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Hydrological Assessment for additional listed activities and water uses relating to the development of the Sun Central Cluster 1 300 MW Solar PV facility (previously known as Phase 1) in the Northern Cape

Version - Final 1

09 January 2023

Ecoleges Environmental Consultants

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Client Reference: Sun Central Cluster 1

HYDROLOGICAL ASSESSMENT

Report
Version - Final 1

09 January 2023

Ecoleges Environmental Consultants

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LEGAL NOTICE

DECLARATION OF INDEPENDENCE

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

EXECUTIVE SUMMARY

GCS Water and Environment (Pty) Ltd (GCS) was appointed by Ecoleges Environmental Consultants (Ecoleges) to undertake a hydrology assessment for additional listed activities and water uses relating to the development of the Sun Central Cluster 1 300 MW Solar PV facility (previously known as Phase 1) in the Northern Cape.

As the current project scope has grown beyond what was originally foreseen for Phase 1 (now known as Sun Central Cluster 1), additional authorisations will be required to allow necessary road upgrades to the MTS, due to the size and weight of the MTS transformers and associated transport vehicles and to ensure compliance with Eskom's minimum road requirements. Additionally, a Cost Estimate Letter (CEL) issued by Eskom during the baseline S & EIA in 2016, made provision for Loop-In, Loop-Out (LILO) into the 400 kV transmission closest to the MTS (known as Line 2). Subsequently, Eskom has notified SolarAfrica Energy (SAE), that the project now needs to utilise Line 1, a parallel transmission line approximately 2.5 km away from Line 2 (refer to Figure 1). The project will initially utilise Line 2 and in future, due to the anticipated expansion of the MTS, also Line 1.

As additional activities, the following is also proposed:

- Floodlights and a telecommunications tower will be added to the Dx (Cluster 1 Switching Station) footprint and MTS footprint.
- A pipeline will be laid underground from BH13/BH14 and through an active channel (S21(c) & (i)) (a tributary of the Brak River) to an abstraction point located at the shortest distance to the nearest road. Boreholes 13 & 14 are alongside one another.

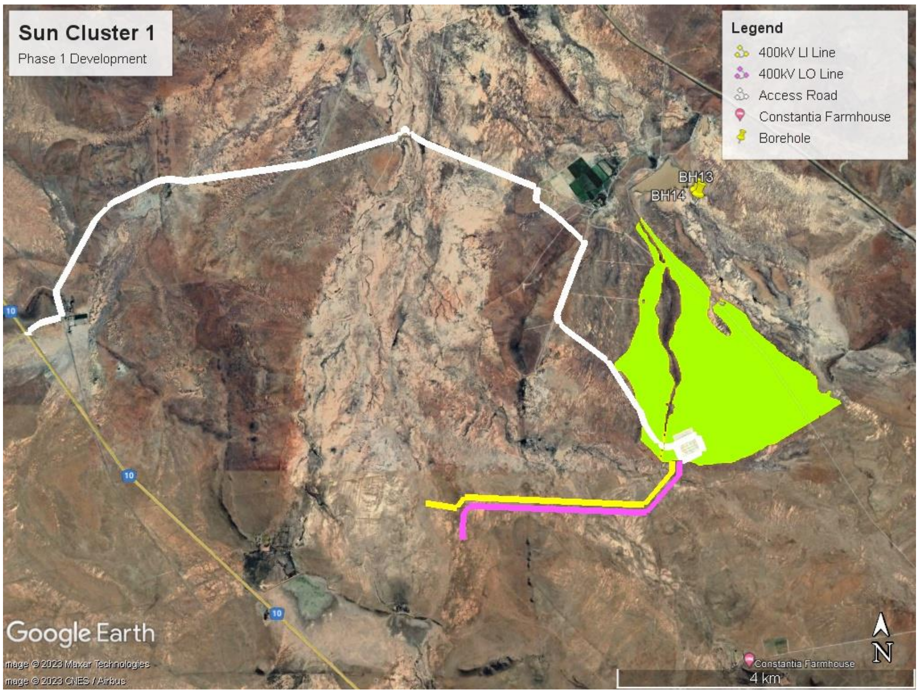

Figure 1 Access roads, LILO transmission lines and boreholes – Sun Cluster 1

The project falls within quaternary catchment D62D of the Orange Water Management Area (WMA) (DWS, 2016). This hydrological assessment and hydrological report are required to supplement the EIA and WULA for the proposed Phase 2 development.

Eight (8) hydrological response units (HRUs) describe the natural drainage for the study area. The HRUs delineated correspond well to known non-perennial rivers and drainage lines associated with the project area. Drainage in the HRUs is towards the northwest in the form of a multitude of non-perennial drainage lines, which drains towards the non-perennial Brak River, of which the proposed consolidated access road to MTS will cross. The Brak River and a tributary thereof (bounding the Sun Central 1 development) are the only recognised water courses in the area. Topography data and Google imagery were used to delineate several ephemeral drainage lines, which contribute to the overall drainage of the Brak River. It is observed that there are potentially eight (8) ephemeral drainage line crossings, associated with the proposed road and transmission line development

No clearly defined drainage channels could be located in the field. It was observed that the topography is such that there is drainage from various areas with no clearly defined flow paths. As such, sheet flow from micro-sub catchments towards lower topographical areas or isolated depressions form temporarily flooded areas. Irregular occurrences of ponded water were visible across the project area, even in areas with no defined drainage lines or stream channels.

The flood line assessment undertaken for the project area suggests that the area is prone to exhibiting ponded flood occurrence zone, in the absence of clearly defined drainage channels or streams. This is due to the micro-catchment style drainage associated with the project area (refer to Section 5).

The CSWMP indicates that:

- There are at least eight (8) non-perennial crossings, of which two (2) will require stormwater management.
- A box culvert and dampening system, as well as a concrete drift crossing, can be considered to manage stormwater, and prevent sedimentation and erosion.
- Free drainage is the preferred stormwater management option associated with this project.

The risk assessment for the construction phase of the project is considered marginal, with mostly reversible and manageable impacts. Erosion and sedimentation at crossings associated with the MTS, roadway and transmission lines are the largest risk areas. The risk of flooding, poor quality seepage via the vadose zone, and impacts on surface water quality are predicted to be marginal during the construction phase of the project, and zero during the operational phase. This is largely due to the absence of any surface water streams in the project area and the nature of the development.

A monitoring plan for both the proposed stormwater system and surface water resources identified in the area was drafted and is available in Section 6 and Section 8. Several recommendations that should be considered for the EMPr and EIA are presented in Section 9.

This hydrological assessment cannot find any grounds or identify high hydrological risks that prevent continuing with the development and licensing thereof. This is grounded on the assumption that the proposed mitigation measures (Section 7), CSWMP, EMPr and EIA recommendations are implemented during the construction and operational phase of the development.

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

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

Requirements from Appendix 6 of GN 326 EIA Regulation 2017	Chapter
(a) Details of: (i) The specialist who prepare the reports; and (ii) the expertise of that specialist to compile a specialist report including a curriculum vitae	Appendix D.
(b) Declaration that the specialist is independent in a form as may be specialities by the competent authority	Appendix C.
(c) Indication of the scope of, and purpose for which, the report was prepared	Section 1.
(cA) Indication of the quality and age of base data used for the specialist report	Sections 1, 2 and 3.
(cB) A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change	Section 7.
(d) Duration, Date and seasons of the site investigation and the relevance of the season to the outcome of the assessment	Section 1.4.
(e) Description of the methodology adopted in preparing the report or carrying out the specialised process include of equipment and modelling used	Section 2.
(f) Details of an assessment of the specifically identified sensitivity of the site related to the proposed activity or activities and its associate's structures and infrastructure, inclusive of a site plan identifying alternative	Sections 1, 4 and 7.
(g) Identification of any areas to be avoided, including buffers	Section 9.1.
(h) Map superimposing the activity and associated structures and infrastructure on environmental sensitivities of the site including areas to be avoided, including buffers	Section 1, 3.
(i) Description of any assumptions made and uncertainties or gaps in knowledge	Section 2, 4, 5.
(j) A description of the findings and potential implications of such findings on the impact of the proposed activity including identified alternatives on the environment or activities	Executive summary, Section 9.
(k) Mitigation measures for inclusion in the EMPr	Section 9.2
(l) Conditions for inclusion in the environmental authorisation	Refer to Section 9.
(m) Monitoring requirements for inclusion in the EMPr or environmental authorisation	Refer to Section 9.
(n) Reasoned opinion – (i) as to whether the proposed activity, activities or portions thereof should be authorised. (iA) regarding the acceptability of the proposed activity or activities; and (ii) if the opinion is that the proposed activity, activities or portions thereof should be authorised, and avoidance, management, and mitigation measures should be included in the EMPr, and where applicable, the closure plan	Section 9.3.
(o) Description of any consultation process that was undertaken during preparing the specialist report	*None required.*
(p) A summary and copies of any comments received during any consultation process and where applicable all responses thereto	*None required.*
(q) Any other information requested by the competent authority	*None required.*

CONTENTS PAGE

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF ACRONYMS

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

1 INTRODUCTION

GCS Water and Environment (Pty) Ltd (GCS) was appointed by Ecoleges Environmental Consultants (Ecoleges) to undertake a hydrology assessment for additional listed activities and water uses relating to the development of the Sun Central Cluster 1 300 MW Solar PV facility (previously known as Phase 1) in the Northern Cape (refer to Figure 1-2).

The project falls within quaternary catchment D62D of the Orange Water Management Area (WMA) (DWS, 2016). This hydrological assessment and hydrological report are required to supplement the EIA and WULA for the proposed Phase 2 development.

1.1 Project background

In 2016 Ecoleges undertook an S&EIA for the development of a 225 MW Solar PV facility between Hanover and De Aar in the Northern Cape. Three alternative footprints (PV01, PV02, PV03) were investigated during the assessment process. The central footprint (PV02) was identified as the preferred option because of its lower environmental impact and proximity to an existing 400kV Eskom powerline when compared with PV 01 and PV03. The National Department of Environmental Affairs granted an environmental authorisation (DEA Reference: 14/12/16/3/3/2/998) on 16th April 2018. This project was originally known as Phase 1.

An amendment to increase the capacity (not the footprint) of the facility to 300 MW due to technological advancements in solar photovoltaic efficiency and electrical output was granted on 24th November 2020.

A second amendment was granted in 2021 for the inclusion of containerised lithium-ion battery storage and dual-fuel backup generators with associated fuel storage as part of the Risk Mitigation Independent Power Producers Procurement Program (RMIPPPP).

The competent authority was the National Department of Environmental Affairs because the application was part of the REIPPPP or RMIPPPP BID rounds, which formed part of a Strategic Infrastructure Project (SIP) as described in the National Development Plan, 2011. Soventix SA (Pty) Ltd was an unsuccessful bidder.

Soventix is also currently busy with an application for environmental authorisation to develop an additional 300 MW on the PV03 footprint (Phase 2) that was considered during the initial S&EIA. It is proposed to connect this second phase to the substation that forms part of the authorised facility on PV02 (Phase 1).

Additionally, Soventix is also busy with an application for environmental authorisation to develop Phase 3, which involves the development of a third 400 MW Solar Photovoltaic (PV) facility on the remainder of Farm Goede Hoop 26C and Portion 3 of Farm Goede Hoop 26C. The two additional Solar PV facilities (Phase 2 and 3) will feed into the authorised Main Transmission Sub-station (MTS) on the Phase 1 footprint. Consequently, the expansion of the MTS, inclusion of a 132 kV switching yard, additional access road and staging area, requires a third Part 2 amendment to the existing environmental authorisation (EA Reference: 14/12/16/3/3/2/998), which is currently sitting with the competent authority for decision. The additional activities and associated infrastructure require additional water use authorisations in the form of General authorisation for specifically Section 21 (a), (b), (c), (i) & (g). Another Part 1 amendment is also currently underway following the sale of shares and project rights by Soventix SA to SolarAfrica Energy (SAE). Change of details and responsible party of the water use authorisations are also being applied for.

1.2 Proposed activities

As the current project scope has grown beyond what was originally envisaged for Phase 1 (now known as Sun Central Cluster 1), additional authorisations will be required to allow necessary road upgrades to the MTS, due to the size and weight of the MTS transformers and associated transport vehicles and to ensure compliance with Eskom minimum road requirements.

Additionally, a Cost Estimate Letter (CEL) issued by Eskom during the baseline S&EIA in 2016, made provision for Loop-In, Loop-Out (LILO) into the 400 kV transmission closest to the MTS (known as Line 2).

Subsequently, Eskom has notified SolarAfrica Energy (SAE), that the project now needs to utilise Line 1, a parallel transmission line approximately 2.5 km away from Line 2 (refer to Figure 1-1). The project will initially utilise Line 2 and in future, due to the anticipated expansion of the MTS, also Line 1.

As additional activities, the following is also proposed:

- **Floodlights** and a **telecommunications tower** will be added to the Dx (Cluster 1 Switching Station) footprint and MTS footprint.
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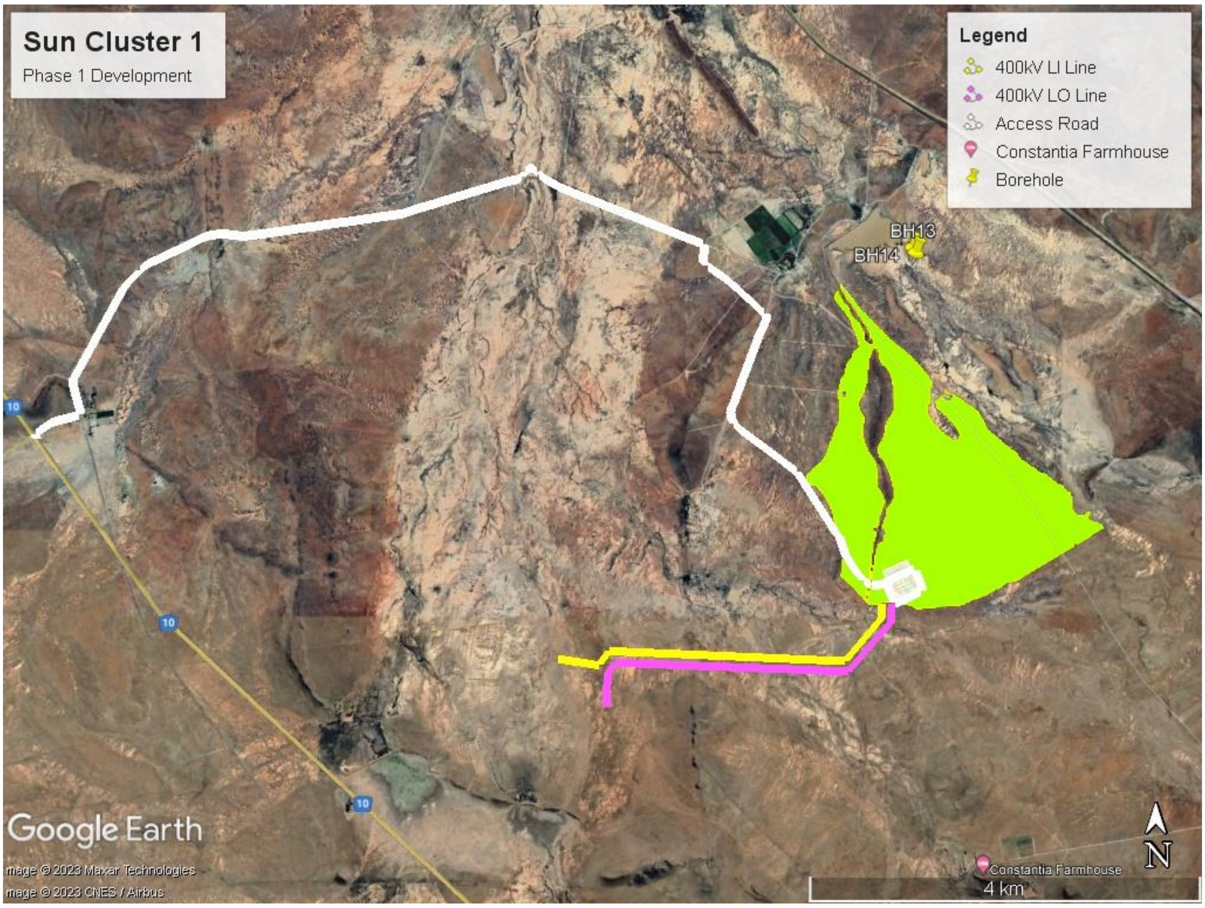

Figure 1-1: Access roads, LILO transmission line and boreholes - Sun Cluster 1

1.3 Objectives

The objectives of this study, were as follows:

- Evaluate the site's hydrological setting (i.e., climate, rainfall, drainage, etc.).
- Determine the 1:10, 1:20, 1:50, and 1:100-year peak flows for the drainage streams associated with the project area.
- Develop a conceptual stormwater management plan (CSWMP) to provide mitigative steps to circumvent erosion and control stormwater runoff.
- Undertake a hydrological risk assessment and compile mitigation measures; and
- Compile surface water and stormwater monitoring plan to monitor the impact on the receiving environment.

