

Design Report

D3 Energy Hydrological Assessment

Prepared for: EIMS (Pty) Ltd

12 June 2026

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Abbreviations and Acronyms

Abbreviation / Acronym / Symbol	Explanation / Description
DEM	Digital Elevation Model
EIA	Environmental Impact Assessment
EA	Environmental Authorisation
EMPr	Environmental Management Programme
HDD	Horizontal Directional Drilling
km ²	Square kilometres
m	Meters
m ³ /s	Cubic meters per second
m/s	Meters per second
MAP	Mean Annual Precipitation
SOTER	Soil and Terrain Databases
SRTM	Shuttle Radar Topography Mission
SWMP	Storm Water Management Plan
WUL	Water Use Licence

1. Introduction

SMEC South Africa (Pty) Ltd. was appointed by Environmental Impact Management Services (Pty) Ltd (EIMS) to undertake a Hydrological Study for D3 Energy South Africa (Pty) Ltd who is proposing a new natural gas production area indicated in Figure 1-1.

The purpose of this hydrological study is to serve as a component of the Environmental Impact Assessment (EIA) study. The objectives of the EIA are to determine the overall impacts and potential mitigation measures, on the hydrological environment, to ensure environmental legal compliance and efficient, cost-effective surface water management.

The project area is situated approximately 20 kilometres (km) south-east of Virginia in the Freestate Province of Sout Africa, as shown in Figure 1-1 below. The approximate geographical coordinates of the centre of project area are:

Latitude- 28°14'12.00"S

Longitude 26°58'24.00"E

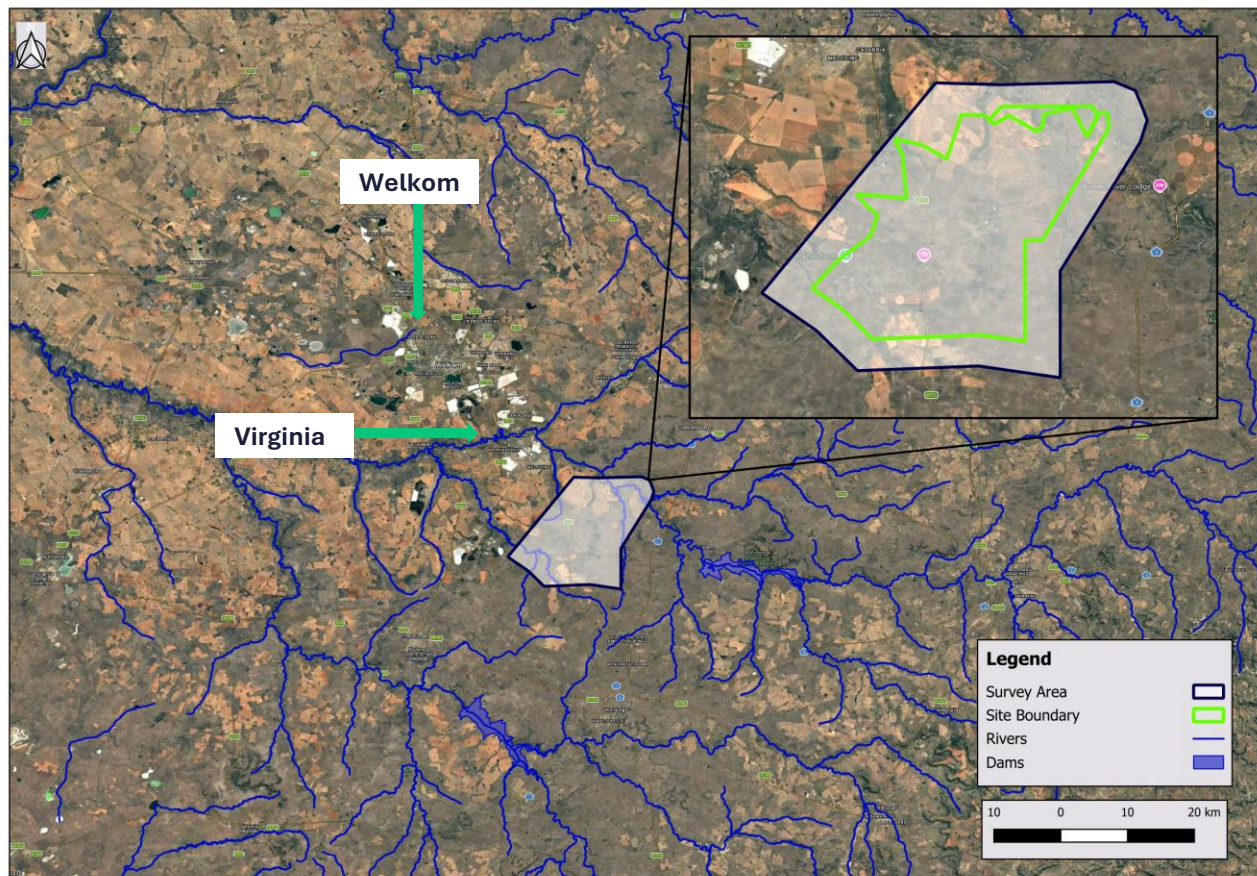


Figure 1-1: Project Area Location

The extent of the Project area boundary is shown in Figure 1-2. The area of the site is approximately 15 000 Hectares.

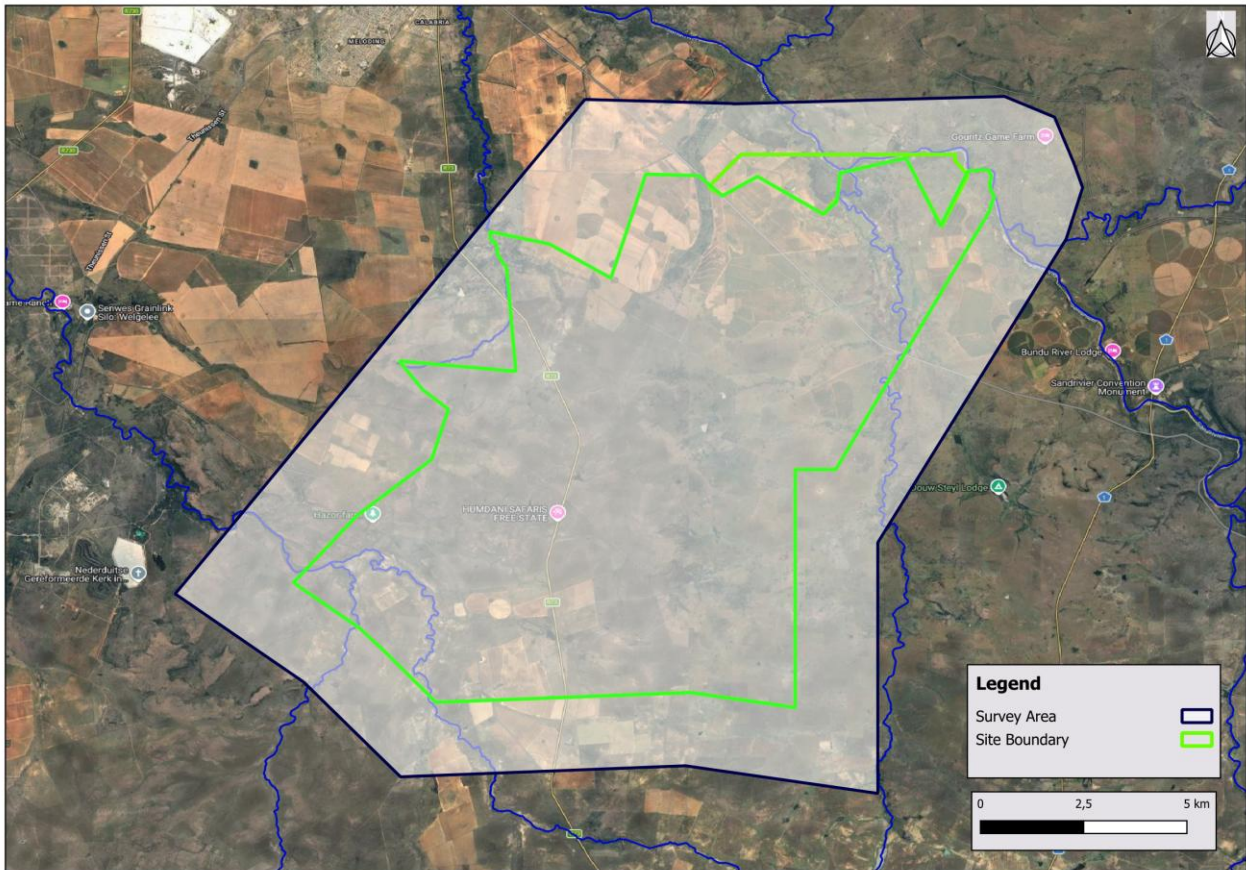


Figure 1-2: Project Area Boundary

The main drainage features traversing the project area include the Sand River, the Maselspruit River, the Doring River and Merriespruit, of which the Sand River is the major system originating in the east and draining to the north-west past Welkom and through the Project site, refer to Figure 1-2 above. No dams exist on the river reaches modelled in GeoHECRAS, where the rivers are located within the Project Area.

