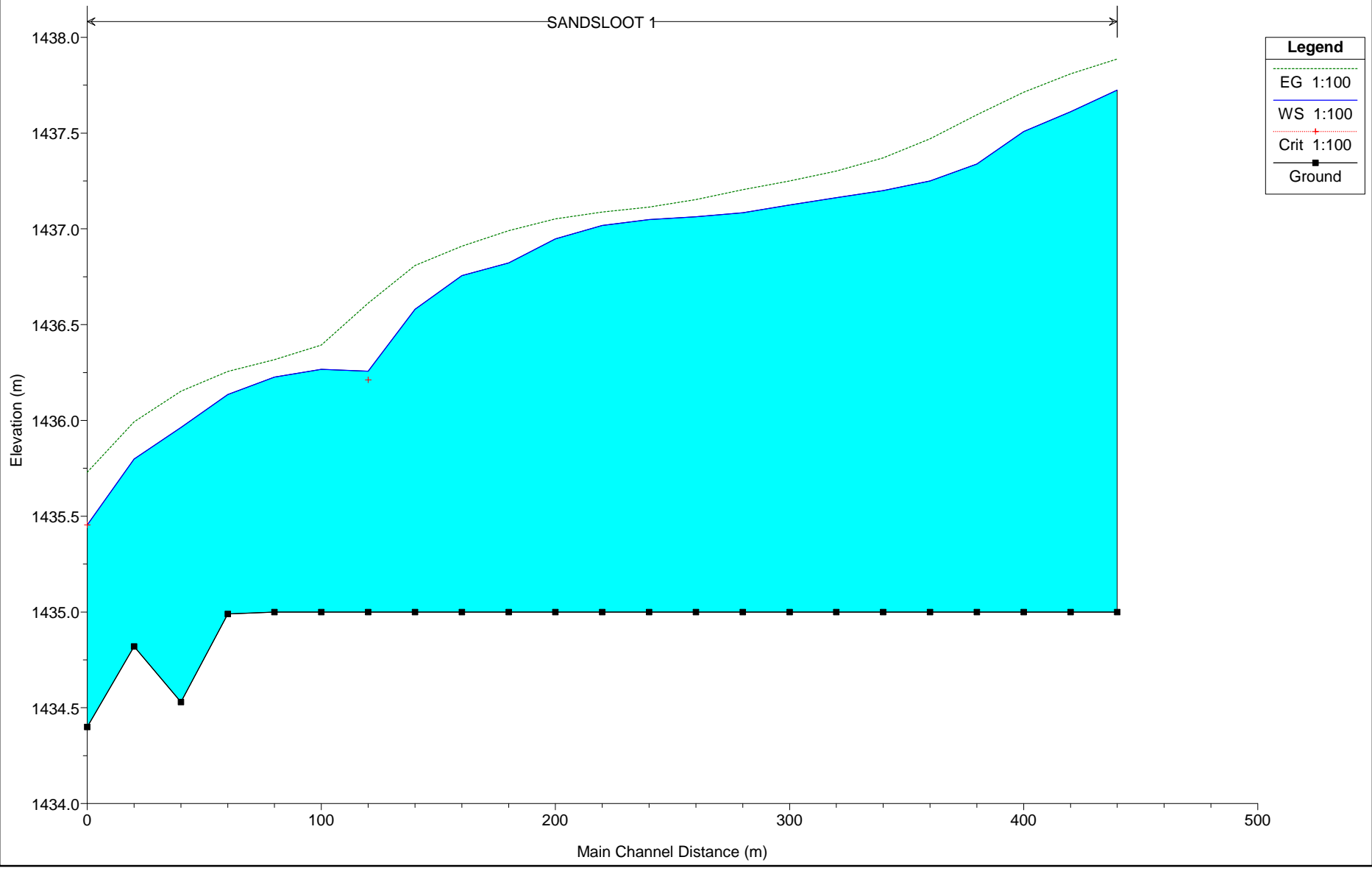
HEC-RAS Plan: Current mode River: SANDSLOOT Reach: 1 Profile: 1:100

Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
1	123	1:100	433.56	1435.00	1437.73		1437.89	0.003087	1.78	243.78	168.07	0.47
1	122	1:100	433.56	1435.00	1437.61		1437.81	0.004476	1.97	220.12	172.08	0.56
1	121	1:100	433.56	1435.00	1437.51		1437.71	0.004978	2.01	216.19	178.21	0.58
1	120	1:100	433.56	1435.00	1437.34		1437.60	0.006402	2.25	192.79	161.63	0.66
1	119	1:100	433.56	1435.00	1437.25		1437.47	0.005180	2.08	208.50	167.76	0.60
1	118	1:100	433.56	1435.00	1437.20		1437.37	0.003524	1.83	236.61	172.37	0.50
1	117	1:100	433.56	1435.00	1437.16		1437.30	0.002526	1.65	262.72	174.39	0.43
1	116	1:100	433.56	1435.00	1437.13		1437.25	0.002225	1.57	276.23	179.69	0.40
1	115	1:100	433.56	1435.00	1437.09		1437.20	0.002192	1.53	283.26	189.31	0.40
1	114	1:100	433.56	1435.00	1437.06		1437.15	0.002074	1.32	327.44	260.94	0.38
1	113	1:100	433.56	1435.00	1437.05		1437.11	0.001257	1.13	382.54	264.46	0.30
1	112	1:100	433.56	1435.00	1437.02		1437.09	0.001248	1.18	368.21	239.05	0.30
1	111	1:100	433.56	1435.00	1436.95		1437.05	0.002070	1.44	301.53	212.05	0.39
1	110	1:100	433.56	1435.00	1436.82		1436.99	0.004029	1.81	239.13	195.74	0.52
1	109	1:100	433.56	1435.00	1436.76		1436.91	0.003657	1.74	249.21	201.83	0.50
1	108	1:100	433.56	1435.00	1436.58		1436.81	0.006222	2.12	204.91	184.33	0.64
1	107	1:100	433.56	1435.00	1436.26	1436.21	1436.61	0.014988	2.64	164.35	205.34	0.94
1	106	1:100	433.56	1435.00	1436.27		1436.39	0.004443	1.57	276.02	301.50	0.52
1	105	1:100	433.56	1435.00	1436.23		1436.32	0.002474	1.34	324.50	291.30	0.40
1	104	1:100	433.56	1434.99	1436.14		1436.26	0.003508	1.54	282.33	267.21	0.48
1	103	1:100	433.56	1434.53	1435.96		1436.15	0.007069	1.92	225.43	257.49	0.66
1	102	1:100	433.56	1434.82	1435.80		1435.99	0.009036	1.95	222.36	299.10	0.72
1	101	1:100	433.56	1434.40	1435.45	1435.45	1435.73	0.019206	2.33	186.42	338.89	1.00

ANNEXURE 4: LONGITUDINAL FLOW PROFILE FOR THE FLOOD PEAK

MATWABENG

SANDSLOOT 1



ANNEXURE 5: FLOW CROSS SECTIONS FOR THE FLOOD PEAK