1.4 Scope of work

The scope of work completed, was as follows:

1. **Baseline Hydrology Review:**
    a. Hydro-meteorological data collection and analysis.
    b. Catchment delineation and drainage characteristics.
    c. Determination of catchment hydraulic and geometric parameters.
2. **Peak Flows & Flood Line Modelling:**
    a. Peak flood volume calculation for the 1:10, 1:20, 1:50, and 1:100-year recurring events.
    b. Flood line modelling using HEC-RAS hydraulic software – 1:50 and 1:100-year flood lines were presented; and
    c. Analysis of the modelling results.
3. **Conceptual Storm Water Management Plan and Stormwater Monitoring:**
    a. Identification of stormwater sub-catchments (i.e., clean, and dirty areas)
    b. Determination of stormwater flows and volumes (1:10, 1:20, 1:50 and 1:100- yr return periods) were undertaken.
    c. Indications and explanations of the placement of stormwater attenuation infrastructure were offered.
    d. A stormwater monitoring system plan was drafted, to ensure that the stormwater discharge impact on the environment is managed and controlled.
4. **Risk assessment:**
    a. A hydrological risk assessment was undertaken, to contextualize the potential surface water risk of the project.
5. **Surface Water Monitoring Plan:**
    a. A surface water monitoring plan was developed.
6. **Reporting:**
    a. This report was compiled, composing the components above.

1.5 Study relevance to the season in which it was undertaken

This study was undertaken as a once-off study and relies on historical hydrological and climate data for the site; as well as recognized hydrological and water resource databases for South Africa. Data generated during the time of this study is not seasonally bound, even though low, and high flow yield estimates were evaluated, as average yearly data was applied where required and as scientifically acceptable.

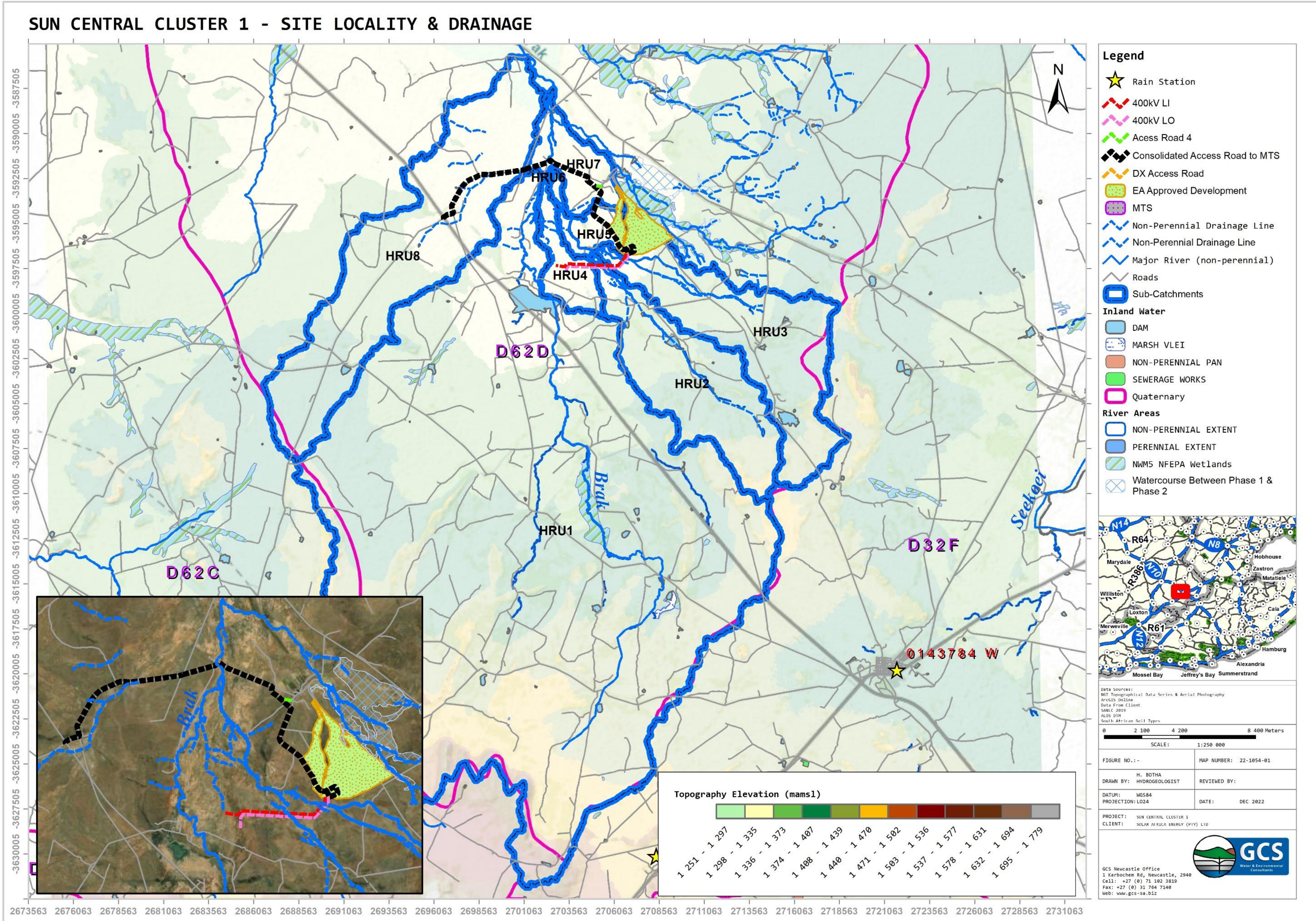

Figure 1-2: Site locality and drainage

2 METHODOLOGY

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

2.1 Legal considerations

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

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

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

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

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

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

Appendix 6 of GN 326 EIA Regulation 2017 regulations further govern hydrology assessments for EIAs. This hydrology report conforms to Appendix 6 of the EIA regulations, which include the following aspects (where applicable to this study) to be addressed:

(a) Details of:

(i) The specialist who prepare the reports; and

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

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

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

(p) A summary and copies of any comments received during any consultation process and where applicable all responses thereto.

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

2.2 Hydrological overview

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

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

2.2.1 Catchment description and delineation

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

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

2.2.2 Design rainfall and peak flow

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

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

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

Table 2-1: Summary of peak flow methods

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

2.3 Flood line modelling

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

2.4 Conceptual stormwater management plan (CSWMP)

The SWMP was designed in conjunction with the provided existing infrastructure layout plans and available topographical data. The Rational Method was applied to determine stormwater peak flows (sub-catchments < 15 km^2), and the SDF method for larger sub-catchments.

The conceptual SWMP was designed to consider relevant South African legislation – the National Water Act (1998) (NWA, 1998) and the Council for Scientific and Industrial Research (CSIR) Human Settlement Planning and Design guidelines (CSIR, 2005).

2.5 Hydrological risk assessment

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

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

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

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

Table 2-2 provides a summary of the criteria used to assess the significance of the potential impacts identified. An explanation of these impact criteria is provided in Table 2-3.

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

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

Environmental Significance = (Consequence x (Probability + Reversibility))

Table 2-2: Proposed Criteria and Rating Scales to be used in the Assessment of the Potential Impacts

Criteria	Rating Scales	Notes
Nature	Positive (+)	An evaluation of the effect of the impact related to the proposed development.
	Negative (-)	
Extent	Footprint (1)	The impact only affects the area in which the proposed activity will occur.
	Site (2)	The impact will affect only the development area.
	Local (3)	The impact affects the development area and adjacent properties.
	Regional (4)	The effect of the impact extends beyond municipal boundaries.
	National (5)	The effect of the impact extends beyond more than 2 regional/provincial boundaries.
	International (6)	The effect of the impact extends beyond country borders.
Duration	Temporary (1)	The duration of the activity associated with the impact will last 0-6 months.
	Short-term (2)	The duration of the activity associated with the impact will last 6-18 months.
	Medium-term (3)	The duration of the activity associated with the impact will last 18 months-5years.
	Long-term (4)	The duration of the activity associated with the impact will last more than 5 years.
Severity	Low (1)	Where the impact affects the environment in such a way that natural, cultural and social functions and processes are minimally affected.
	Moderate (2)	Where the affected environment is altered but natural, cultural and social functions and processes continue albeit in a modified way; and valued, important, sensitive, or vulnerable systems or communities are negatively affected.
	High (3)	Where natural, cultural, or social functions and processes are altered to the extent that the natural process will temporarily or permanently cease; and valued, important, sensitive, or vulnerable systems or communities are substantially affected.
Potential for impact on irreplaceable resources	No (0)	No irreplaceable resources will be impacted.
	Yes (1)	Irreplaceable resources will be impacted.
Consequence	Extremely detrimental (-25 to -33)	A combination of extent, duration, intensity, and the potential for impact on irreplaceable resources.
	Highly detrimental (-19 to -24)	
	Moderately detrimental (-13 to -18)	
	Slightly detrimental (-7 to -12)	
	Negligible (-6 to 0)	
	Slightly beneficial (0 to 6)	
	Moderately beneficial (13 to 18)	
	Highly beneficial (19 to 24)	
	Extremely beneficial (25 to 33)	
Probability (the likelihood of the impact occurring)	Improbable (0)	It is highly unlikely or less than 50% likely that an impact will occur.
	Probable (1)	It is between 50 and 70% certain that the impact will occur.
	Definite (2)	It is more than 75% certain that the impact will occur, or the impact will occur.
Significance	Very high - negative (-49 to -66)	A function of Consequence and Probability.
	High - negative (-37 to -48)	
	Moderate - negative (-25 to -36)	
	Low - negative (-13 to -24)	
	Neutral - Very low (0 to -12)	
	Low-positive (0 to 12)	
	Moderate-positive (13 to 24)	
	High-positive (24 to 48)	
	Very high - positive (49 to 66)	

Table 2-3: Explanation of Assessment Criteria

Criteria	Explanation
Nature	This is an evaluation of the type of effect the construction, operation, and management of the proposed development would have on the affected environment. Will the impact of change on the environment be positive, negative, or neutral?
Extent or Scale	This refers to the spatial scale at which the impact will occur. The extent of the impact is described as footprint (affecting only the footprint of the development), site (limited to the site), and regional (limited to the immediate surroundings and closest towns to the site). The extent of scale refers to the actual physical footprint of the impact, not to the spatial significance. It is acknowledged that some impacts, even though they may be of a small extent, are of very high importance, e.g., impacts on species of very restricted range. To avoid "double counting, specialists have been requested to indicate spatial significance under "intensity" or "impact on irreplaceable resources" but not under "extent" as well.
Duration	The lifespan of the impact is indicated as temporary, short, medium, and long-term.
Severity	This is a relative evaluation within the context of all the activities and the other impacts within the framework of the project. Does the activity destroy the impacted environment, alter its functioning, or render it slightly altered?
Impact on irreplaceable resources	This refers to the potential for an environmental resource to be replaced, should it be impacted. A resource could be replaced by natural processes (e.g., by natural colonization from surrounding areas), through artificial means (e.g., by reseeding disturbed areas or replanting rescued species) or by providing a substitute resource, in certain cases. In natural systems, providing substitute resources is usually not possible, but in social systems, substitutes are often possible (e.g., by constructing new social facilities for those that are lost). Should it not be possible to replace a resource, the resource is essentially irreplaceable e.g., red data species that are restricted to a particular site or habitat to a very limited extent.
Consequence	The consequence of the potential impacts is a summation of the above criteria, namely the extent, duration, intensity, and impact on irreplaceable resources.
Probability of occurrence	The probability of the impact occurring is based on the professional experience of the specialist with environments of a similar nature to the site and/or with similar projects. It is important to distinguish between the probability of the impact occurring and the probability that the activity causing a potential impact will occur. Probability is defined as the probability of the impact occurring, not as the probability of the activities that may result in the impact.
Significance	Impact significance is defined to be a combination of the consequence (as described below) and the probability of the impact occurring. The relationship between consequence and probability highlights that the risk (or impact significance) must be evaluated in terms of the seriousness (consequence) of the impact, weighted by the probability of the impact occurring. In simple terms, if the consequence and probability of an impact are high, then the impact will have a high significance. The significance defines the level to which the impact will influence the proposed development and/or environment. It determines whether mitigation measures need to be identified and implemented and whether the impact is important for decision-making.
Degree of confidence in predictions	Specialists and the EIR team were required to indicate the degree of confidence (low, medium, or high) that there is in the predictions made for each impact, based on the available information and their level of knowledge and expertise. The degree of confidence is not taken into account in the determination of consequence or probability.
Mitigation measures	Mitigation measures are designed to reduce the consequence or probability of an impact or to reduce both consequence and probability. The significance of impacts has been assessed both with mitigation and without mitigation.

2.6 Surface water and stormwater monitoring plan

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

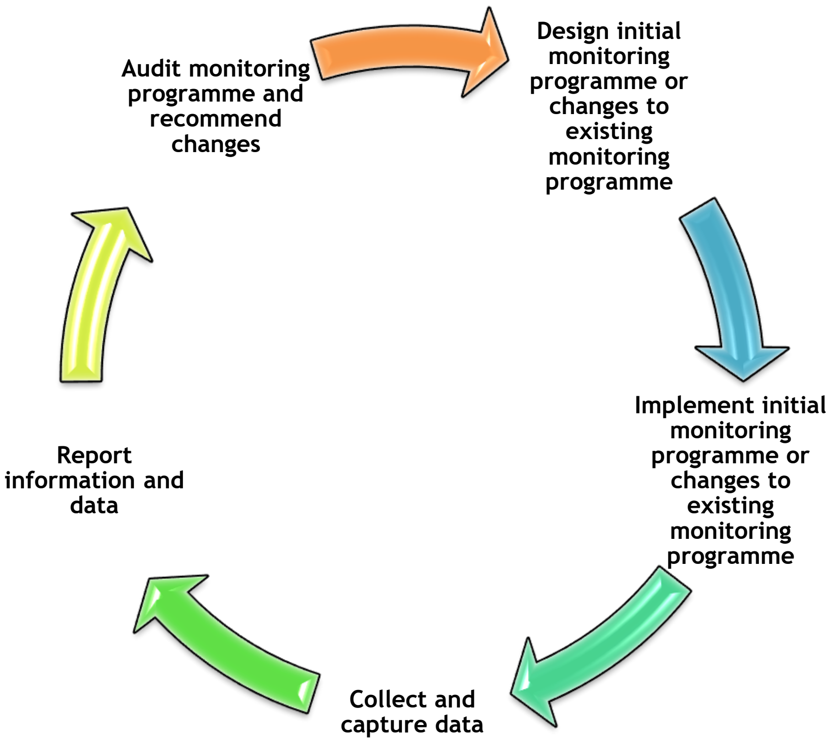


Figure 2-1: Monitoring Process

A surface water monitoring plan was drafted and is based on the hydrological risks identified for the site and stormwater/natural runoff from the site.

3 SITE OVERVIEW AND HYDROLOGY

As mentioned previously, the project falls within quaternary catchment D62D of the Orange Water Management Area (WMA) (DWS, 2016). The topography of the study area is generally flat with elevations on the site typically ranging from 1310 to 1370 metres above mean sea level (mamsl).

3.1 Sub-catchments / hydrological response units (HRUs)

Eight (8) hydrological response units (HRUs) describe the natural drainage for the study area (using a 1:10 000 stream count and 15 m DTM fill) – refer to Figure 1-2 and Figure 3-1. The HRUs delineated correspond well to known non-perennial rivers and drainage lines associated with the project area.

Drainage in the HRUs is towards the northwest in the form of a multitude of non-perennial drainage lines, which drains towards the non-perennial Brak River, of which the proposed consolidated access road to MTS will cross. The Brak River and a tributary thereof (bounding the Sun Central 1 development) are the only recognised water courses in the area. Topography data and google imagery were used to delineate several ephemeral drainage lines, which contribute to the overall drainage of the Brak River. It is observed that there are potentially eight (8) ephemeral drainage line crossings, associated with the proposed road and transmission line development (refer to Table 3-1).