The Allemanskraal Dam is located in the middle reaches of the Sand River situated about 15 km upstream of the eastern boundary of the Project Area. Other lakes or dams situated within the Project catchments area do not contribute to the hydrological input parameters due to their limited surface areas.

2. Scope of Work

The Scope of Work for the Hydrological Impact Assessment can be summarised as follows:

1. Desktop Assessment:
 - a. A description of the hydrological baseline receiving environment was prepared based on publicly available data.
 - b. Identification and description of surface water drainage systems that occur in the study area, and how these may be affected by the proposed activities were undertaken.
2. Hydrology:
 - a. The catchment size was assessed, and run-off factors and catchment characteristics were determined.
 - b. Historical rainfall data for the area were sourced from the Technical Report TR 102: Design Rainfall Estimation in South Africa (TR102 Design Rainfall)
 - c. Time of concentration was calculated for each catchment along its longest watercourse, using methods and formulae appropriate to the hydrological method selected.
 - d. 1:100-year flood peaks were calculated using the most appropriate hydrological methods for each catchment.
 - e. Climate change impacts were considered rainfall data and its impacts on runoff factors.
3. Hydraulic Modelling:
 - a. A 1D river hydraulic model was compiled for each of the identified rivers using GeoHEC-RAS river modelling software.
 - b. Appropriate boundary conditions were selected based on the likely hydraulic regime.
 - c. The model geometry was based on topographic survey data to be provided by the Client.
 - d. Hydraulic roughness factors were determined through an assessment of site and aerial photos.
4. Floodlines:
 - a. Delineate the floodlines on a map, with respect to any known locations of pipe routes, well locations and plant areas.
5. Risk Assessment:
 - a. A description of all surface water impacts and proposed mitigation measures, using EIMS' standard EIA Risk and Mitigation methodology.
 - b. Site sensitivities and relevant potential surface water constraints to the project were identified.
6. Reporting:
 - a. Recommendations on required hydrological management and mitigation measures have been provided.

3. Legal Framework

The EIA study was conducted by EIMS to comply with relevant legislation and policies. The direct applicable guiding legislation is the following

3.1 National Water Act (Act 36 of 1998)

The National Water Act, 1998 (Act No. 36 of 1998) (NWA) is the principal legal instrument relating to water resource management in South Africa. As guardian and trustee of the nation's water resources, the Government (specifically the Department of Water and Sanitation) must ensure that water is protected, used, developed, conserved, managed and controlled in a sustainable and equitable manner for the benefit of all persons and in accordance with its constitutional mandate.

In accordance with GN509 of 2016 as it relates to the National Water Act, 1998 (Act No. 36 of 1998), a regulated area of a watercourse in terms of water uses as listed in Section 21c and 21i is defined as:

- The outer edge of the 1 in 100-year floodline and/or delineated riparian habitat, whichever is the greatest distance, measured from the middle of the watercourse of a river, spring, natural channel, lake or dam;
- In the absence of a determined 1 in 100-year floodline or riparian area the area within 100 m from the edge of a watercourse where the edge of the watercourse is the first identifiable annual bank fill flood bench (to be determined on location by the Environmental Specialist); or
- A 500m radius from the delineated boundary (extent) of any wetland or pan in terms of this regulation (to be determined on location by the Environmental Specialist).

3.2 National Environmental Management Act (Act 107 of 1998)

The National Environmental Management Act, 1998 (Act No. 107 of 1998) and the associated EIA Regulations, 2014 as amended, states that prior to any development taking place within a wetland or riparian area and/or within 32m of a watercourse, an environmental authorisation process needs to be followed provided the stipulated development thresholds are exceeded as specified in the EIA Regulations Listing Notices. This could follow either the Basic Assessment Report (BAR) process or the Environmental Impact Assessment (EIA) process depending on the scale of the impact and/or other triggered activities associated with the proposed development. Provincial regulations must also be considered.

3.3 The Constitution of South Africa, 1996

The environment and the health and well-being of people are safeguarded under the Constitution of the Republic of South Africa, 1996 by way of section 24. Section 24(a) guarantees a right to an environment that is not harmful to human health or well-being and to environmental protection for the benefit of present and future generations. Section 24(b) directs the state to take reasonable legislative and other measures to prevent pollution, promote conservation, and secure the ecologically sustainable development and use of natural resources (including water and mineral resources) while promoting justifiable economic and social development. Section 27 guarantees every person the right of access to sufficient water, and the state is obliged to take reasonable legislative and other measures within its available resources to achieve the progressive normalization of this right. Section 27 is defined as a socio-economic right and not an environmental right. However, read with section 24 it requires of the state to ensure that water is conserved and protected and that sufficient access to the resource is provided. Water regulation in South Africa places a great emphasis on protecting the resource and on providing access to water for everyone.

3.4 National Environmental Management: Protected Areas Act (No. 57 of 2003)

This Act governs the establishment and management of protected areas. If the gas extraction project is near a protected area, there could be specific regulations regarding the protection of aquatic ecosystems.

3.5 National Environmental Management: Biodiversity Act (No. 10 of 2004)

This Act could apply if the gas extraction activities are in ecologically sensitive areas, such as wetlands or riparian zones that are hydrologically linked to the surrounding environment.

3.6 Water Services Act, 1997 (Act No. 108 of 1997)

Regulates water supply and sanitation services, particularly where gas operations may affect local water access. Any entity affecting water supply—such as gas companies drilling near water sources—may require authorization from relevant water authorities.

4. Hydrological Characteristics

The project area is located within the Water Management Area 5 of South-Africa, refer to Figure 4-1.

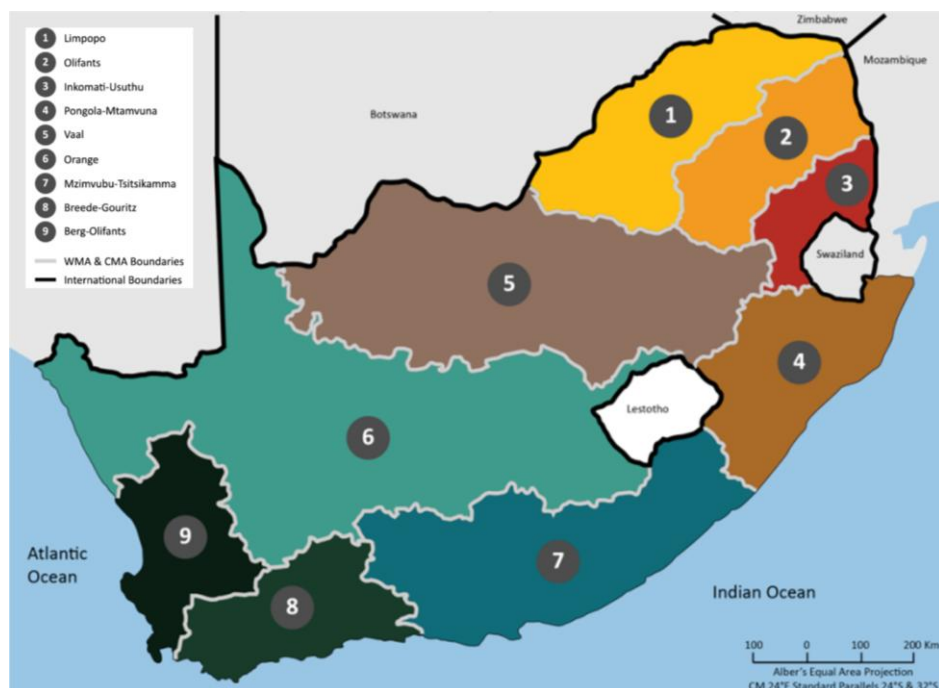


Figure 4-1: The Water Management Areas of South Africa (Source: DWS, April 2016)

The project area is further located within quaternary catchments C42K, C42H and C43G as defined by Water Resources of South Africa, 2012 study (WR 2012). Refer to Figure 4-2 for the location of the project areas in relation to the quaternary catchments.



Figure 4-2: Project Area in relation to Quaternary Catchments C42K, C42H and C43G.

The main drainage features traversing the project area include the Sand River, the Maselspruit, the Merriespruit and the Doring River:

- The Sand River is the major system originating in the east and draining north-west past Virginia and forming the northern border of the Project site.
- The Maselspruit, a tributary of the Sand River, drains from south of the project site north to the Sand River on the eastern side of the Project site.
- Another tributary drains through the northern part of the project area west of the Maselspruit toward the Sand River.
- The Merriespruit drains toward the north on the western boundary of the project area.
- The Doring River and its tributaries drain the southwestern part of the Project Area

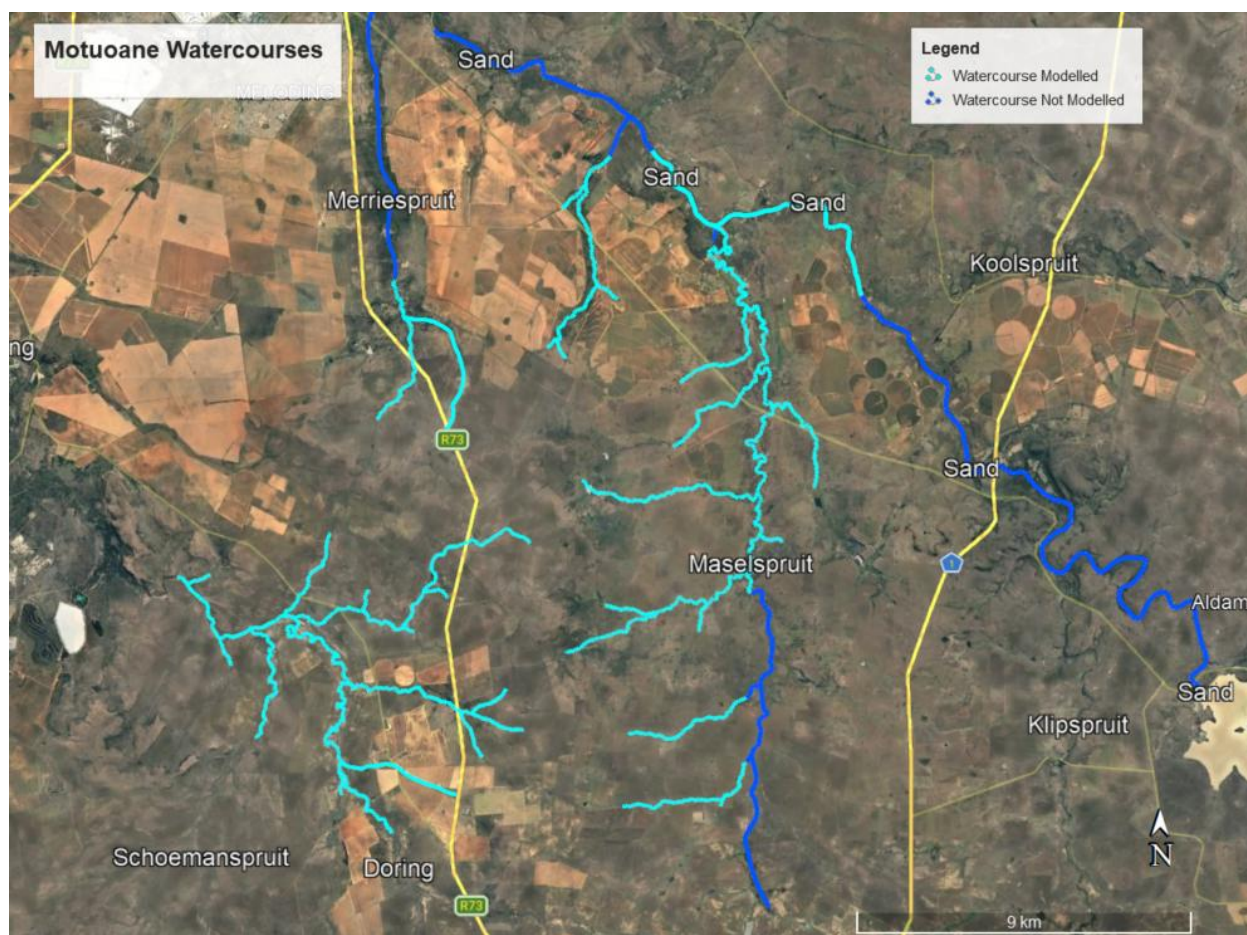


Figure 4-3: Modelled Watercourses

Based on the observations made from Google Earth Pro satellite imagery (Google Earth, 2025), as well as GIS data (Landcover - SA_NL_2022_GEO.tif, Soil - SOTER soil association map and Vegetation - 2024 Beta Vegetation dataset), the project area comprises mostly of grasslands and farmlands with some scattered bush areas. The project area is generally flat (<10% slope based on the available topographic survey data). A flat topography means the hydrological response of the catchment to rainfall is slower than a catchment with steeper slopes meaning that the flood timing and peak flow characteristics are different to a similar size but steeper catchment.

Soils that are well drained produce a lower stormflow response than poorly drained soils.

According to the “SANRAL Drainage Manual, 6th Edition”, the soils in the project area have a moderately low to moderately high internal drainage capacity and generalised SCS soil grouping classification for South Africa. The permeabilities of the catchments were therefore estimated as follows:

- Highly permeable areas were estimated to be insignificant and rated as 0%
- Impermeable areas were estimated to make up 10% of the catchment areas, and
- The rest of the catchment was estimated to be equally distributed between Permeable and Semi-permeable at 45% each.

Although the project area and its river sections contained within it, covers several quaternary catchments, it is really the specific sub-catchments within these quaternary catchments that are important for the flood analysis in question here. The delineation of catchment areas draining to the above-mentioned rivers was undertaken using the open-source topography of the area derived from the SRTM DEM data. A catchment area is generally defined as that area from which all rainfall will drain into a drainage system through surface flow, to a common point.

The focus of the reporting within this section is on the major points of the major rivers in the project area. However, the project area has multiple small tributaries that drain into the major rivers at multiple points. To account for this, these were individually considered as flow change locations in the river modelling. This was done so that the peak flow at the downstream end of a river does not represent the entire rivers flow characteristics. The catchment areas are shown below:

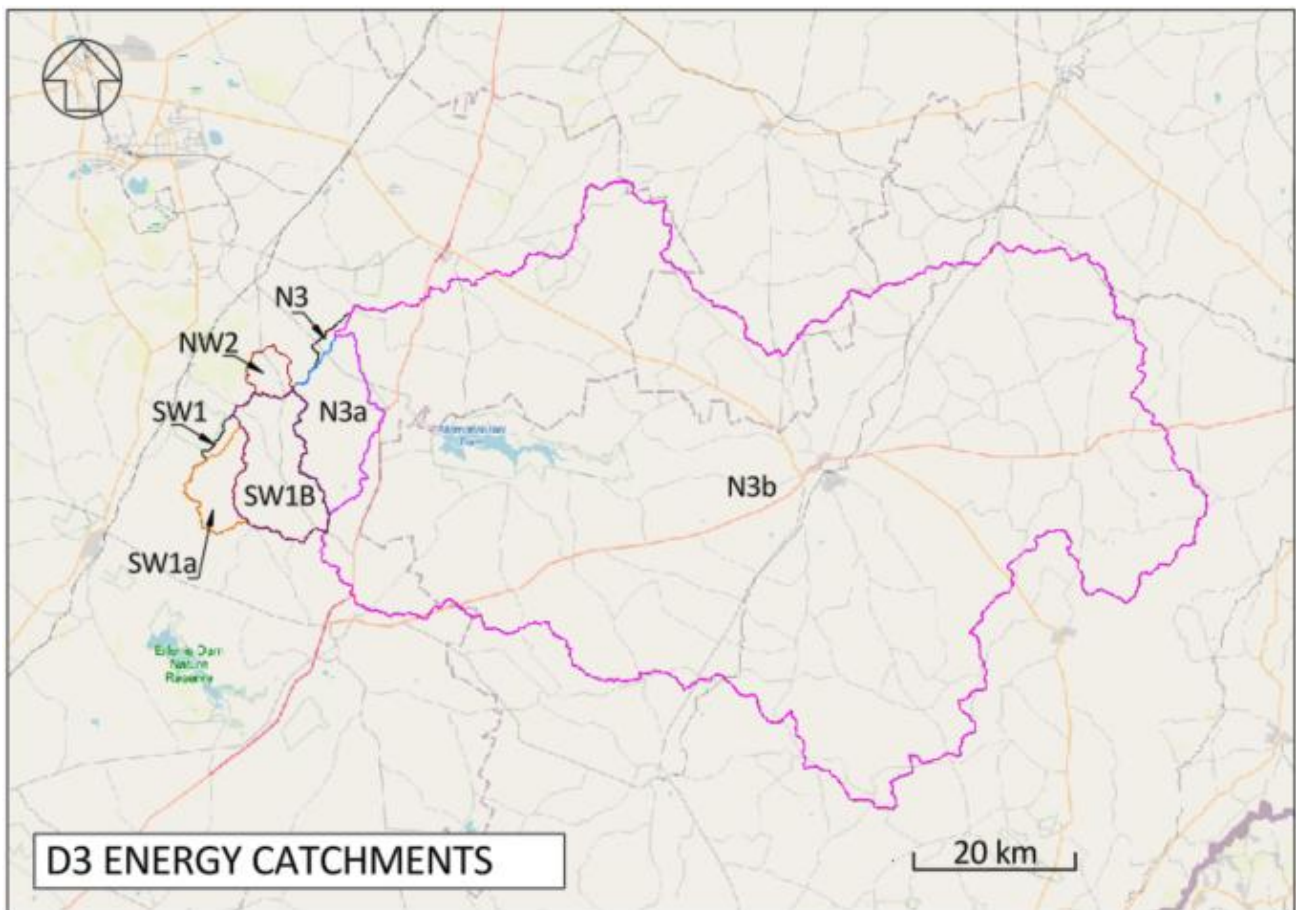


Figure 4-4: Catchment Boundaries

The physical properties of the various catchment areas shown in Figure 4-4 are summarised in Table 4-1.