A site walkover assessment was undertaken during the week of the 7 to 11th of March 2022 to confirm drainage lines and surface water resources. No clearly defined drainage channels could be located in the field. It was observed that the topography is such that there is drainage from various areas with no clearly defined flow paths. As such, sheet flow from micro-sub catchments towards lower topographical areas or isolated depressions forms temporarily flooded areas. Irregular occurrences of ponded water were visible across the project area, even in areas with no defined drainage lines or stream channels.

Table 3-1: Identified non-perennial river and stream crossings

Likely Crossing	Latitude (WGS84)	Longitude (WGS84)	Type	Activity
C1	-30.85154438	24.27633442	Non-Perennial River (Brak River)	Road
C2	-30.89347031	24.31485336	Ephemeral Stream	400kV LO Line
C3	-30.89311282	24.31384346	Ephemeral Stream	400kV LI Line
C4	-30.89698608	24.30286398	Ephemeral Stream	400kV LO Line
C5	-30.89596689	24.30165052	Ephemeral Stream	400kV LI Line
C6	-30.89463276	24.31368255	Ephemeral Stream	400kV LO Line
C7	-30.89422033	24.31275147	Ephemeral Stream	400kV LI Line
C8	-30.86251539	24.23307474	Ephemeral Stream	Road

3.2 Land cover and slope

Thicket low shrubland, fynbos, succulent karoo, natural lakes, natural rock surfaces and dune sand types dominate the sub-catchment (DEA, 2019) – refer to Figure 3-1. The land cover data were used to classify land types into 4 groups, as presented in Table 3-2. The slope rise (%) for each HRU was determined using an ALOS 30 m DTM and can be seen in Figure 3-2.

Table 3-2: Sub-catchments and summary of land cover types

Sub-Catchment		HRU1	HRU2	HRU3	HRU4	HRU5	HRU6	HRU7	HRU8
Area (km²)		405.09	40.471	48.329	9.40	6.99	0.21	12.63	77.34
Longest Drainage Line (km)		36.30	10.58	10.05	1.90	5.24	0.79	4.14	22.32
Average Slope (%)		0.38%	0.62%	0.49%	0.21%	0.34%	0.23%	0.21%	0.48%
Slope (%)	<3	70.61%	65.20%	74.73%	88.49%	87.46%	100.00%	91.80%	81.24%
	3-10	22.05%	30.61%	21.97%	8.97%	9.37%	0.00%	7.72%	16.20%
	10-30	5.42%	4.09%	2.67%	1.85%	2.30%	0.00%	0.48%	2.28%
	>30	1.92%	0.11%	0.63%	0.69%	0.87%	0.00%	0.00%	0.27%
Land Cover	Thick bush & plantation	70.90%	74.95%	70.31%	77.73%	73.28%	81.88%	68.28%	81.91%
	Light bush & farmlands	21.10%	17.37%	20.83%	20.00%	20.85%	17.63%	19.88%	13.04%
	Grasslands	1.42%	1.63%	4.19%	0.19%	0.00%	0.00%	1.19%	1.26%
	No Vegetation	6.65%	6.15%	4.69%	2.08%	5.88%	0.49%	11.71%	3.79%

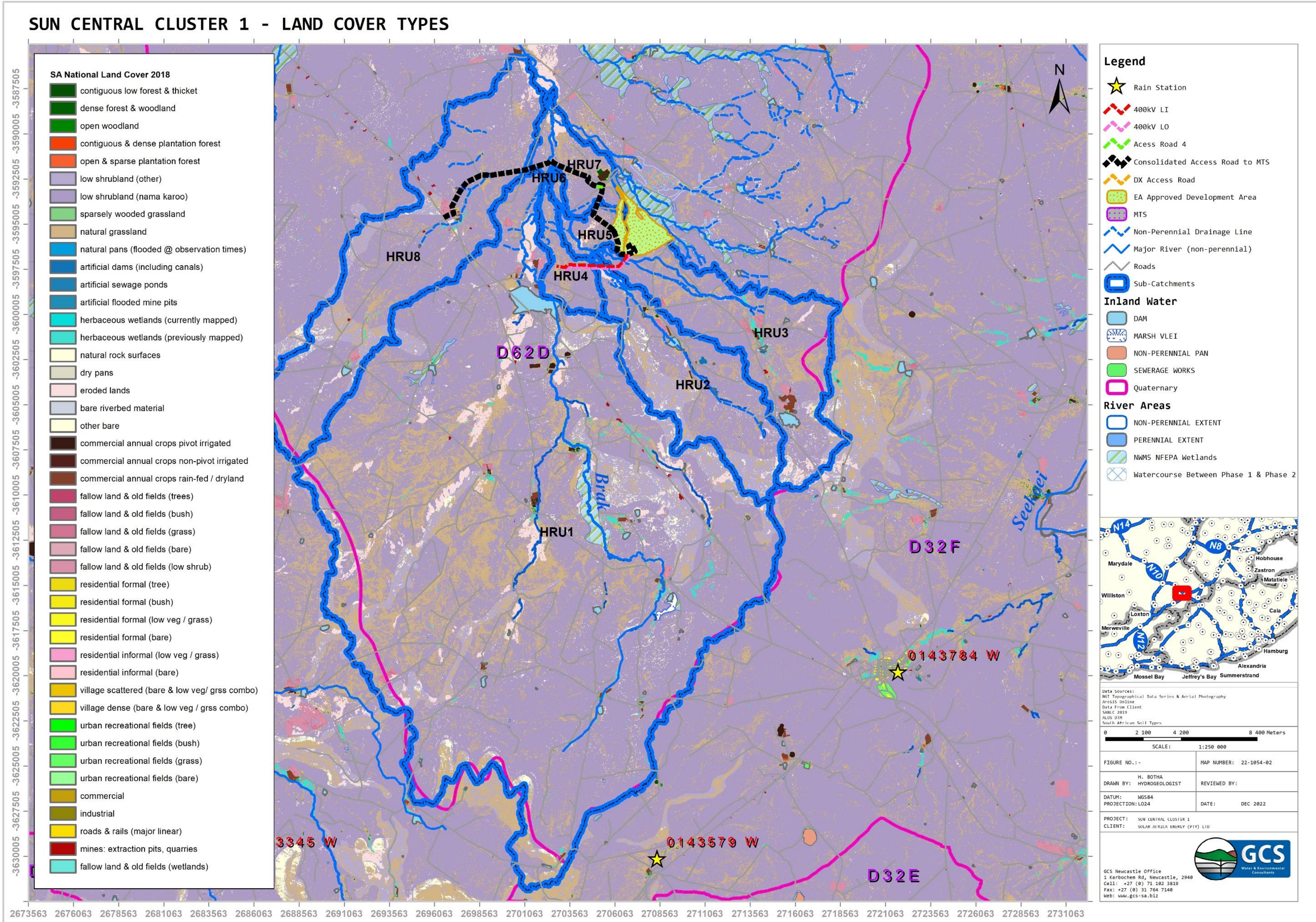


Figure 3-1: Sub-catchment land cover types (SANLC, 2019)

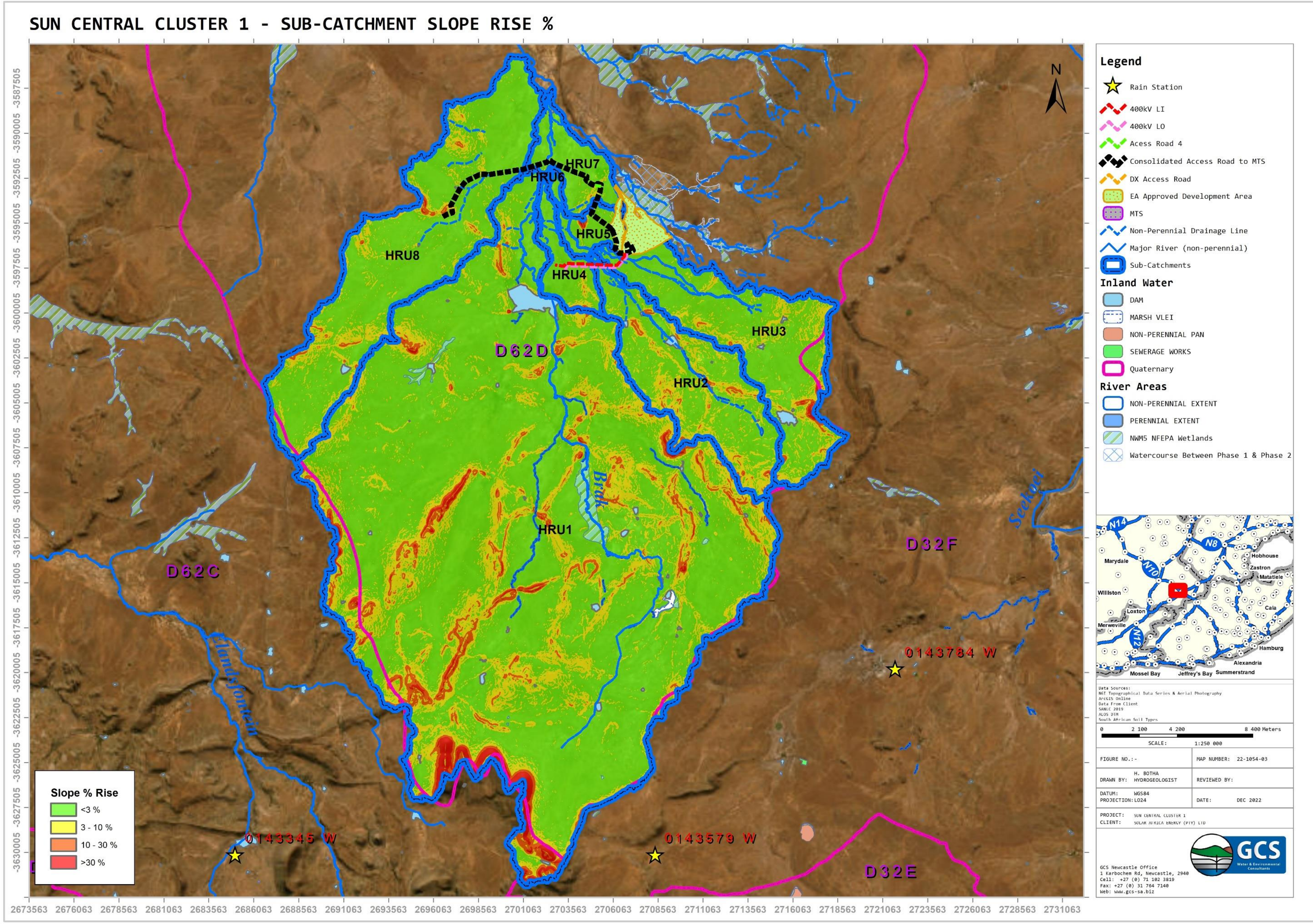


Figure 3-2: Sub-catchment slope rise (%)

3.3 Local geology and soils

According to the 1:1 000 000 series geology map for the area (ESRI Geology Map Series, 2022), the geology of the study area can be described as being underlain by flat-lying sedimentary rocks of the Karoo Supergroup, which have been intruded by innumerable sills and dykes of dolerite.

According to the Land types of South Africa databases (ARC, 2006), the soils in the area fall within the Ae land type. These are typically freely drained, red, eutrophic, apedal soils that comprise > 40% of the land type (yellow soils comprise < 10%). Calcrete soils are also prevalent as a result of the climatic conditions and underlying parent material.

3.4 Climate

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

3.4.1 Temperature

The average yearly temperature (refer to Figure 3-3) for the project area ranges from 15 to 33°C (high) and -4 to 16°C (Low). The study area is situated in a cold semi-arid (steppe) climate (BSk) as per the Köppen Climate Classification (Kottek, et al., 2006). Hence, the area receives more rainfall in the high-sun half of the year (October through March in the Southern Hemisphere). The area falls within a summer rainfall area.

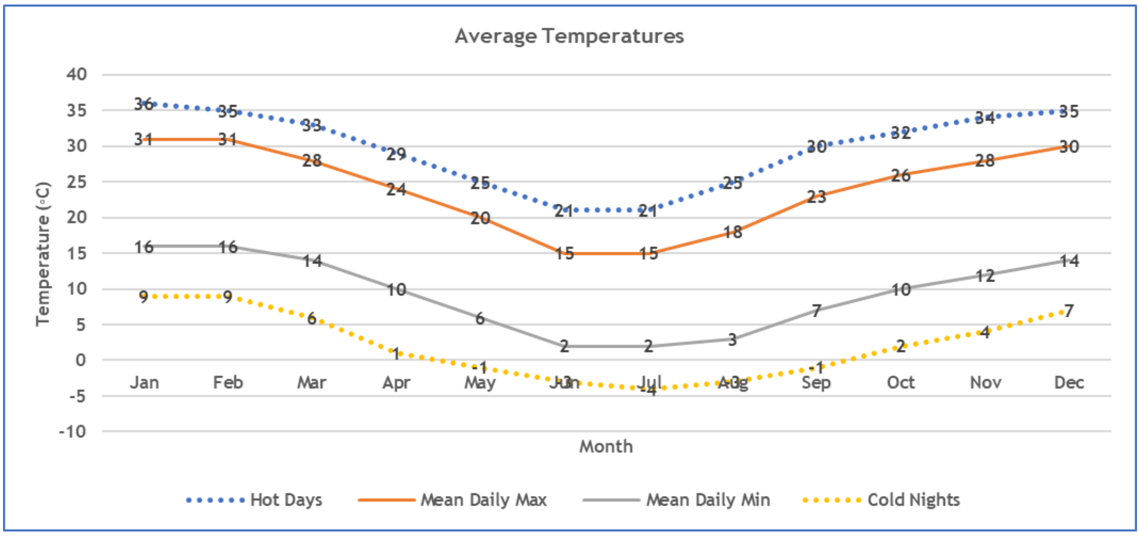


Figure 3-3: Average yearly temperatures (Meteoblue, 2021)

3.4.2 Wind speed and direction

Figure 3-4 shows the wind rose for the project area (the site used as a reference site) and presents the number of hours per year the wind blows from the indicated direction. Wind generally blows from all directions, with predominant stronger winds more frequently coming from ESE, ENE, and W directions.