It should be noted that a letter at the end of a catchment name indicates that this is a sub-catchment. For example, Catchment N3 is comprised of sub-catchment N3a and N3b.

Table 4-1: Catchment Area Physical Properties

Description	Unit	C_NW2	C_SW1	C_SW1a	C_SW1b	C_N3	C_N3a	C_N3b
Size of Catchment Area	km ²	26.56	210.64	56.13	146.91	4927.50	145.46	4774.32
Hydraulic length of Catchment	km	6.24	26.68	17.19	25.09	190.31	29.09	189.13
Stream Slope (10% -85%)	m/m	0.01014	0.00440	0.00542	0.00479	0.00135	0.00413	0.00129

5. Hydrological Analysis

5.1 Methodology

The following methodology was used in the hydrological analysis to determine flood peaks:

Six flood estimation methods were used to determine 1 in 100-year return period flood peaks for the catchment areas under consideration, being the:

- Rational Method 2 (RM 2),
- Rational Method 3 (RM 3),
- Unit Hydrograph Method (UHM)
- Standard Design Flood Method (SDF),
- Empirical Method
 - Midgley and Pitman and
 - Regional Maximum Flood (RMF).

Table 3.2 from the SANRAL Drainage Manual shown in Figure 5-1 indicates the applications and limitations of the flood estimation methods.

Method	Input data	Recommended maximum area (km ²)	Return period of floods that could be determined (years)	Reference paragraph
Statistical method	Historical flood peak records	No limitation (larger areas)	2 – 200 (depending on the record length)	3.4
Rational methods	Catchment area, watercourse length, average slope, catchment characteristics, design rainfall intensity (3 alternative methods)	Usually < 15, depends on method of calculating rainfall intensity	2 – 200, PMF	3.5.1
Unit Hydrograph method	Design rainfall, catchment area, watercourse length, length to catchment centroid (centre), mean annual rainfall, veld type and synthetic regional unit hydrographs	15 to 5000	2 – 100, PMF	3.5.2
Standard Design Flood method	Catchment area, watercourse length, slope and SDF basin number	No limitation	2 – 200	3.5.3
SCS-SA method	Design rainfall depth, catchment area, Curve Number=f(soils, land cover), catchment lag	< 30	2 - 100	3.5.4
Empirical methods	Catchment area, watercourse length, distance to catchment centroid, mean annual rainfall	No limitation (larger areas)	10 – 100, RMF	3.6

Figure 5-1: Table 3.2 extracted from the SANRAL Drainage Manual

Input data for these methods was developed as follows:

- Design rainfall depths were obtained from Water Research Commission Project Number K5/1060 (2002) for Rietvlei Station (South African Weather Bureau (SAWB) Number 0328800_W) for the catchments in and around the project area. For the two large catchments (C_N3 and C_N3b2) the design rainfall figures for Senekal (AGR) SAWB No 0330199_W were used.
- The considered rainfall stations are:
 - Rietvlei (SAWB No. 0328800_W) with MAP of 518mm;

- Senekal (SAWB No. 0553762 W) with MAP of 625mm;
- The catchment areas were delineated using the 30 m SRTM DEM topographical data, using QGIS software.
- The project area is located in SDF Basin number 7, Veld type zone 4 and Kovács region K4 (K=4.6).
- The design flood peaks for 1 in 100-year return periods were then estimated using the above inputs.
- The peak floods were calculate using an inhouse developed spreadsheet for the Rational Methods.
- The Utility Programs for Drainage Software (from University of Pretoria), developed specifically for South African rainfall conditions, was used to calculate the flood peaks for the UHG, SDF and Empirical Calculations.

5.2 Topographical Data

The client provided a topographic survey of the project area.

The survey data was provided in GeoTiff format and 0.50m contour ESRI shapefiles, providing sufficient accuracy for the scale of the project. The survey data, procured from GeoSmart Space, Centre for Geographical Analysis (CGA), Stellenbosch University, was received on 25 May 2026. The provider states that the vertical accuracy of the survey data is 0.5m MAE (mean absolute error).

Note: The floodline maps provided in this study are dependent on the quality and accuracy of the topographical data provided, however SMEC took all the necessary steps to apply best engineering judgment to produce the flood maps as accurately as possible.

5.3 Climate Data

5.3.1 Current Climate Conditions

The climate of the study area is characterised by dry winters and wet summers. The warmest months in the region occur between November and February and the coldest months occur between May and August. Average annual maximum temperature is approximately 28 °C per annum, according to the National Centre for Environmental Information (NCEI). The main characteristics are shown in Table 5-1 below:

Table 5-1: Long-term average minimum and maximum temperatures

Month	Max. Temp (°C)	Min. Temp (°C)
Jan	32	17
Feb	32	17
Mar	30	15
Apr	27	11
May	24	6
Jun	20	3
Jul	20	2
Aug	24	5
Sep	28	9
Oct	30	13
Nov	31	14
Dec	32	16
Average	28	11

The Rietvlei rainfall station is located approximately 9.5 km south from the centre of the project area. The Mean Annual Precipitation (MAP) for the project area is 518 mm based on the Rietvlei SAWS number 0328800_W rainfall station data. This station has a 61-year record. This station was applied to peak flow calculations involving the smaller catchment areas (C_SW1 1a & 1b, C_NW2 and C_N3a) nearest to the station.

Catchment areas C_N3 and C_N3b are draining from well outside of the project with the Senekal (AGR) SAWS Number 0330199_W rainfall station central to these catchments. The Senekal (AGR) rainfall station has a 94-year record. The MAP (625 mm) and rainfall depth was applied to determine the peak run-off for catchments C_N3 and C_N3b.

The 24-hour storm rainfall depths for various return periods at the stations are presented in Table 5-2.

Table 5-2: Design Rainfall - 24-hour Rainfall Depths at Rainfall Stations within the Project Area (mm)

Rainfall Station	Return Period (years)					
	2	5	10	20	50	100
Senekal (AGR)	48.2	64.2	75.5	86.9	102.6	115.1
Rietvlei	46.1	62.3	73.5	84.7	99.8	111.6

5.3.2 Future Climate Conditions

5.3.2.1 Baseline Climate

The following information on climate change was extracted from a report for a nearby development, of which climate data was provided by Airshed Climate Change Experts.

Climate change metrics focused on temperature; the number of very hot days (where the maximum temperatures exceed 35°C); rainfall and extreme rainfall events (more than 20 mm of rain occurring within 24 hours).

The baseline (1961 to 1990) annual averages for these metrics were accessed for the area near the project site from the South Africa 'Green Book' (CSIR, 2019). The metrics include three percentiles (10th, 50th, and 90th) as an indication of the variability within the measured data set.

The baseline annual average temperature was in the range 16.1°C (10th percentile) and 16.3°C (90th percentile) with the number of very hot days varying between 2 (10th percentile) and 4.5 (90th percentile) days per year. The annual average rainfall range between the 10th and 90th percentiles is 1 079 mm and 1 168 mm. Extreme rainfall days varied between 12.4 (10th percentile) and 13.8 (90th percentile) days per year.

Recent change in climatic conditions near the project site were accessed from MeteoBlue a weather forecasting platform developed at the University of Basel, Switzerland. Based on a point selected over the project site, an increasing trend in the annual average temperatures have been observed from 16.9°C in 1979 to 17.5°C in 2023. The change in rainfall over the same period (1979 – 2023) displays a slight decreasing trend from 646 mm in 1979 to 555 mm in 2023.

5.3.2.2 Projected Climate Change

The projected climate change is modelled using Representative Concentration Pathways (RCP).

RCP 4.5 is described by the Intergovernmental Panel on Climate Change (IPCC) as a moderate scenario in which emissions peak around 2040 and then decline. It assumed that effective mitigating measures will be implemented.

RCP 8.5 is the highest baseline emissions scenario in which emissions continue to rise throughout the twenty-first century. It should be noted that current conditions and emissions are tracking closely to the RCP 8.5 pathway, indicating a trajectory towards higher greenhouse gas concentrations and more pronounced climate impacts in the future.