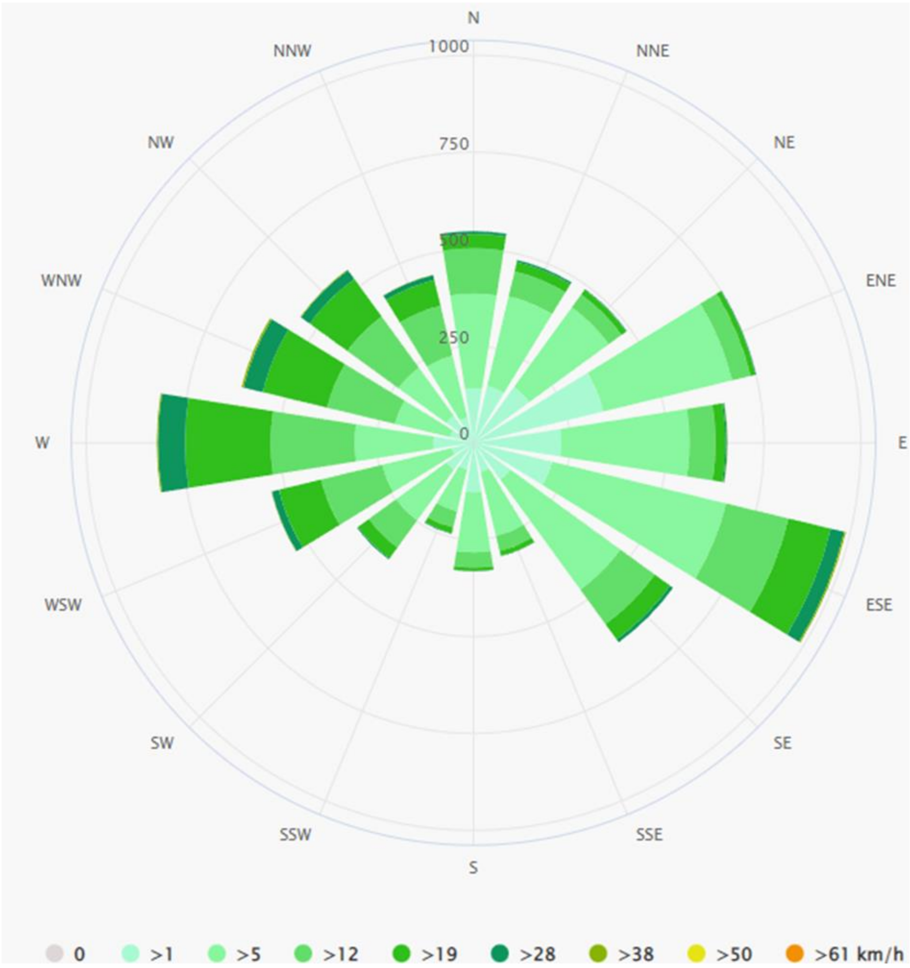
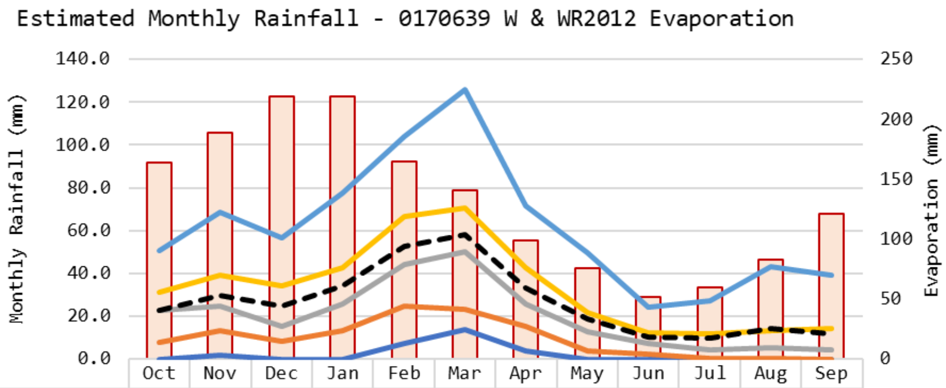


Figure 3-4: Wind rose (Meteoblue, 2021)

3.4.3 Rainfall and evaporation

The project area is situated in rainfall zone D6C. The rainfall data used to calculate Mean Annual Precipitation (MAP) was obtained from rainfall station 0170639W (station Rooiwal situated 12 km N of the site). Available rainfall data suggest a MAP ranging from 112.4 (30th percentile) to 738.9 (90th percentile) mm/yr, based on a historical record of 69 years (i.e., 1920 to 1989). The average rainfall is in the order of 320 mm/yr. Design rainfall data (Station: Rooiwal) suggest a MAP in the order of 319 mm/yr – hence the data is in the same order of magnitude. Monthly rainfall for the site is likely to be distributed as shown in Figure 3-5, below.

The site falls within evaporation zone 17A, of which Mean Annual Evaporation (MAE) ranges from 2 000 to 2 150 mm/yr. The MAE far exceeds the MAP for the site, which implies greater evaporative losses when compared to incident rainfall. Due to evaporation being about 85% more than local rainfall, non-perennial streams and rivers will only have water when there are flooding events (i.e., 1:2, 1:5, 1:50 and 1:100-year flood events). Monthly evapotranspiration for the site is likely to be distributed as shown in Figure 3-5, below.

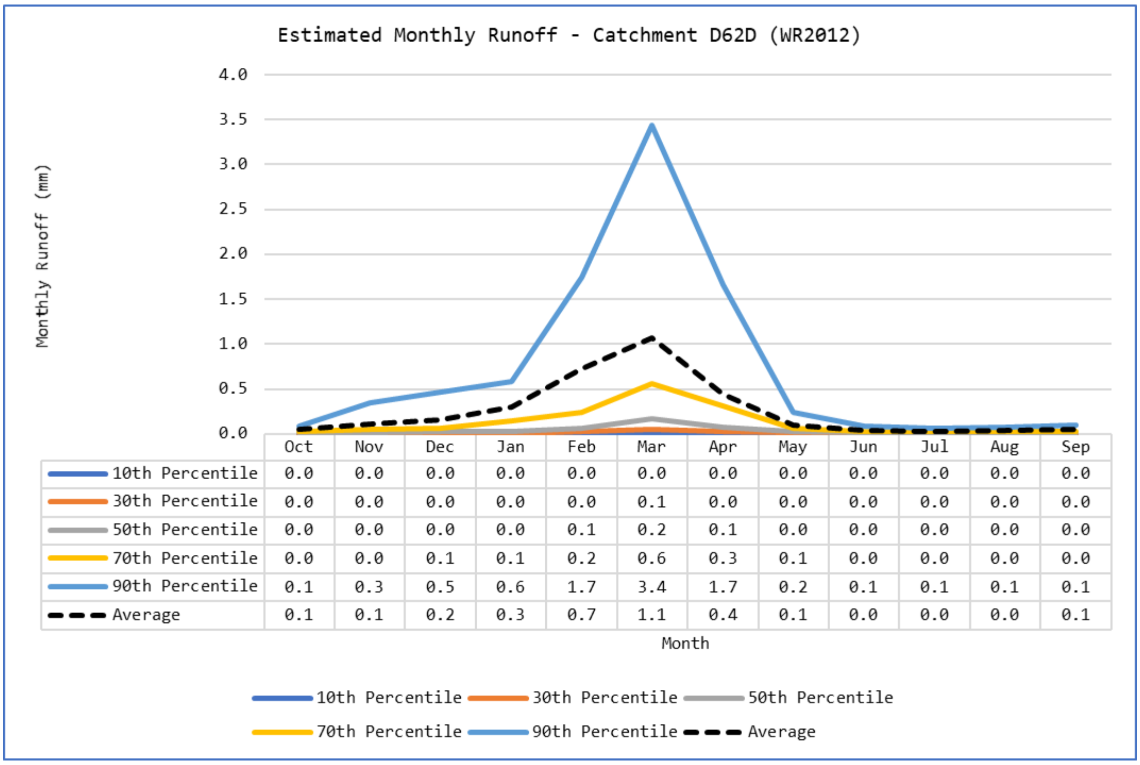


	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Evaporation (mm)	164	189	219	219	165	141	99	76	52	60	83	121
10th Percentile	0.0	1.9	0.0	0.0	7.4	14.0	4.1	0.0	0.0	0.0	0.0	0.0
30th Percentile	7.8	13.4	8.3	13.1	24.8	23.1	15.3	3.8	2.1	0.4	0.3	0.0
50th Percentile	22.6	24.7	15.5	25.8	44.0	50.0	25.5	12.7	7.3	4.5	5.1	4.2
70th Percentile	31.1	39.0	34.4	42.6	66.6	70.6	42.6	21.9	12.1	12.0	13.1	14.2
90th Percentile	50.5	68.7	56.4	77.7	103.9	125.8	71.8	49.7	24.2	27.4	43.0	39.2
Average	23.0	29.6	24.9	34.0	52.8	58.1	33.4	18.9	10.2	10.0	14.1	11.6

Figure 3-5: Rainfall distribution (station 0170639W) (WRC, 2015)

3.4.4 Runoff

Runoff from natural (unmodified) catchments in Catchment D62D is simulated in WR2012 as being equivalent to 3.1 mm/yr over the surface area (WRC, 2015). This is equal to approximately 0.9% of the MAP and amounts to approximately 7.4 Mm^3/yr over the surface of the quaternary catchment. Runoff is directly related to rainfall intensity, and longer precipitation events, closure rainfall occurrences/frequencies and precipitation intensity events will drive runoff formation. Monthly runoff is distributed as shown in Figure 3-6, below.



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
10th Percentile	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30th Percentile	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
50th Percentile	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.0
70th Percentile	0.0	0.0	0.1	0.1	0.2	0.6	0.3	0.1	0.0	0.0	0.0	0.0
90th Percentile	0.1	0.3	0.5	0.6	1.7	3.4	1.7	0.2	0.1	0.1	0.1	0.1
Average	0.1	0.1	0.2	0.3	0.7	1.1	0.4	0.1	0.0	0.0	0.0	0.1

Figure 3-6: Simulated runoff for quaternary catchment D62D (WRC, 2015)

3.4.5 Climate change

The projected rainfall decrease for the area as a result of climate change is estimated to decrease by as much as 150 mm, reducing the total rainfall to about 170 mm/yr by 2050. It should be noted that the projected changes in the annual average number of extreme rainfall days throughout the district over the period 2021-2050 under the RCP 8.5 scenario suggest either a decrease or increase in rainfall events. It is anticipated that under the scenarios put forth, the groundwater resources in the project area may become completely replenished in the event of 1:50 and 1:100-year storm events that occur in the project area. As a climate change scenario, the 170 mm annual rainfall for the area is used.

3.5 Hydrogeology and depth to groundwater

The hydrogeology map for the study area (2924 Bloemfontein - 1:500 000 hydrogeology series) the hydrogeology of the study area is characterised by argillaceous rocks (sedimentary rocks consisting of shale, mudstone, and subordinate siltstone). Groundwater is generally associated with intergranular and fractured occurrences in sedimentary rock. Groundwater is generally observed in bedding planes in shale or interbedded sandstone of the Beaufort Group and jointed and fractured contact zoned between sedimentary rocks and dolerite dykes (Meyer, P.S., Chetty, T., Jonk, F., 2002). The aquifer underlying the study area is considered a moderate-high-yielding aquifer - with median yields of 0.5 to 2 l/sec (Meyer, P.S., Chetty, T., Jonk, F., 2002). According to WR2012 (Bailey & Pitman, 2015) and DWAF GRAII (DWAF, 2006) data, the groundwater level in the study area on average is in the order of 6.9 mbgl (metre below ground level).

3.6 Wetland and ecological areas

Based on available National Wetland Freshwater Ecosystem Priority Areas (NFEPA) (Van Deventer, 2018) no recognised wetland units are present in the study area. The floodplain areas of the Brak River and its tributaries (green) are however recorded as riverine systems. The proposed road development and transmission lines will infringe on these ecologically sensitive zones.

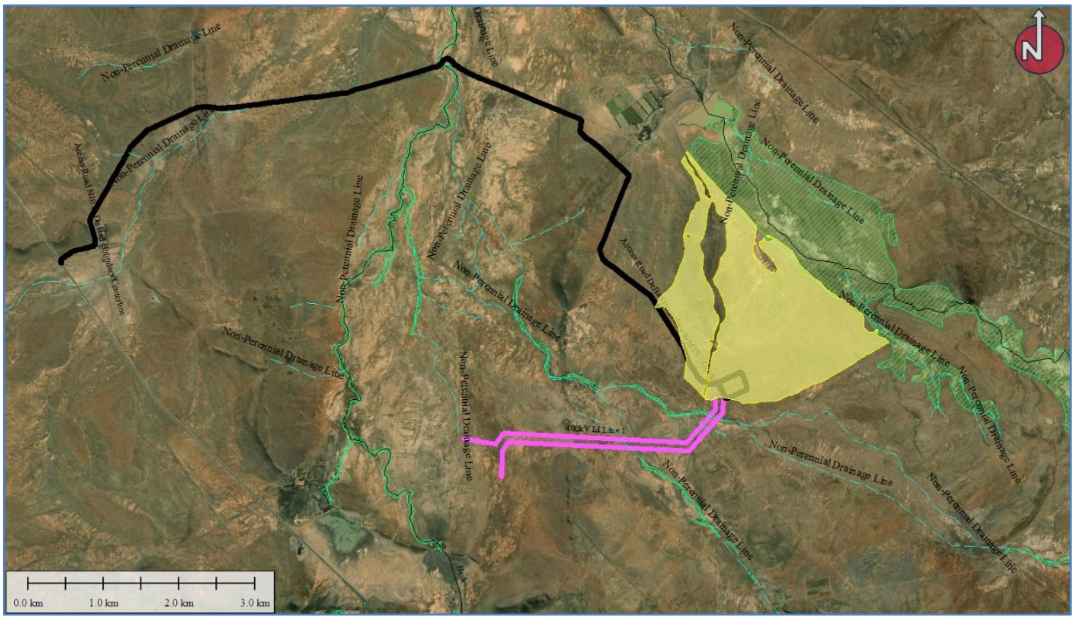


Figure 3-7: Wetland Freshwater Ecosystem Priority Areas (NFEPA) – GREEN =NFEPA River System Areas

3.7 Present ecological state (PES), ecological importance and sensitivity (EIS) and Ecological Water Reserve (EWR)

Table 3-3 provides a summary of the PES, EIS and EWR (as a percentage of the MAR) for the quaternary catchments.

Table 3-3: Summary of PES, EIS and EWR

Quat	PES	EIS	Reserve (EWR) % of NMAR	Source
D62D	Class B: Largely Modified	Low-Marginal	30 to 40%	Desktop Determination (DWAF, 2003)

3.8 Overview of site hydrological cycle

Based on the information attained for the study area (as presented in this section), existing groundwater and surface water users, climate, runoff and estimated baseflow to wetland areas, a sub-catchment-specific hydrological cycle (combined extent of HRU1 to HRU8) was developed (refer to Figure 3-8). *The impact of the proposed/existing activities at the site on the cycle was considered in the hydrological impact assessment.*

With regards to the hydrological cycle for the sub-catchment, the following is estimated:

- Average rainfall over the combined surface of the sub-catchments is in the order of 192.47 Mm^3/yr (50% of the total water budget).
- Average runoff accounts for a volume in the order of 1.87 Mm^3/yr (0.5% of the total water budget).
- The average groundwater contribution to baseflow to rivers/wetlands/streams is in the order of 0 Mm^3/yr (0% of the total water budget).
- Evaporation accounts for a volume in the order of 182.69 Mm^3/yr (47.5% of the total water budget); and
- Estimated groundwater use on a sub-catchment level accounts for 0.21 Mm^3/yr (0.1%) and surface water use accounts for 0 Mm^3/yr – very low volumes on a sub-catchment scale.

The total water balance for the sub-catchments assessed is estimated in the order of 384.948 Mm^3/yr.

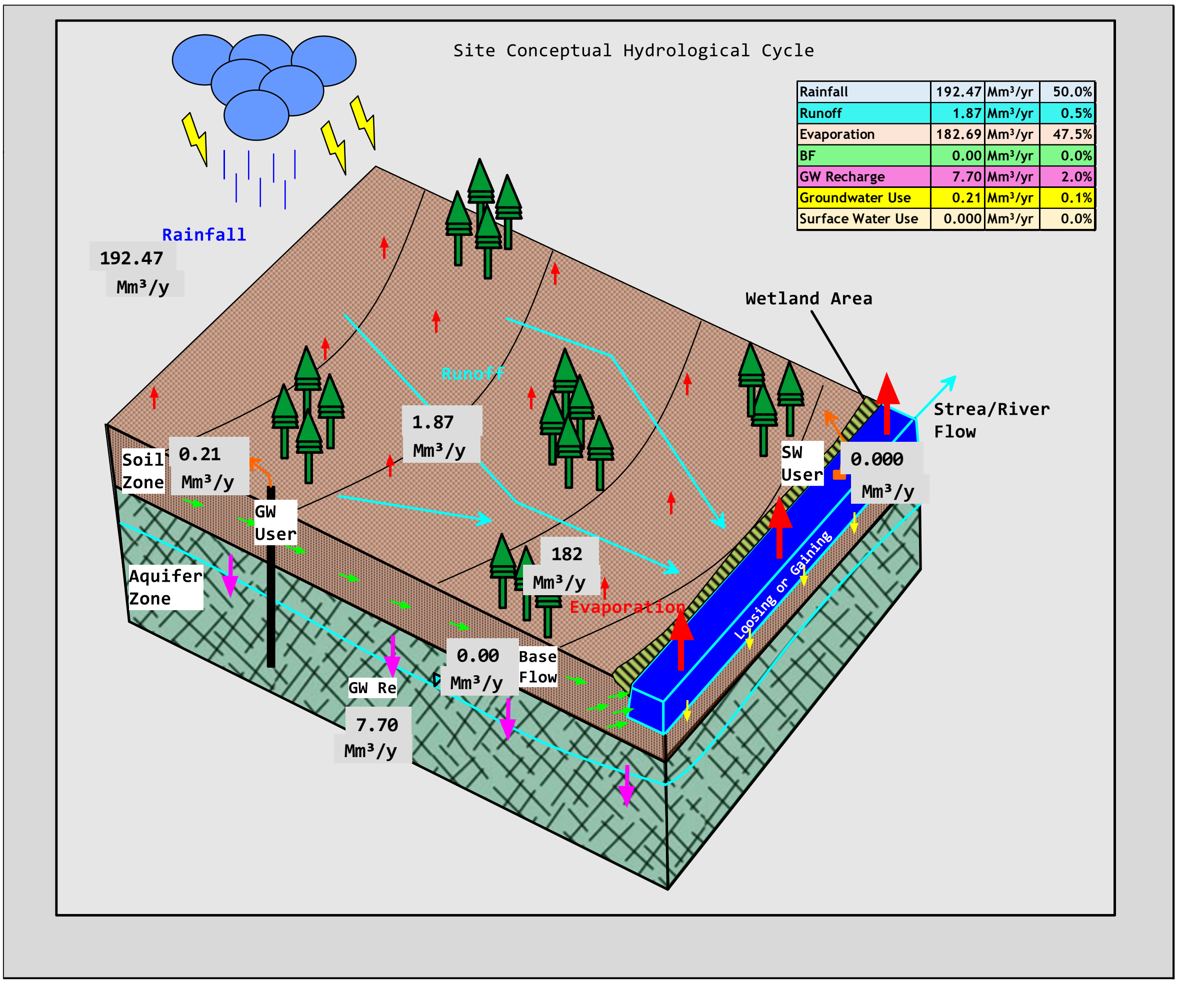


Figure 3-8: Simplified overview of the hydrological cycle at the site

4 WATER QUALITY

The following section supplies an overview of the surface water (SW) and groundwater (GW) chemistry for the site. Data were derived from field and literature sample data.