5.3.2.2.1 RCP4.5 Trajectory

The Green Book (CSIR. 2019. Green Book: Adapting South African settlements to climate change. Available at: www.greenbook.co.za) projected temperature changes in the near future (2021 to 2050) indicate a 50th percentile increase of 2.3°C and a 90th percentile increase of 2.8°C (Engelbrecht, et al., 2019). The number of very hot days are expected to increase by 9.7 days per year (50th percentile) to 15.1 days per year (90th percentile). Between 2021 and 2050 the **annual rainfall near the project site is projected to increase by 180 mm** (50th percentile) (Engelbrecht, et al., 2019), with extreme rainfall days potentially increasing by 1.7 days (50th percentile) in the near future (Engelbrecht, et al., 2019).

5.3.2.2.2 RCP8.5 Trajectory

The Green Book projected temperature changes in the near future (2021 to 2050) indicate a 50th percentile increase of 2.6°C and a 90th percentile increase of 3.2°C (Engelbrecht, et al., 2019). The number of very hot days are expected to increase to 17.1 days per year (50th percentile). Between 2021 and 2050 the **annual rainfall near the project site was projected to increase by 200 mm** between 2021 and 2050 (50th percentile) (Engelbrecht, et al., 2019), with extreme rainfall to increase by 1.5 days (Engelbrecht, et al., 2019).

This trajectory suggests that the expected increase will realize over the intermediate-term period (approximately 30 years). It is not every year that will have the increase, but rather over that period the annual rainfall could go up by 180-200 mm.

Conclusion

Both the RCP 4.5 and RCP 8.5 scenarios project similar increases in Mean Annual Precipitation (MAP) over the next 30 years. Given this convergence in projected rainfall trends, a uniform increase of 200 mm has been adopted as a representative estimate. This adjustment is considered to effectively capture the potential climate change impacts on rainfall within the project area, reflecting the influence of both emission pathway trajectories. By using this approach, the analysis ensures a balanced and comprehensive assessment of future hydrological conditions, accounting for projected climate variability under both moderate and high-emission scenarios.

5.4 Adjustment for Climate Change

When assessing the impacts of climate change on floodlines, it is important to understand what the likely impact of climate change is on the peak flow rates generated by rainfall events. Flow rates directly impact the extent of floodlines and must be assessed under climate change conditions then.

For this reason, it is then important to understand the main parameters that impact the value of peak flows/runoffs as determined using rainfall/runoff models.

The most common and widely accepted rainfall/runoff model used in South-Africa and Internationally as well, is the Rational Method, which also forms the basis of the SDF method used and selected for the design case on this project.

The Rational Method is a simple formula stating that the peak flow/runoff (Q-value) is a function of three main parameters, i.e. the catchment characteristics or C-value, the rainfall intensity or I-value and the area of the catchment or A-value. When these are multiplied (using appropriate units), the peak flow rate Q is determined, refer to Equation 5-1: Rational Method Formulae

for the Rational Method Formulae.

$$Q = C i A$$

Equation 5-1: Rational Method Formulae

For South-Africa, the Rational Method has been calibrated whereby the catchment characteristic (C-value) is a function of the MAP of the catchment. Since the climate change studies discussed earlier, suggest an increase in the MAP for the Project Area, there is therefore an expected increase in the catchment characteristic C-value for the catchment too. For example, higher MAP areas have typically higher soil moisture content and therefore higher

runoff resulting from rainfall. Higher runoff means an increase in stream flow rates and therefore floodlines of larger extent.

Refer to the next chapter for the calculation of the derived impact of Climate Change (higher MAP) on the C-value and therefore the peak flows.

Over and above the relationship between the MAP and the C-value, the Consultant has illustrated that there is also a relationship between the MAP and the rainfall depth and thus rainfall intensity (I-value) in the Rational Formulae. This relationship means a relationship between the runoff/peak flow (Q-value) and climate change through the MAP rainfall depth/intensity relationship.

Refer to the next chapter where it is illustrated how both the C-value and the I-values of the Rational Method was correlated with the mean annual precipitation and therefore a Rational Method based assessment of the impacts of climate change on the runoff/peak flows for the Project Area.

5.4.1 MAP vs 100 Year 24-hour Rainfall Depth

5.4.1.1 Increase in Rainfall Depth

In a recent study by Airshed Planning Professionals (2017) for a nearby gas development located within the same major catchment, rainfall data was analysed for approximately 20 rainfall stations in the area.

The conclusion drawn was that a direct relationship exists between the rainfall depth and the mean annual precipitation of the area. The relationship showed that for an anticipated increase in MAP of 200mm as per the adopted climate change model, the rainfall depth will increase by about 4% as the catchment becomes wetter on average (larger MAP).

The same 4% increase in rainfall depth is proposed for the D3 Energy Development being adjacent to the said nearby gas development and being in the same hydrological catchment.

5.4.1.2 Increase in Run-Off Coefficient

Three factors namely surface slope, ground permeability and vegetation cover and density determine how much of rain is retained on the surface during and after a rainfall event. Separate coefficients are assigned to these three factors as shown in Figure 5-2 below (Table 3C.1 – SANRAL Drainage Manual) making up the combined C-factor as explained earlier with the Rational Method Formulae. The higher coefficients indicate that less of the rainfall is retained and that more rainfall runs off and enters the streams or rivers.

For the Rational Method application, the run-off or catchment characteristic coefficients (C-values) are separated into columns representative of three rainfall ranges. Project areas with a MAP of 600mm and less will be drier, and the ground is expected to absorb more of the initial rainfall than in the higher rainfall area where the ground surface is expected to be already partially saturated at the start of the rain event, resulting in larger runoff and therefore increase runoff/peak flow rates.

Table 3C.1				
Rural (C₁)				
Component	Classification	Mean annual rainfall (mm)		
		600	600 - 900	900
Surface slope (C_s)	Wetlands and pans (<3%)	0,01	0,03	0,05
	Flat areas (3 to 10%)	0,06	0,08	0,11
	Hilly (10 to 30%)	0,12	0,16	0,20
	Steep areas (>30%)	0,22	0,26	0,30
Permeability (C_p)	Very permeable	0,03	0,04	0,05
	Permeable	0,06	0,08	0,10
	Semi-permeable	0,12	0,16	0,20
	Impermeable	0,21	0,26	0,30
Vegetation (C_v)	Thick bush and plantation	0,03	0,04	0,05
	Light bush and farm-lands	0,07	0,11	0,15
	Grasslands	0,17	0,21	0,25
	No vegetation	0,26	0,28	0,30

Figure 5-2: Table 3C.1 extracted from SANRAL Drainage Manual

The MAP for the project area is between 518 mm and 625 mm before application of climate change and falls mostly within the 600mm range but when considering the future up to the year 2050 the MAP increases to a value corresponding with the 600 – 900 mm MAP range. The run-off / catchment characteristic coefficient increases consequently. Total run-off coefficient (C-value or C₁) was adjusted from the 600mm MAP range to the 600-900mm range by applying the Surface Slope (C_s), Permeability (C_p), and Vegetation (C_v) in area proportional ratios to arrive at an overall combined C-factor for the increased MAP under Climate Change Conditions.

Again, for the neighbouring gas development facility, the increase in C-factor as a result of the MAP increasing by 200mm per year resulted in a value of 40%. This means that 40% more flow as a combined impact of wetter climate (higher MAP) on the topography in question, the permeability of soils and the vegetation for the project will likely be seen.

Combining the 4% increase in rainfall depth and estimated 40% increase in runoff results in an overall increase in runoff of 46% for the project area.

5.4.2 Conclusions on Climate Change Impacts

For additional insights, a recent report by S. Schütte, R.E. Schulze, and D.J. Clark, titled "A National Assessment of Potential Climate Change Impacts on the Hydrological Yield of Different Hydro-Climatic Zones of South Africa - Report 1: Methodology and Results," was reviewed. This report affirms the data from Airshed, confirming that higher MAP values are expected in the project area in the future.

Based on this, it is concluded that the projected higher MAP values from climate change studies (RCP 4.5 and RCP 8.5) should guide adjustments to runoff and peak flow values. These adjustments are essential for assessing the impact of climate change on flood levels and flood lines in the future.

Additionally, the well-established relationship between runoff/peak flows and key catchment characteristics—such as the C-value (runoff coefficient) and the rainfall depth/intensity (I-value)—as defined by the internationally recognized Rational Method, which underpins the SDF method, provides a robust framework for evaluating the impacts of increased MAP on flood lines within the project area.

5.4.3 Recommendations on Climate Change Impacts

The recommendation adopted in this report was to implement the impact of climate change on the runoff from the catchments draining to the rivers in question for which floodlines were delineated.

Rainfall and runoff coefficients were modified to reflect the estimated 46% increase in runoff to obtain the most relevant floodlines for the project. All flood estimation methods considered for the project rely on rainfall data and some form of catchment runoff or catchment response parameter, both of which are predicted to increase under climate change conditions, for this reason all flood estimation methods are recommended to be adjusted for climate change impacts as assessed and quantified in this report.