4.1 Groundwater quality

The groundwater quality for the region will be variable and will depend on the underlying geology and hydrogeology characteristics associated with groundwater recharge (i.e., older rock and aquifers with ion exchange will have higher EC, and recently recharged more permeable younger rocks will have lower EC). Literature and available hydrogeology maps for the area (refer to Figure 4-1) suggests that the electrical conductivity (EC) for the underlying aquifers generally ranges from 70 to 300 mS/m (milli Siemens/metre). The pH for the region ranges from 6 to 8. This means that groundwater abstracted from the aquifer can generally be used for domestic and recreational use (DWAF, 1996b).

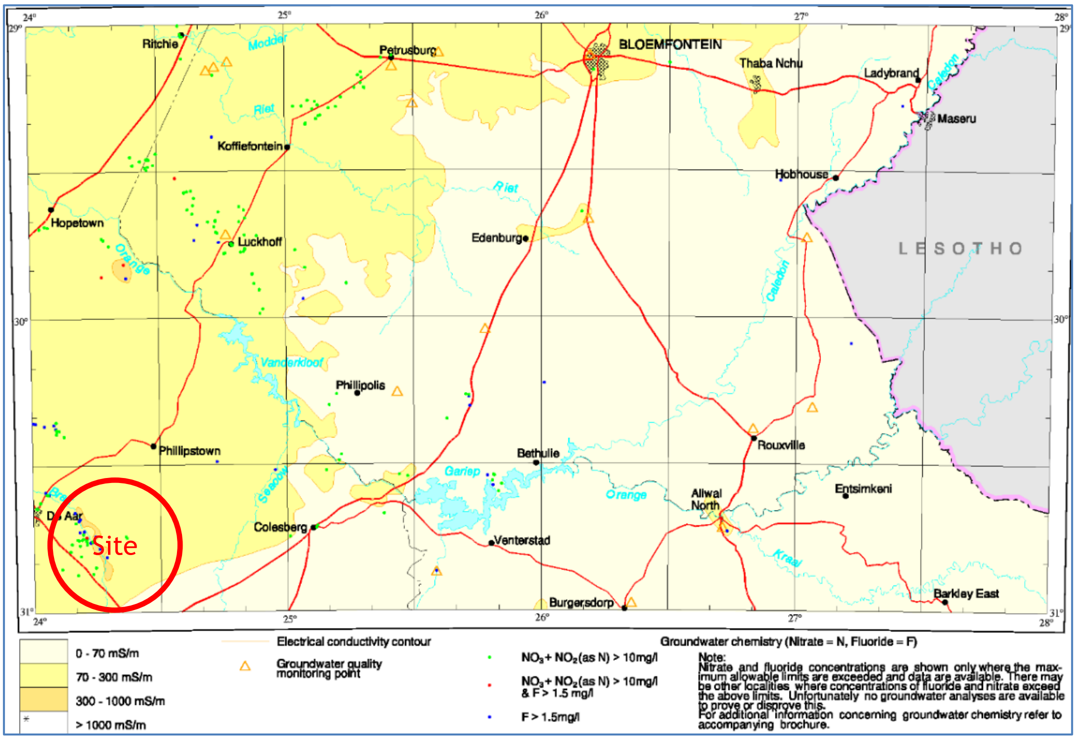


Figure 4-1: Groundwater quality (Meyer, P.S., Chetty, T., Jonk, F., 2002)

4.2 Surface water quality

An in-situ pH/EC/TDS meter was used in the field to evaluate surface water quality on a preliminary level. Table 4-1 provides a summary of the screening points. pH for screening sites ranged from 7.1 to 7.5, with groundwater-fed pans exhibiting higher EC and TDS compared to rainwater-fed dams.

Table 4-1: Summary of surface/groundwater-fed screening sites

 pH = 6.8, EC = 810 uS/cm, Temp = 16.8. Water Level: 16.6 mbcl, Collar: 0 m Lat: -30.88434 Lon: 24.31464 Elevation: 1335 mamsl Solar borehole 5 is used for livestock water. The water from the storage dam is allowed to trickle to a depression, forming a small surface water ponding area.
 pH = 7.5, EC = 15 mS/m, TDS = 70 mg/l Lat = -30.843873° Lon: 24.339434° Rainwater collection dam along the northern railway leaving the Phase 1 area.
 pH = 7.1, EC = 74 mS/m, TDS = 360 mg/l Lat = - -30.851940° Lon: 24.334293°

5 PEAK FLOWS AND FLOOD LINE ASSESSMENT

Flood peak flows for the delineated sub-catchments were calculated using the Rational (Method 3), Midgley and Pitman (MIPI) and the SDF methods (refer to **Appendix A**). Design rainfall was retrieved from station 0170639W [station Rooiwal situated 12 km N of the site]. and used to calculate peak flow volumes. Table 5-1 provides a summary of the design rainfall data used to calculate peak flows. The upper "U" rainfall intensity values were used, and catchment-based time concentration estimates, in the estimation of the return period peak flows.

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

Duration	Return Period (years)						
	2	5	10	20	50	100	200
5 min	9.1	12.8	15.6	18.4	22.4	25.5	28.9
10 min	12.6	17.8	21.6	25.5	31	35.4	40.1
15 min	15.3	21.6	26.1	30.9	37.5	42.9	48.6
30 min	18.8	26.6	32.2	38.1	46.2	52.8	59.8
45 min	21.2	30	36.4	43	52.2	59.6	67.6
1 hr	23.1	32.7	39.6	46.8	56.9	65	73.7
1.5 hr	26.1	36.9	44.8	52.9	64.2	73.4	83.2
2 hr	28.5	40.2	48.8	57.7	70	80	90.7
4 hr	33.7	47.7	57.8	68.3	82.9	94.8	107.4
6 hr	37.3	52.6	63.8	75.4	91.6	104.6	118.6
8 hr	40	56.4	68.4	80.9	98.2	112.2	127.2
10 hr	42.2	59.6	72.2	85.4	103.7	118.5	134.3
12 hr	44.1	62.3	75.5	89.3	108.4	123.9	140.4
16 hr	47.3	66.8	81	95.8	116.3	132.9	150.7
20 hr	50	70.6	85.6	101.1	122.8	140.3	159.1
24 hr	52.2	73.8	89.5	105.8	128.4	146.7	166.3
1 day	44.2	62.4	75.6	89.4	108.6	124.1	140.6
2 days	51.6	72.9	88.3	104.4	126.8	144.9	164.2
3 days	56.5	79.8	96.7	114.3	138.8	158.6	179.8
4 days	60.7	85.7	103.9	122.8	149.2	170.4	193.2
5 days	64.2	90.6	109.9	129.9	157.8	180.2	204.3
6 days	67.2	94.9	115	136	165.1	188.6	213.8
7 days	69.8	98.6	119.5	141.3	171.6	196.1	222.3

5.1 Pre-development peak flows

Calculated peak flows are summarised in Table 5-2, and shown in Figure 5-1. The SDF method produced greater peak flows, compared to the RM (3) and MIPI methods. The Geometric Mean of the dataset was applied to the HEC-RAS model. The flood line assessment is aimed at providing a worst-case inundation scenario to evaluate potential flooding risks associated with the non-perennial drainage lines in the study area. For drainage lines that contribute to the peak flow in a particular HRU, the peak flows were normalised to the area contributing to the flow.

Table 5-2: Summary of design peak flows for the delineated sub-catchments (m³/s) - Pre-Development

Catchment	Method											
	RM (3)			SDF			MIPI			Geometric Mean		
	1:20yr	1:50yr	1:100yr	1:20yr	1:50yr	1:100yr	1:20yr	1:50yr	1:100yr	1:20yr	1:50yr	1:100yr
	(m³/s)											
HRU1	73	110	152	229	343	439	186	258	326	146	214	279
HRU2	21	31	42	63	94	120	46	65	81	39	57	75
HRU3	23	34	47	72	107	137	52	72	91	44	64	84
HRU4	9	13	18	30	46	58	21	29	37	18	26	34
HRU5	4	7	9	15	22	29	15	21	26	10	15	19
HRU6	1	2	3	3	5	6	3	4	5	2	3	4
HRU7	8	13	18	26	39	50	23	32	41	17	25	33
HRU8	19	28	39	70	104	133	61	85	107	43	63	82

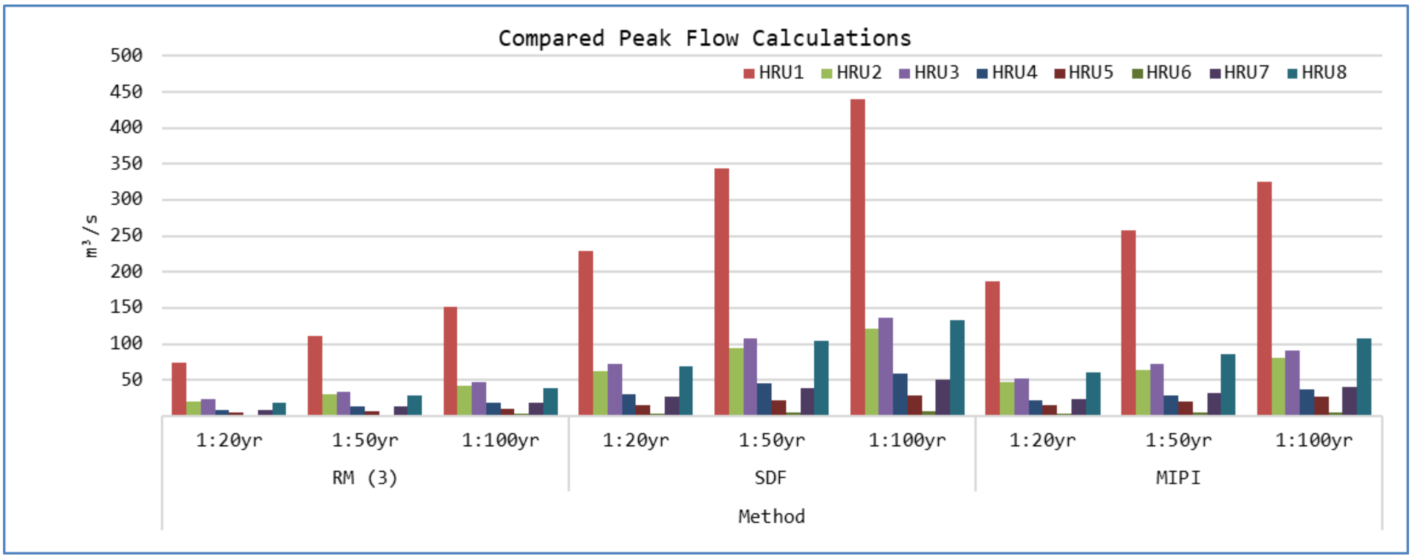


Figure 5-1: Calculated peak flows - pre-development

5.2 Post-development peak flows

Based on the proposed activity (i.e., construction/upgrade to the road network and installation of transmission lines and transfer station) no increases in flood peaks are anticipated. Considering scaling, the catchments will not be significantly altered which could lead to a reduction or increase in flood peak flows.

5.3 Flood line modelling

5.3.1 Software

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

5.3.2 Topography profile data

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

5.3.3 Manning's roughness coefficients

Manning's roughness factor (n) is used to describe the channel and adjacent floodplain's resistance to flow. A Manning factor of 0.035 to 0.045 best represents the frictional characteristics of both the micro-catchment drainage areas, non-perennial channels, and bank areas. This is due to isolated flow paths noted in the field, with a mixture of dense shrubs and karoo bushels.

5.3.4 Inflow and boundary conditions

Based on the HRUs and the confirmed drainage lines/ streams in the project area, a total of five (5) HEC-RAS rivers were defined, consisting of both critical depth (upstream) and normal depth slope boundary conditions. The normal depth slope was determined based on the ALOS DTM slope rise for the given sub-catchment drainage line.

5.3.5 Hydraulic structures

Weirs in known non-perennial drainage areas (which form dams), concrete drift crossings along the Brak River, existing pipe culvert structures on the district road and railway box culverts along the railway are the only hydraulic man-made structures identified in the project area.

Hydraulic structures were not incorporated into the HEC-RAS model. Modelling these hydraulic structures would have been hampered by the lack of good resolution topographical data (better than 30 m ALOS data), as such, including these structures would have been ineffective in the hydraulics of the streams as well as ineffective areas that were raised (i.e., roads, dam walls, buildings, culverts etc.)

5.3.6 Model assumptions

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

- The ALOS topographic data provided was of sufficient accuracy and coverage to enable hydraulic modelling at a suitable level of detail.
- The Manning's 'n' values used are considered suitable for use in the flooding events modelled, representing all the channels and floodplains.
- No abstractions or discharges into the stream sections were considered during the modelling.
- Steady-state hydraulic modelling was undertaken, which assumes the flow is continuous at the peak rate; and
- A mixed flow regime that is tailored to both subcritical and supercritical flows was selected for running the steady-state model.

5.4 Model results

The 1:50 and 1:100-year flood areas are shown in Figure 5-2. As no clearly defined non-perennial drainage channels occur, ponded flood occurrence zones were produced by the HEC-RAS model. This is due to the micro-catchment style drainage associated with the project area.

5.5 Site-specific sensitivity & buffers (avoidance areas)

Depending on the season in which the flood occurs (i.e., winter where there is less vegetation vs summer where there is more vegetation) the area will be prone to sedimented runoff and flood path erosion. This is based on the fine sedimentary sands that cover the study area, being more compacted in depressional areas and less compacted near hilltops.

The flood lines also suggest a low flooding risk associated with the project area, as no clearly defined drainage lines occur. Micro-sub catchment sheet flow towards lower laying areas within the non-perennial river flood plains is likely to dominate flood propagation, and isolated flooded areas are predicted to occur. As such, no clearly defined exclusion zones/protection buffer areas could be mapped.

Care should be taken in areas where development does take place within the likely flooding zones. For these areas, proper flooding protocols (i.e., ensure drainage and stormwater systems are put in place to minimize flooding potential) and erosion prevention measures should be implemented.

Flood damage associated with the proposed transmission lines is not anticipated due to these structures being raised > 5 m and anchored with cables. For the road network, proper stormwater management and flood conveying systems would need to be considered. The MTS is situated outside zones of inundation, suggesting no flooding risk for the Sun Central Cluster 1 PV development and MTS development area.

5.6 Limitations

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

Despite the above mentioned, Manning's coefficients for the vegetation observed, and the medium-low resolution topographic data, the flood risk to the surface infrastructure has been adequately assessed for the project area. No further flood modelling work is considered necessary and would only be considered necessary when more detailed topographical data is available.

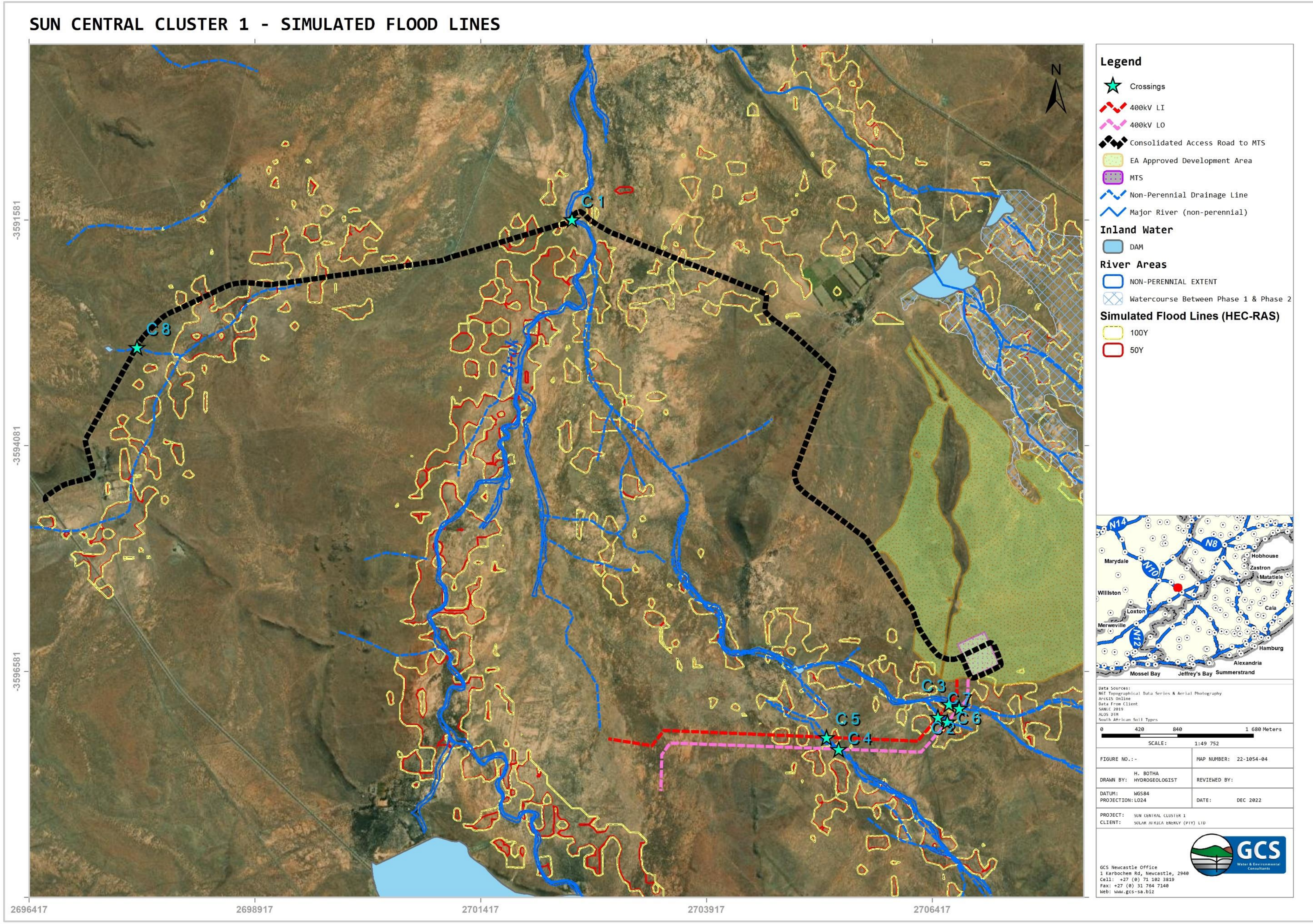


Figure 5-2: **1:20, 1:50 and 1:100-year flood areas**

6 CONCEPTUAL STORMWATER MANAGEMENT PLAN

The following section describes the CSWMP developed and is based on available hydrological data and site layout data.

6.1 Aim of the stormwater management plan

The CSWMP aims to:

- Illustrate likely stormwater sub-catchments (HRUs) and preferential overland runoff flow paths.
- Determine likely dirty and clean water HRUs (if any).
- Provide water containment and diversion systems to prevent the mixing of clean and dirty water, prevent soil erosion and flooding; and
- Attenuate stormwater back to the natural environment.

6.2 Existing stormwater infrastructure

As the solar farm is zoned on agricultural land, no stormwater infrastructure occurs on-site. There is very little stormwater infrastructure associated with the existing access road to Sun Central Cluster 1, the only notable infrastructure is a concrete drift crossing in the Brak River (on another road that will not be upgraded). Stormwater in the study area is generally isolated due to the micro-catchments resulting from the topography.

6.3 Delineation of clean and dirty water areas

Based on the nature of the project (construction/upgrade to the road network and installation of transmission lines and transfer station) no dirty stormwater generation areas are anticipated. As all stormwaters will be subjected to micro-catchment style stormwater runoff erosion and sediment transport will likely take place.

6.4 Assumptions and limitations

The following assumptions pertain to the CSWMP:

- The ALOS DTM used to delineate the sub-catchment areas is of sufficient resolution to accurately describe the runoff from the site(s).
- No dynamic stormwater modelling or stormwater sizing was undertaken (not part of this scope). It is assumed that the concepts presented in this report will be modelled and developed by a professional civil engineer.

6.5 Stormwater peak flows

As stated previously, it is observed that there are potentially eight (8) ephemeral drainage line crossings, associated with the proposed road and transmission line development (refer to Table 3-1). These crossings can be considered critical stormwater management areas, where there will be an activity that could alter the natural conditions of the rivers/streams, which could lead to sedimentation and erosion. The former is however only likely during storm events and will be limited to the construction phase of the development. The crossings are shown in Figure 6-3 to Figure 6-7.

Table 6-1: Identified non-perennial river and stream crossings

Likely Crossing	Latitude (WGS84)	Longitude (WGS84)	Type	Activity
C1	-30.85154438	24.27633442	Non-Perennial River (Brak River)	Road
C2	-30.89347031	24.31485336	Ephemeral Stream	400kV LO Line
C3	-30.89311282	24.31384346	Ephemeral Stream	400kV LI Line
C4	-30.89698608	24.30286398	Ephemeral Stream	400kV LO Line
C5	-30.89596689	24.30165052	Ephemeral Stream	400kV LI Line
C6	-30.89463276	24.31368255	Ephemeral Stream	400kV LO Line
C7	-30.89422033	24.31275147	Ephemeral Stream	400kV LI Line
C8	-30.86251539	24.23307474	Ephemeral Stream	Road

Stormwater drainage to the crossings is fed by both local micro catchments, and for larger non-perennial rivers such as the Brak River, by large catchment areas. For larger crossings, such as C1, C2, C3, C4 and C5 the stormwater peak flows will be in the same order as the calculated flood peak flows.

The rational method was used to calculate the stormwater peak flows for the MTS area, C6 to C8. The soils in the study area have an SCS rating of B/C soil types, with an erodibility rating of 7. Considering the vegetation cover observed on-site, the land cover translates to a run-off coefficient (C) in the order of 0.06 (6%). 1:2, 1:10, 1:50 and 1:100 yr return periods are presented and are tabulated in Table 6-2.

The stormwater infrastructure should be sized to handle these minimum peak flow estimates, as per the proposed sizing in the next section.

Table 6-2: Stormwater return period estimates for the proposed development areas

Storm HRU	Q2 -m³/s	Q10 -m³/s	Q50 -m³/s	Q100 -m³/s
C-Sub	0.84	1.44	2.07	2.36
C6-7	2.58	4.43	6.36	7.26
C8	37.50	64.30	92.24	105.39
C1	*NA*	*NA*	*375.43*	*490.04*
C2	*NA*	*NA*	*64.01*	*83.57*
C3	*NA*	*NA*	*64.01*	*83.57*
C4	*NA*	*NA*	*57.20*	*74.67*
C5	*NA*	*NA*	*57.20*	*74.67*

6.6 Proposed stormwater management measures

6.6.1 Construction phase

During the construction phase, it is recommended that sandbags and temporary berms be used, to manage stormwater runoff (if storms do occur). It is recommended that the construction phase take place during dry months, with a decreased probability of storm events. Temporary stormwater systems should be sufficient to manage the stormwater at the site during the construction phase.

6.6.2 Stormwater management measures that need to be considered

The proposed roadway will cross two (2) non-perennial drainage lines, namely at C1 (Groot Brak River) and C8 (ephemeral drainage line). Moreover, the proposed MTS site may need some stormwater systems to manage runoff and prevent erosion. The crossings and proposed stormwater management systems are shown in Figure 6-3 to Figure 6-7.

The proposed construction and long-term management for the higher-risk areas are captured in Table 6-3. As discussed above, free drainage is recommended and will be the least invasive, however for C1, C8 and the MTS the following is recommended:

1. C1 – Due to the size of the Brak River flood plain, and the predicted irregular flood generation (refer to flooding section) it is proposed that a concrete drift crossing be developed to allow for overflow and passage through the river flood plain. The construction of a typical drift crossing is shown in Figure 6-1.
2. C8 – The road will cross an ephemeral drainage line, and hence, a permanent box culvert under the roadway will be required. Preliminary calculations suggest a rectangular culvert with a diameter of 3 m, design depth of 10 m and slope of 0.057 (m/m) should be able to handle a maximum flow volume of 207 m^3/sec (the calculated peak flows range from 90 to 105 m^3/sec), with a flow depth efficiency of 55%. The intakes should be stabilised by a reno mattress, as well as the outlet should have energy-dampening systems in place. A typical energy-dampening system that can be considered is shown in Figure 6-2.
3. MTS – For the MTS, and **only if erosion and ponding are noted**, a vegetated swale or V-drain should be considered, that drains to outlets stabilised by rock rip-rap/reno mattresses. Otherwise, free drainage should be sufficient.

Table 6-3: Summary of proposed stormwater measures

Likely Crossing / Stormwater Work Area	Construction Phase	Proposed Long-Term Management
C1	> Re-Vegetate Eroded Area > Ensure access is limited to one point, to prevent sedimentation. > Undertake work, if possible, during dry months. > Stabilise work areas with temporary sandbags/berms, or shallow channels, to prevent water ponding, erosion and sediment runoff.	Concrete Drift Crossing
C2		Free Drainage
C3		Free Drainage
C4		Free Drainage
C5		Free Drainage
C6		Free Drainage
C7		Free Drainage
C8		Box Culvert & Energy Dissipator
MTS		Vegetated Swale & Reno-Mattress Outlets / Free Drainage

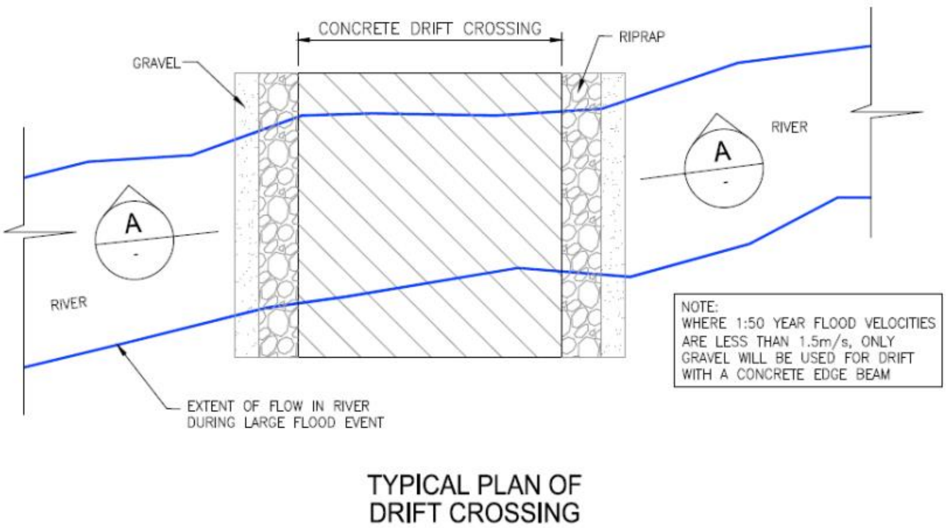


Figure 6-1: Typical plan of a drift crossing

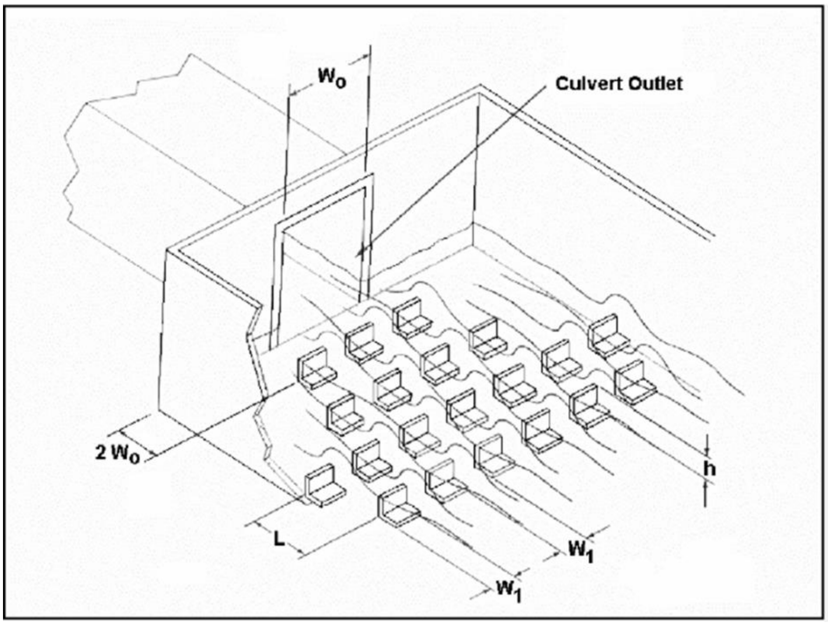


Figure 6-2: Typical energy dampening for box culvert outlet

6.6.3 Operational phase

Considering the proposed activities, the calculated peak flows and the ecological sensitivity of the project area, free drainage from the proposed development area is recommended. The proposed systems (refer to the previous section) would need to be inspected annually to ensure they are operating as per the design criteria.

6.7 Other stormwater considerations

The following should be considered during the live cycle of the project:

- Stormwater management should focus on the following before the work takes place:
  - **Assess the site constraints and any site-specific concerns, including:**
    - Specific vegetation that may need to be identified and/or isolated from the site disturbance.
    - Highly erodible soils may require additional erosion control measures.
    - The type of construction should consider landform. Avoid slab-on-ground construction on steep sites.
    - Up-slope drainage catchments that may need to be diverted around the work site.
    - Workspace limitations may require site-specific sediment control measures and/or the extensive use of skips or bins for material storage and waste management.
    - Expected rainfall intensity during the period of disturbance (wet season vs dry season).

- **Stabilise the site entry/exit points:**
  - A stabilised site access must be established and if possible, limited to one point only. The access allows for the construction vehicles to enter the work area of goods while preventing the unnecessary tracking of sediment onto the nearby environment from multiple locations. A stabilised entry/exit point normally consists of a stabilised rock pad.
- **Prevent erosion & manage stockpiles:**
  - Suitable material storage areas must be located up-slope of the main sediment barrier (e.g., sediment fence).
  - Stockpiles kept on site for more than two weeks will require an impervious cover (e.g., builder's plastic or geofabric) to protect against raindrop impact. Stockpiles of sandy material located behind a sediment fence will only need a protective cover if the stockpiles are likely to be exposed to strong winds.
  - On steep sites and sites with limited available space, erodible materials may need to be stored in commercial-sized bins or mini-skips before use.
- **Manage Site Waste**
  - Adequate waste receptacles must be provided on-site and maintained in a way that potential and actual environmental harm resulting from such material waste is minimised.
  - Building activities must be carried out on a pervious surface, such as grass or open soil, or in such a manner that all sediment-laden runoff is prevented from discharging into a water body.
- Based on the above mentioned, it is recommended that work take place in dry months, and don't leave excavations open or the area unrehabilitated before a rainfall month occurs. If work does commence in wet seasons, it is advised that the measures in this document be considered, as well as any means to prevent erosion and sediment runoff (i.e., temporary sandbags, reed beds, re-vegetation, temporary stilling basins, temporary berms etc.).

- Ensure a stormwater management plan is implemented, and that all stormwater systems are kept clean of any debris to reduce flooding risk.
- Ensure that eroded areas are re-vegetated, to ensure reduced sedimentation risk and reduced runoff volumes to the streams.

- Have fuel/oil spill kits on-site, for immediate clean-up of any hydrocarbons during the proposed activities. Park vehicles in dedicated areas, with drip trays to manage potential leakages.
- Conduct regular inspections and maintenance of the site to ensure that vegetation cover is adequate, and no rivulets are generated.