5.5 Peak Flow Volumes

5.5.1 Peak Flow Rates with Climate Change

The peak flows as reflected in Table 5-3 include for the impacts of climate change as quantified in this report.

Table 5-3: 1:100year Peak Flow Rates (m³/s) - Projected Climate Change

Flood Estimation Method	Peak Flowrates (m ³ /s)						
	C_NW2	C_SW1	C_SW1a	C_SW1b	C_N3	C_N3a	C_N3b
Standard Design Flood (SDF)	404	888	378	682	3731	577	3589
Rational Method 2	201	362	166	277	1417	242	1362
Rational Method 3	127	309	129	237	1748	221	1680
Unit Hydrograph (UHG)	187	510	176	369	1846	318	1792
Empirical - Midgley and Pitman	160	445	178	337	2766	298	2670
Empirical – Regional Maximum Flood	254	601	326	485	3923	482	3851

The climate change SDF peak flow rates as tabulated above were accordingly implemented into the hydraulic model for assessing the most relevant floodlines for the project.

6. Floodline Modelling

The river hydraulics were modelled using the GeoHEC-RAS software suite, developed by CivilGEO Engineering Software. The software utilises the widely used one-dimensional HEC-RAS river hydraulics engine, developed by the US Army Corps of Engineers. The floodlines are based on static flow conditions and do not reflect any additional water rise, due to possible dam break events, in the upstream catchment area. Flood modelling was undertaken for the sections of the above-mentioned rivers that lie within or near the project area boundary.

6.1 Channel Roughness

Channel roughness values are physical parameters describing the irregularity of the surface within a particular stream/river that impacts the water depth, velocity and therefore energy and momentum of water moving from upstream to a downstream location.

Manning's Roughness coefficient/values (n) were estimated using a visual assessment of Google Earth aerial photograph maps and site photographs and interpreted from the Composite Table and Diagram extracted from SANRAL Drainage manual, 6th Edition as shown in Figure 6-1.

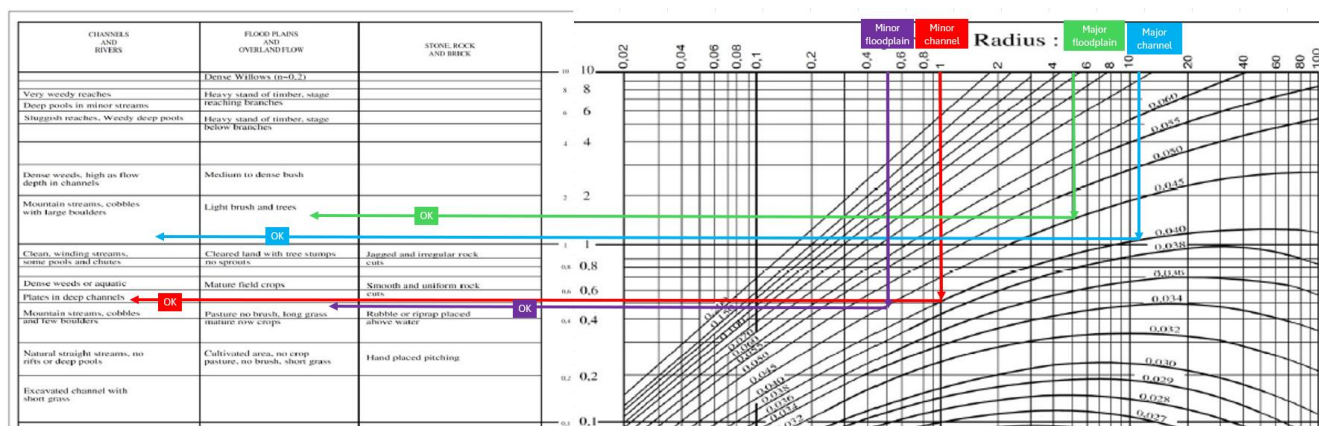


Figure 6-1: Composite Table and Diagram extracted from SANRAL Drainage manual, 6th Edition

Table 6-1: Manning's Roughness Coefficient/values

River Reaches	Left Bank	Channel	Right Bank
Sand River	0.045	0.040	0.045
Doring River	0.045	0.040	0.045

The values above represent the average Manning's roughness values across the rivers inside the project area. Generally, every section along a natural river has a different manning's roughness due to its irregular nature. The following figures indicate the channel characteristics at each of the rivers.



Figure 6-2: Typical Project Area Channel Characteristic

6.2 River Hydraulic Model

6.2.1 Bridges and River Structures

There were no bridges identified in the project area, but there were a few culverts. Most of the culverts were small, which is expected, based on the type of roads found in the vicinity. There are two larger roads which have slightly more robust culverts, and these were assessed more closely. An HY8 model (a culvert capacity analysis software) was created to assess the hydraulic capacity of these culverts and compare that to the peak flowrate in the relevant streams. In all cases it was seen that the culvert capacity could not pass the 1:100-year flowrate, and the roads would therefore be overtopped. Based on this assessment it was decided not to include the culverts in the GeoHEC-RAS model, which results in the software routing floodwater over the road surface (picked up from the surveyed DEM), rather than through the culvert. This is a conservative approach and is deemed a reasonable assumption for this level of floodline study. The same level of flooding of the roads would be seen if the culverts were blocked with debris, which is quite possible.

6.2.2 Boundary Conditions

The normal depth condition was used as the downstream and upstream hydraulic controls / boundaries for all river sections modelled.

6.3 Results

The peak flows estimated by the SDF method as presented in Section 5 were used to simulate the floodlines of the rivers running through the Motuane project area. The floodlines are indicated in

Figure 6-3 below. Refer to Appendix C for a larger image.

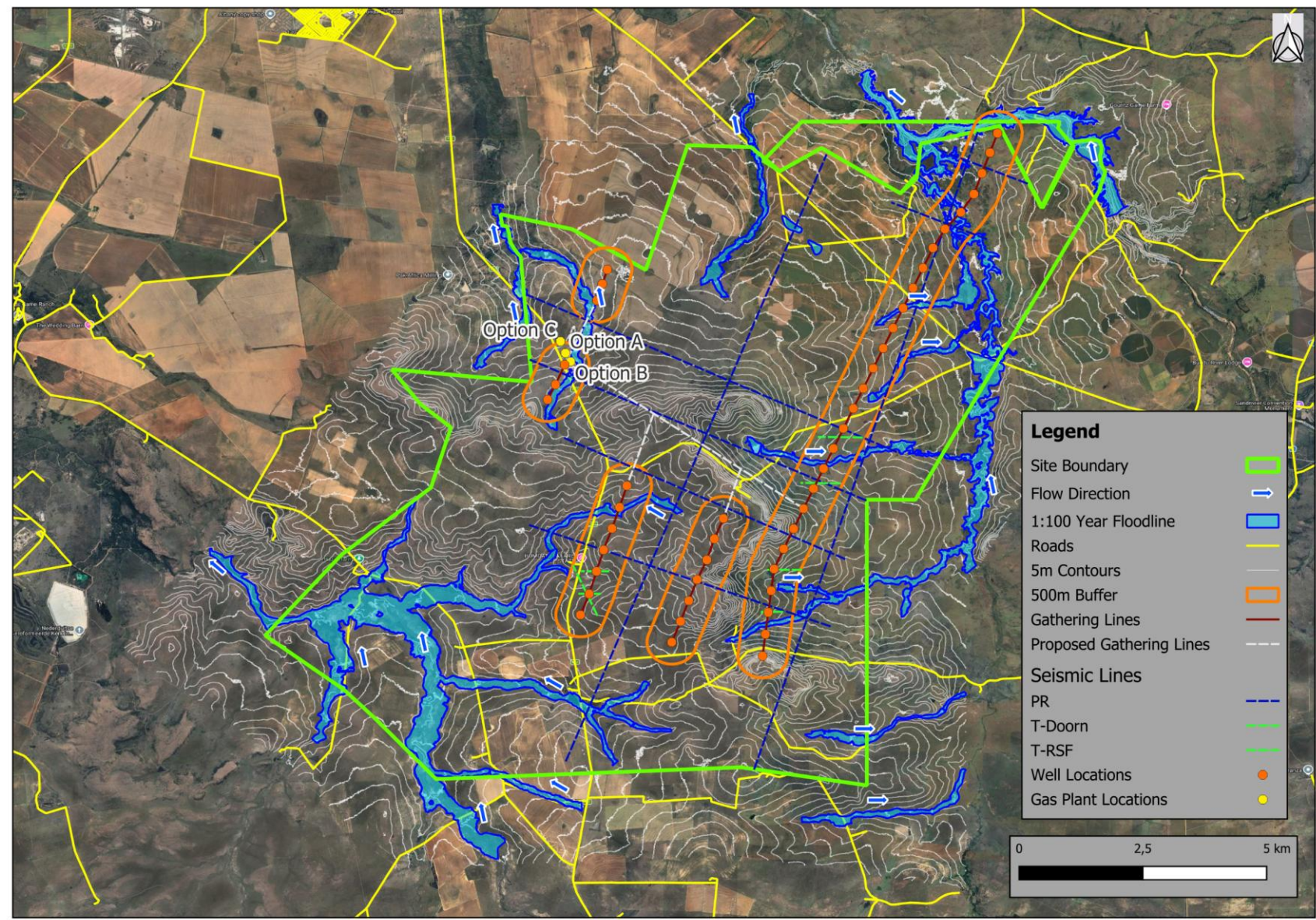


Figure 6-3: 100-Year Floodlines incorporating Climate Change.