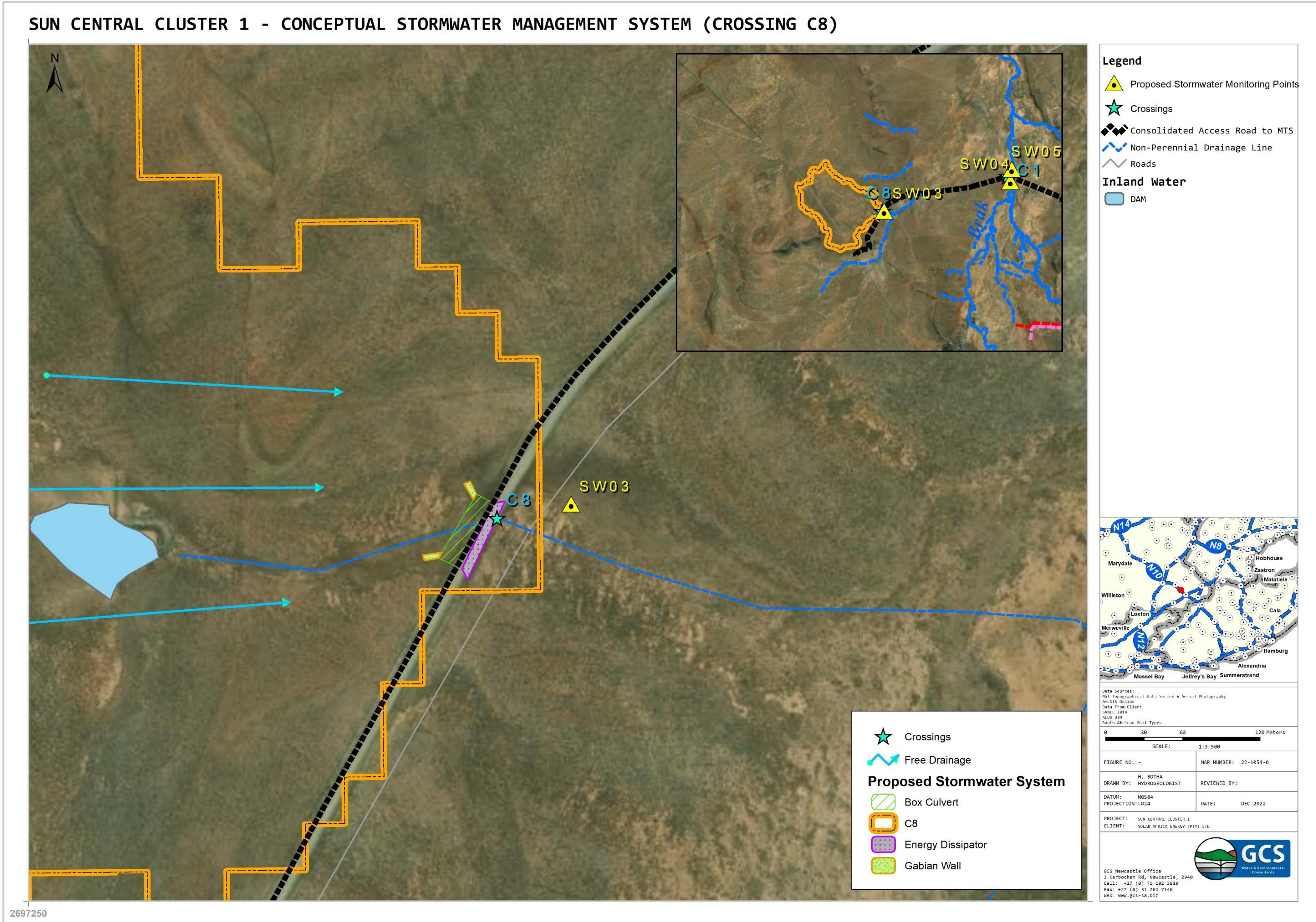


Figure 6-3: Conceptual stormwater management system (Crossing 8)

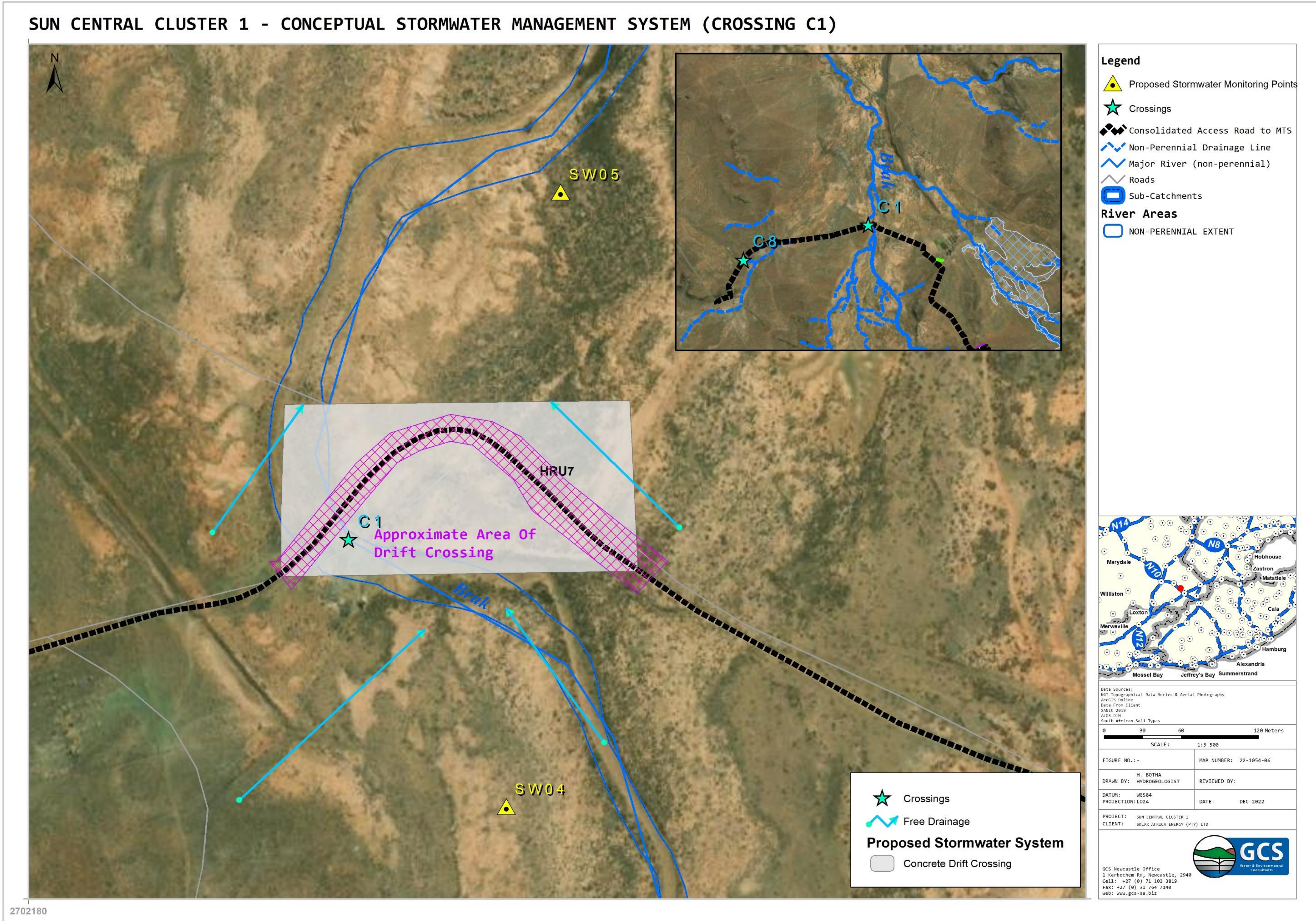


Figure 6-4: Conceptual stormwater management system (Crossing 1 – Brak River)

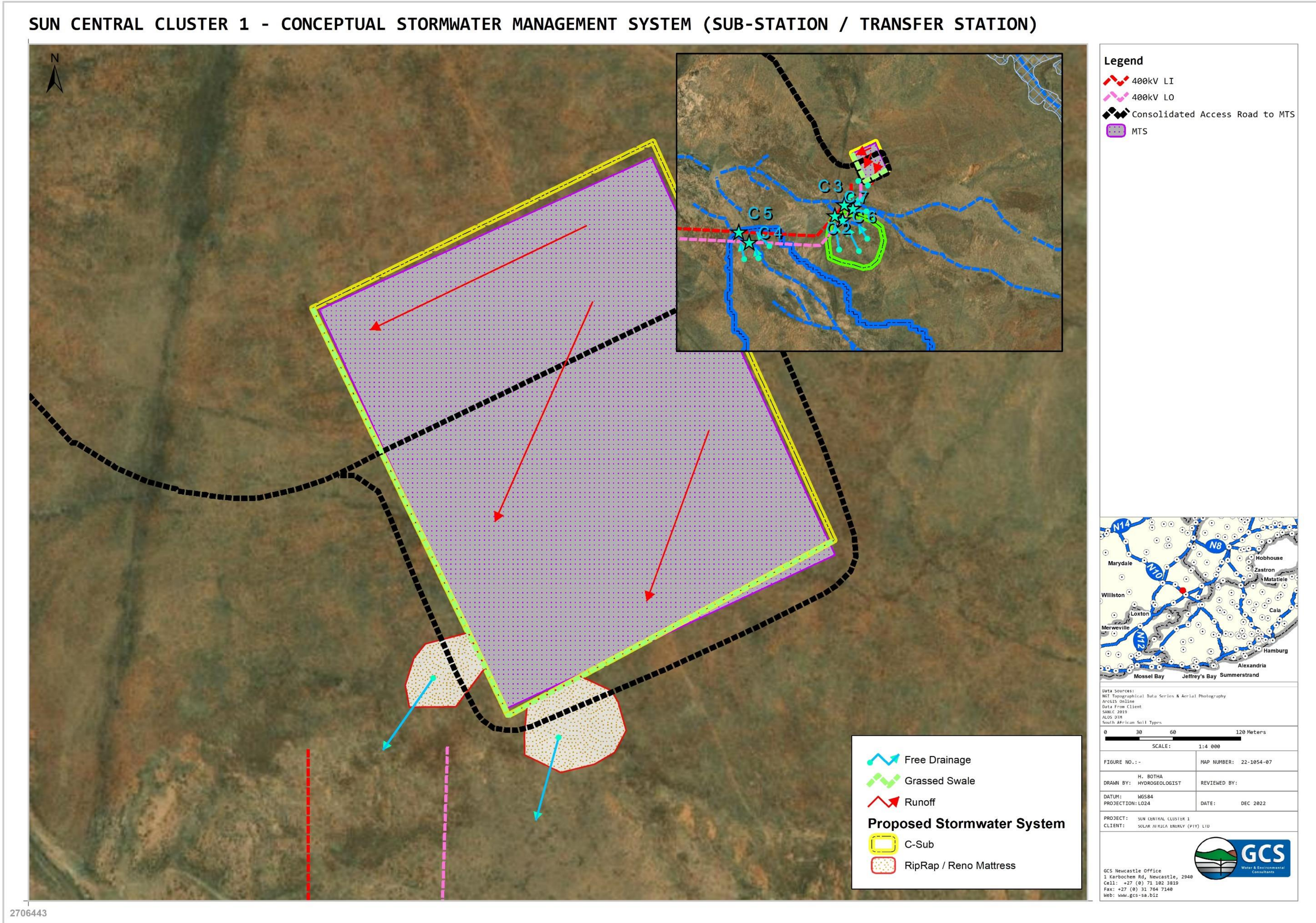


Figure 6-5: Conceptual stormwater management system (MTS)