7. Site Sensitivities

The sensitivities and constraints at the Motuoane project site were assessed in accordance with the National Water Act Regulations (GN509, 2016) and the EIMS sensitivity assessment methodologies.

Based on the National Water Act (GN509, 2016) described in Section 3, the area within the 1:100-year floodline is considered to be highly sensitive. A well site may not be located within the 1:100-year floodline. It is also recommended that the production plant (location A,B or C) is located outside the delineated 1:100-year floodline.

Figure 7-1 indicates a sensitivity map which was developed to assist in identifying sensitive features in relation to the 1:100-year flood within the project area with consideration for climate change impacts.

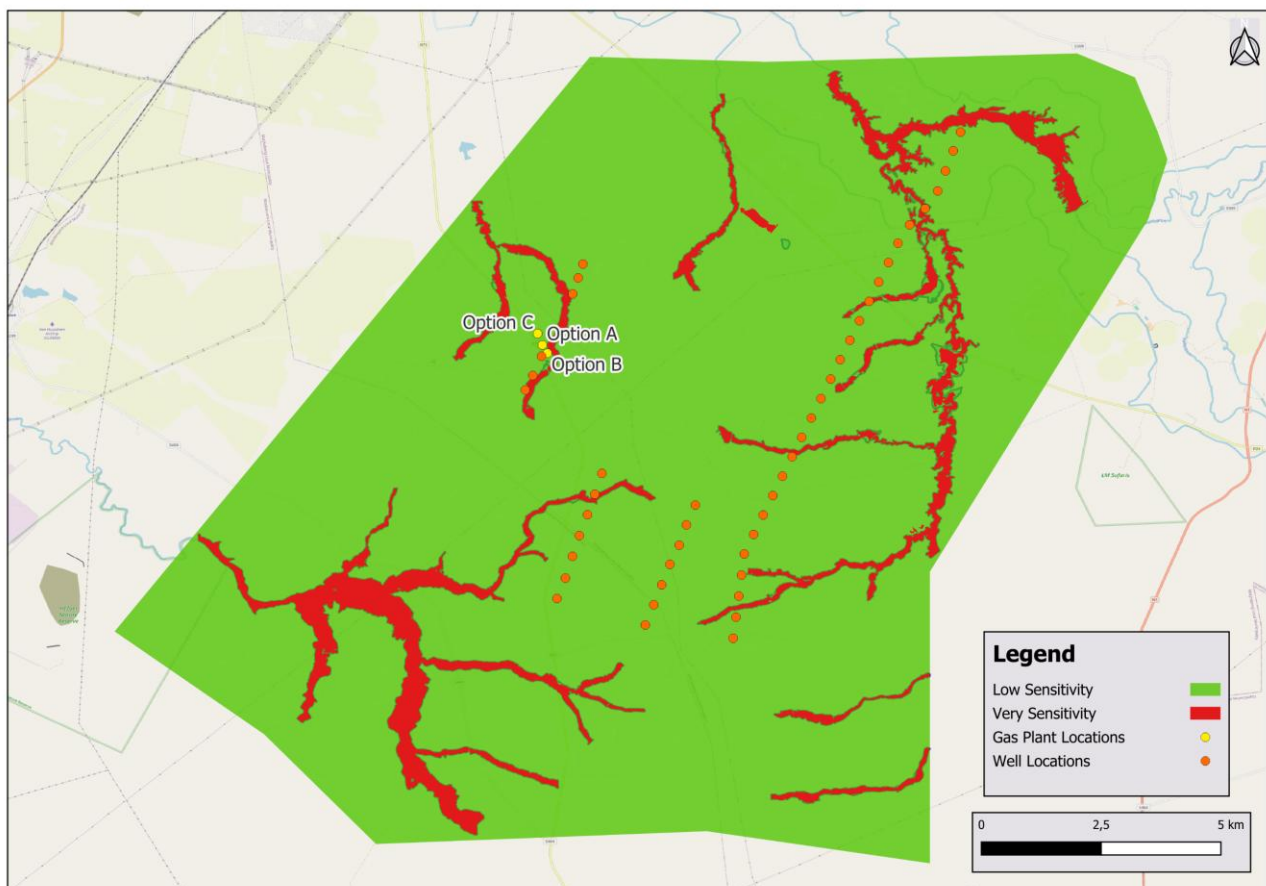


Figure 7-1: Hydrology Sensitivity Map

According to Figure 7-1 there is an estimated 8 gas wells located within or close to the very high sensitivity area (1:100-year floodline) of the project which would form part of the overall analysis and approval of placing final well infrastructure to be determined by the Client/Developer.

8. Conceptual Stormwater Management Framework

8.1 Purpose and Objectives

This document provides a conceptual stormwater management framework to guide the detailed design of stormwater systems for the proposed Motuoane development.

The objective is to ensure that:

- Post-development runoff does not adversely impact the natural environment
- Water quality is protected from contaminants
- Erosion and sediment transport are controlled
- Sensitive areas (e.g. watercourses, floodlines) are protected
- Lifecycle impacts (construction, operation, decommissioning) are addressed

The Design Engineer shall use this document to develop a detailed, compliant stormwater system for environmental approval.

8.2 Development Components

The stormwater design must address the following infrastructure components:

Table 2: Infrastructure Components

Component	Description
Production Plant	Processing facilities, hardstands, roads, storage and tanks
Wells	Distributed well pads and drilling areas
Pipelines	Connections between wells and plant, including river crossings

8.3 Sitewide Stormwater Design Principles

The following overarching principles shall apply:

8.3.1 No-Go Areas

- All watercourses with suitable buffers outside must be treated as strict no-go areas
- Floodlines (as confirmed by detailed flood studies) must be treated as strict no-go areas
- No stockpiling, access tracks or infrastructure within sensitive riparian zones
- All areas defined as wetlands

8.3.2 Floodline Compliance

- All permanent infrastructure must be located outside the 1:100-year floodline (minimum) as calculated
- River crossings must be designed to not increase upstream flood levels or increase scouring of the river channel or banks

8.3.3 Stormwater Infrastructure

- All road drainage infrastructure (cut-off drains, side drains, cross drains, culverts/bridges) must be designed to the selected return period storm applicable to the road class and traffic volumes, here the SANRAL Drainage Manual may be consulted.
- All high value building floor levels must be set to at least the 1:100-year floodline level or a defined height above the maximum stormwater hydraulic grade line in the vicinity of the building.

8.3.4 Conditional Constraint Areas

Areas where development is permitted subject to strict controls:

Table 3: Conditional Constraint Areas

Area	Controls Required
Watercourse crossings	Horizontal Directional Drilling HDD) preferred: minimal distance; reinstatement required
Flood fringe zones	Raised platforms, attenuation, erosion protection
Steep slopes	Cut-off drains, energy dissipation, revegetation
High groundwater zones	Controlled dewatering and discharge management

8.4 Construction Phase Stormwater Management

8.4.1 General Impacts

Construction activities will result in:

- Increased runoff and erosion due to exposed soils
- Sedimentation of watercourses where runoff is not managed
- Risk of hydrocarbon contamination
- Disturbance of riverbeds and banks
- Wastewater generation

8.4.2 Key Stormwater Design Requirements

The following design requirements apply to the distinct areas within the project footprint:

8.4.2.1 Production Plan

The following impacts and design requirements are specified for the production plant:

Table 4: Design Requirements (Production Plant)

Impact	Design Requirement
Hardened surfaces	Provide attenuation ponds; limit peak flows
Hydrocarbon contamination	Oil-water separators; bunded areas
Sediment runoff	Silt traps and vegetated swales
Wastewater	On-site treatment or controlled disposal

8.4.2.2 Wells

The following impacts and design requirements are specified for the wells:

Table 5: Design requirements (Wells)

Impact	Design Requirement
Drilling fluid contamination	Fully bunded well pads; lined containment systems
Runoff	Perimeter berms and collection ponds
Erosion	Immediate stabilisation of disturbed areas
Spill risk	Spill kits and emergency response protocols

8.4.2.3 Pipelines

The following impacts and design requirements are specified for the pipelines:

Table 6: Design requirements (Pipelines)

Impact	Design Requirement
River crossings excavation	Prefer Horizontal Directional Drilling (HDD) to minimise disturbance
Dewatering of trench excavations	Treat and filter before discharge
Sedimentation	Temporary sediment barriers and traps
Bank instability	Reinstate to near-natural condition

8.4.2.4 Mandatory Mitigation Measures

The following mandatory mitigation measures are stated:

Table 7: Mandatory Mitigation Measures

Issue	Requirements
Erosion	Minimise footprint; progressive rehabilitation where possible
Access control	Restrict machinery movement to designated routes
Pollution	Safe storage and disposal of construction waste
Vegetation	Remove alien species; rehabilitate with indigenous plants

8.5 Operational Phase Stormwater Management

8.5.1 General Impacts

- Ongoing erosion from maintenance activities
- Risk of pollution from hydrocarbon leaks
- Increased pollutant load in runoff
- Vegetation disturbance

8.5.2 Design Requirements

The following design requirements are set for the design of infrastructure and associated stormwater systems to ensure continued operation to minimize impact to the natural environment:

8.5.2.1 Production Plant

Table 8: Production Plant Design Requirements (Operational)

Impact	Design Requirements
Hardened area runoff	Permanent attenuation systems
Contamination	Oil separators and biofiltration
Water quality	Monitoring points at discharge locations

8.5.2.2 Wells

For the design of the wells, the following impacts will require corresponding design requirements as stated below:

Table 9: Wells Design Requirements (Operational)

Impact	Design Requirements
Surface runoff	Controlled drainage away from wellheads
Maintenance disturbance	Stabilised access routes

8.5.2.3 Pipelines

For the design of pipelines, the following impacts will require corresponding design requirements as stated below:

Table 10: Pipelines - Design Requirements (Operation)

Impact	Design Requirements
Maintenance activity impacts	No equipment access in watercourse
Leak detection	Monitoring system and isolation valves
Erosion along route	Regular inspection and maintenance

8.5.3 Operational Controls

The following operational controls are set to ensure proper operation of the infrastructure from a stormwater perspective:

Table 11: Operational Controls

Requirement	Implementation
Inspection	Routine inspection of stormwater infrastructure
Post-rain checks	Inspection after storm/flood events
Waste Management	Controlled disposal of oils and hazardous waste
Vegetation Control	Ongoing alien species removal

8.6 Decommissioning Phase of Stormwater Management

8.6.1 General Impacts

- Increased erosion due to vehicle movement
- Risk of contaminated groundwater release (where applicable)
- Disturbance of soils and vegetation

8.6.2 Design Requirements

The following design requirements for the system is proposed to ensure that stormwater aspects are properly managed during the decommissioning phase.

8.6.2.1 Production Plant

For the production plant the following applies:

Table 12: Production Plant - Design Requirements (Decommissioning)

Impact	Requirements
Removal of infrastructure	Controlled dismantling and drainage management
Surface rehabilitation	Regarding and revegetation

8.6.2.2 Wells

For the wells the following applies:

Table 13: Wells - Design Requirements (Decommissioning)

Impact	Requirements
Groundwater contamination	Proper well capping
Surface restoration	Reinstate to natural topography

8.6.2.3 Pipelines

For the pipelines the following impacts and requirements apply:

Table 14: Pipelines - Design Requirements (Decommissioning)

Impact	Requirements
Trench reinstatement	Backfill and compact to match natural conditions
Erosion risk	Install temporary and permanent stabilisation

8.6.3 Rehabilitation Requirements

The following rehabilitation requirements apply for the development of the design of the stormwater system removal after the intended life of the system.

Table 15: Rehabilitation Requirements

Requirement	Implementation
Topsoil Management	Stockpile and reuse for rehabilitation
Stabilisation	Use geotextiles where required
Revegetation	Indigenous species planting
Site restoration	Return to near-original condition

8.7 Erosion and Sediment Control Strategy

The Design Engineer responsible for the stormwater management development and stormwater system design shall include the following in the design:

- Silt fences/traps, sediment traps and attenuation ponds
- Energy dissipation structures at stormwater infrastructure outlets
- Vegetated swales and buffer strips for all river sections not carrying floodlines
- Progressive rehabilitation strategy

8.8 Water Quality Management

The management of water quality throughout the project lifecycle is critical, from construction through operation and decommissioning.

The following key requirements will apply in developing the stormwater system design:

- Separation of clean and dirty water systems
- Treatment of contaminated runoff
- Controlled discharge into natural systems
- Monitoring of water quality during all phases

8.9 Stormwater System Deliverables

The following deliverables will form part of the stormwater system design:

- Stormwater layout drawings
- Floodline delineation and compliance assessment
- Attenuation and hydraulic design calculations
- Water quality treatment system design
- Erosion and sediment control plans
- Construction and operational phase management plans
- Rehabilitation and decommissioning strategy

8.10 Recommendation and Way Forward

8.10.1 Stormwater Risks

The proposed development presents manageable stormwater risks, provided that:

- Environmental controls are implemented
- Disturbance is minimised
- Watercourses are protected
- Robust stormwater infrastructure is designed and maintained

In general, the impacts foreseen from a stormwater perspective are generally low provided mitigation measures are implemented effectively.

8.10.2 Indicative Stormwater Attenuation Storage

The production plant will cover an anticipated area of 1.5 ha, or 15,000m².

Adopting the following assumptions

- Predeveloped runoff coefficient = 0.4
- Post developed runoff coefficient (with some paving, gravel and other hard surfaces) = 0.8
- Time of centration = 0.5 hours (dependent on layout of plant – not yet available)
- 0.5 hour – 10-year return period storm = 37.2 mm
- 0.5 hour – 10-year storm intensity = 74.4 mm/hour
- Q (pre-developed) = 0.124m³/s
- Q (post-developed) = 0.248m³/s
- Assume that post developed peak is reduced to pre developed peak for attenuation sizing

Figure 8-1 illustrates that for the assumed hydrological parameters listed above for the Production Plant, an attenuation facility of approximately 350 m³ will be required to attenuation the post developed 1:10 year storm down to the pre-developed 1:10 year storm flow. Depending on the site layout, the attenuation may be split over more than one site, depending on the orientation and final location of the Production Plant site.

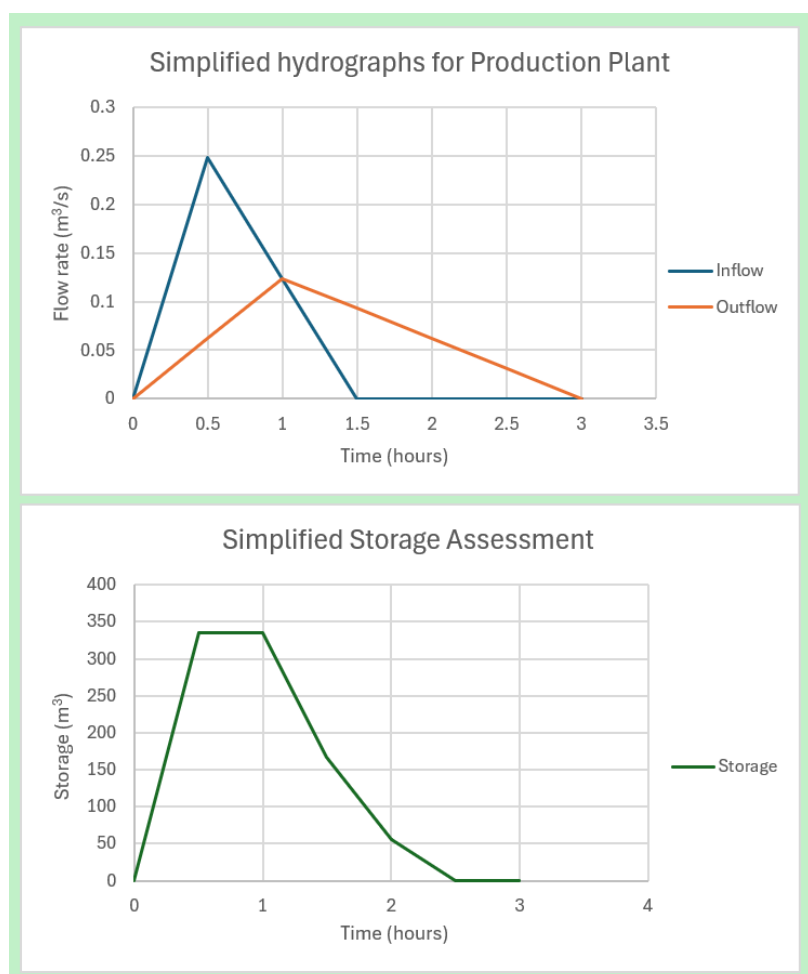


Figure 8-1: Stormwater Attenuation Volume

Appendix A - Maps



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