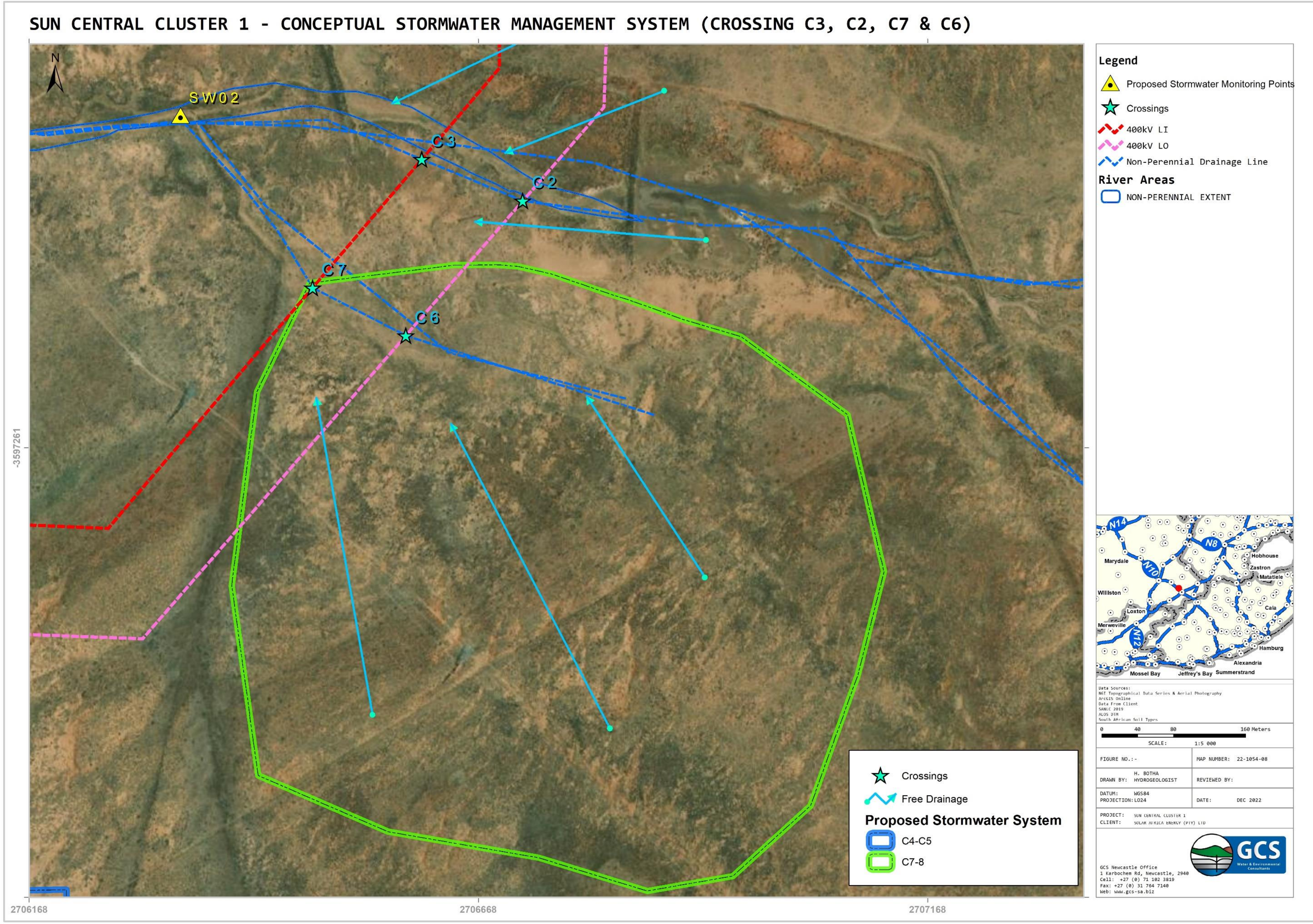


Figure 6-6: **Conceptual stormwater management system (Crossing 2, 3, 6 and 7)**

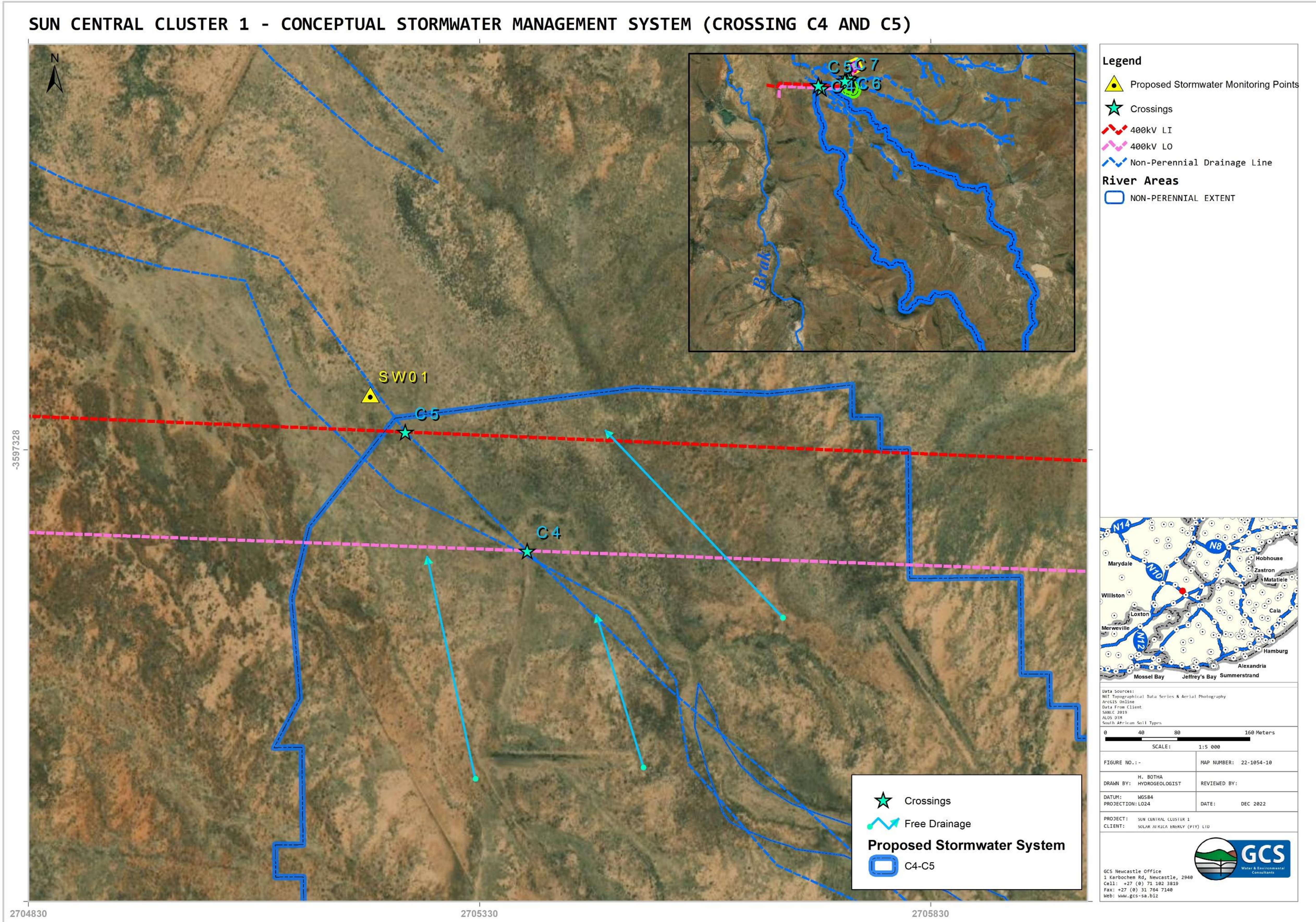


Figure 6-7: Conceptual stormwater management system (Crossing 4 and 5)

7 HYDROLOGICAL RISK ASSESSMENT

The anticipated hydrological risk concerning the construction and operational phases was assessed. The SPR model (DWAF, 2008) was used to evaluate potential pollution sources and primary receptors within the study area.

Risk assessment entails understanding the generation of a hazard, the probability that the hazard will occur, and the consequences if it should occur. The net consequence is established by the following equation:

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

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

Environmental Significance = (Consequence x (Probability + Reversibility))

The risk significance rating is summarised in Table 7-1.

Table 7-1: Risk rating scale

Criteria	Rating Scales
Significance	Very high - negative (-49 to -66)
	High - negative (-37 to -48)
	Moderate - negative (-25 to -36)
	Low - negative (-13 to -24)
	Neutral - Very low (0 to -12)
	Low-positive (0 to 12)
	Moderate-positive (13 to 24)
	High-positive (24 to 48)
	Very high - positive (49 to 66)

In terms of the proposed development, several hydrological risks during the construction phase of the development were identified. The potential impacts identified and environmental significance for the construction phase is listed in Table 7-2 (for the access road) and Table 7-3 (for the transmission lines, MTS and abstraction from boreholes). *No operational risks were identified, due to the nature of the proposed activities. For all identified groundwater risks please refer to GCS (2022) – Geohydrology Report. The closure phase risk will highly likely be similar to that of the construction phase.*

Based on the SPR model applied to the site, the following potential hydrological risks are identified:

- Construction phase risk (development of roadway, MTS, the establishment of stream crossings and culverts and erection of transmission lines).

- Leakages from construction and contractor vehicles accessing the site may cause soil pollution (i.e., un-inspected vehicles dripping oils/hydrocarbons onto soils may cause contamination of soil and surface water resources).
- Disturbing soils (land capability) due to some vegetation clearing may promote sedimented runoff during storm events.
- Expansion of existing road material borrows pits on the leased properties (if commercially sourced materials are not used) for road-building material may cause temporary sedimentation during storm events.
- Disturbing sediments associated with a non-perennial stream/river to install dedicated stream crossings and road culverts may promote sediment runoff.

The risk assessment for the construction phase of the project is considered marginal, with mostly reversible and manageable impacts. Potential runoff and stormwater discharge from the site into the surrounding may cause erosion. This is the largest risk and should be managed as per the conceptual stormwater management plan as proposed in this document (or detailed stormwater designs from the developer).

The risk of flooding, poor quality seepage via the vadose zone, and impacts on surface water quality are predicted to be marginal during the construction phase of the project. This is largely due to the absence of any surface water streams in the project area and the nature of the development.

7.1 Existing impacts

Based on the existing land use and the field investigation undertaken, as well as the unique hydrology for the project area, no existing anthropogenic impacts were noted. The area is a greenfield site, with livestock (sheep and cattle) being the main user of the land.

7.2 Cumulative impacts

Limited cumulative impacts are likely, as the development is linear where only small areas will be disturbed and this only during the construction phase.

Table 7-2: Construction (preparation and development) phase hydrological risk - access road

Component Being Impacted On	Activity Which May Cause the Impact	Activity	Pre- Mitigation Duration (D)	Extent (E)	Potential for impact on irreplaceable resources (I)	Severity (S)	Consequence (C)	Probability (P)	Significance	Recommended Mitigation Measures	Post Mitigation Duration (D)	Extent (E)	Potential for impact on irreplaceable resources (I)	Severity (S)	Consequence (C)	Probability (P)	Significance	Confidence
Vadose zone soils	Disturbing vadose zone during excavations activities, contractor laydown areas. Excavations associated with the borrow pits for road-building material may subject the surroundings to temporary sedimentation during storm events. There is a potential for some erosion if there are storm events. Hydrocarbon/oil spillages onto soils have the potential to contaminate the soils.	Earthworks and road construction	Short-term (2)	Site (2)	Yes (1)	Medium (-2)	Slightly detrimental (-7 to -12) (-10)	Definite (2)	Low (-20)	• Only excavate / clear areas applicable to the project area. • Keep the site clean of all general and domestic wastes. • All development footprint areas to remain as small as possible and vegetation clearing to be limited to what is essential. • Retain as much indigenous vegetation as possible / re-vegetate. • Have fuel/oil spill clean-up kits on site. • Exposed soils are to be protected using a suitable covering or sandbags or berms to control erosion.	Short-term (2)	Site (2)	Yes (1)	Low (1)	Negligible (0 to -6) (-5)	Definite (2)	Neutral (0 to -12) (-10)	Medium
Primary Surface Water Receivers - > Non-perennial streams	Erosion and sedimentation of watercourses due to unforeseen circumstances (i.e., bad weather). Alteration of natural drainage lines may lead to ponding or increased runoff patterns (i.e., may cause stagnant water levels or increase erosion). Installation of road culverts or pylons for transmission lines may cause temporary sedimentation after storm events.	Earthworks and road construction	Short-term (2)	Site (2)	Yes (1)	Medium (-2)	Slightly detrimental (-7 to -12) (-10)	Definite (2)	Low (-20)	• Cover soil stockpiles with a temporary liner to prevent contamination (where required and visually determined). • Ensure stormwater systems are sized by a professional engineer to accommodate at least 1:100yr flood events.	Short-term (2)	Site (2)	Yes (1)	Low (1)	Negligible (0 to -6) (-5)	Definite (2)	Neutral (0 to -12) (-10)	Medium

Table 7-3: Construction (preparation and development) phase hydrological risk - transmission line, batching plant and additional groundwater abstraction

Component Being Impacted On	Activity Which May Cause the Impact	Activity	Pre- Mitigation							Recommended Mitigation Measures	Post Mitigation							Confidence
			Duration (D)	Extent (E)	Potential for impact on irreplaceable resources (I)	Severity (S)	Consequence (C)	Probability (P)	Significance		Duration (D)	Extent (E)	Potential for impact on irreplaceable resources (I)	Severity (S)	Consequence (C)	Probability (P)	Significance	
Vadose zone soils	Disturbing vadose zone during excavations activities, contractor laydown areas. Excavations associated with the borrow pits for road-building material may subject the surroundings to temporary sedimentation during storm events. There is a potential for some erosion if there are storm events. Hydrocarbon/oil spillages onto soils have the potential to contaminate the soils.	Earthworks and MTS and transmission line construction	Short-term (2)	Site (2)	Yes (1)	Medium (-2)	Slightly detrimental (-7 to -12) (-10)	Definite (2)	Low (-20)	• Only excavate / clear areas applicable to the project area. • Keep the site clean of all general and domestic wastes. • All development footprint areas to remain as small as possible and vegetation clearing to be limited to what is essential. • Retain as much indigenous vegetation as possible / re-vegetate. • Have fuel/oil spill clean-up kits on site. • Exposed soils are to be protected using a suitable covering or sandbags or berms to control erosion.	Short-term (2)	Site (2)	Yes (1)	Low (1)	Negligible (0 to -6) (-5)	Definite (2)	Neutral (0 to -12) (-10)	Medium
Primary Surface Water Receivers - > Non-perennial streams	Erosion and sedimentation of watercourses due to unforeseen circumstances (i.e., bad weather). Alteration of natural drainage lines may lead to ponding or increased runoff patterns (i.e., may cause stagnant water levels or increase erosion). Installation of road culverts or pylons for transmission lines may cause temporary sedimentation after storm events.	Earthworks and MTS and transmission line construction	Short-term (2)	Site (2)	Yes (1)	Medium (-2)	Slightly detrimental (-7 to -12) (-10)	Definite (2)	Low (-20)	• Cover soil stockpiles with a temporary liner to prevent contamination (where required and visually determined). • Ensure stormwater systems are sized by a professional engineer to accommodate at least 1:100yr flood events.	Short-term (2)	Site (2)	Yes (1)	Low (1)	Negligible (0 to -6) (-5)	Definite (2)	Neutral (0 to -12) (-10)	Medium
Regional groundwater table	Oil/fuel spillages may enter the regional groundwater table if prolonged percolation via the vadose zone takes place	Earthworks and MTS and transmission line construction	Short-term (2)	Site (2)	Yes (1)	Low (-1)	Negligible (-6 to 0) (-5)	Improbable (0)	Very low (0 to -12) (0 - ZERO)	No mitigation is possible. Impact projected to be zero.								Medium
Groundwater users	Poor quality seepage from oil/fuel spills during the construction phase, at any point in the project area, may	Earthworks and MTS and transmission line construction	Short-term (2)	Site (2)	Yes (1)	Low (-1)	Negligible (-6 to 0) (-5)	Probable (1)	Very low (0 to -12) (-10)	• Do not overproduce from boreholes used as part of the project. 8 hours of pumping	Short-term (2)	Site (2)	Yes (1)	Low (1)	Negligible (0 to -6) (-5)	Improbable (0)	Neutral (0 to -12) (0 - ZERO)	Medium

	impact the shallow groundwater table. Groundwater boreholes are generally situated within and downstream of the development areas, hence are potential receptors to pollution.									per day is recommended. • Ensure routine water quality monitoring is undertaken. • Conduct multi-borehole water level logging, to ensure that no cumulative dewatering impacts are taking place for boreholes which may be in the same contact zones.									

8 SURFACE WATER MONITORING

It is proposed that a proper monitoring programme be implemented to monitor water quality downstream of crossings or construction works areas (**when there is water in the area to monitor**). No quantity monitoring is proposed due to the lack of flowing water in the project area.

Water and soil monitoring should focus on active excavation and equipment / heavy machinery parking areas, as well as excavation areas. Regular visual inspections of these areas need to be undertaken (i.e., weekly). Moreover, placement and monitoring of drip trays underneath parked construction vehicles will help to determine which vehicles need to be repaired/taken off-site to prevent contamination while in service. This should be enforced by the environmental control officer (ECO).

Proposed sample points where visual inspections are recommended, upstream and downstream of the crossings, are listed in Table 8-1. Sample positions are shown in Figure 6-3 to Figure 6-7. No monitoring is proposed for the operational phase of this project. It is proposed that the applicant be responsible for the water monitoring.

For groundwater monitoring aspects we refer to the “The development of three Solar Photovoltaic (PV) facilities and associated infrastructure (Phases 1, 2 and 3) between De Aar & Hanover, Emthanjeni Local Municipality, Pixley Ka Seme District Municipality, Northern Cape Province, South Africa – GCS (2022) Report.

Table 8-1: Proposed monitoring points for the construction phase & monitoring frequency

ID	Latitude (WGS84)	Longitude (WGS84)	Type	Frequency
SW01	-30.89564576	24.30129996	Visual inspection of the ground for signs of erosion and contamination **Only undertake water quality monitoring if there is water to monitor AND signs of pollution.**	Monitoring during the construction phase only. Visual inspections are to be done first. If there are visual signs of pollution, laboratory samples to screen for hydrocarbons (BTEXN). If erosion and sedimentation are noted, then efforts should be made to stabilise and rehabilitate the erosional areas (i.e., use temporary sandbags, earth berms, vegetation or rip-rap).
SW02	-30.8927332	24.31143042		
SW03	-30.86243076	24.23359022		
SW04	-30.85315456	24.27743527		
SW05	-30.8494506	24.27781369		

9 CONCLUSION

Based on the investigation undertaken, the following conclusions are made:

- The site is situated in Quaternary D62D of the Orange Water Management Area (WMA)
  - The site means annual precipitation (MAP) is in the order of 320 mm/yr.
  - Natural runoff was recorded as approximately 3.1 mm/yr, which represents approximately 1% of the MAP.
  - Evaporation is reported as 1 500-1 600 mm/annum (S-Pan).
- Eight (8) hydrological response units (HRUs) describe the natural drainage for the study area. The HRUs delineated correspond well to known non-perennial rivers and drainage lines associated with the project area. Drainage in the HRUs is towards the northwest in the form of a multitude of non-perennial drainage lines, which drains towards the non-perennial Brak River, of which the proposed consolidated access road to MTS will cross. The Brak River and a tributary thereof (bounding the Sun Central 1 development) are the only recognised water courses in the area. Topography data and google imagery were used to delineate several ephemeral drainage lines, which contribute to the overall drainage of the Brak River. It is observed that there are potentially eight (8) ephemeral drainage line crossings, associated with the proposed road and transmission line development
- No clearly defined drainage channels could be located in the field. It was observed that the topography is such that there is drainage from various areas with no clearly defined flow paths. As such, sheet flow from micro-sub catchments towards lower topographical areas or isolated depressions forms temporarily flooded areas. Irregular occurrences of ponded water were visible across the project area, even in areas with no defined drainage lines or stream channels.
- The flood line assessment undertaken for the project area suggests that the area is prone to exhibiting ponded flood occurrence zone, in the absence of clearly defined drainage channels or streams. This is due to the micro-catchment style drainage associated with the project area.
- The CSWMP indicates that:
  - There are at least eight (8) non-perennial crossings, of which two (2) will require stormwater management.
  - A box culvert and dampening system, as well as a concrete drift crossing, can be considered to manage stormwater, and prevent sedimentation and erosion.
  - Free drainage is the preferred stormwater management option associated with this project.

- The risk assessment for both construction and post-construction phases of the project is considered marginal, with mostly reversible and manageable impacts. Erosion and sedimentation at crossings associated with the MTS, roadway and transmission lines are the largest risk areas. The risk of flooding, poor quality seepage via the vadose zone, and impacts on surface water quality are predicted to be marginal during the construction phase of the project, and zero during the operational phase. This is largely due to the absence of any surface water streams in the project area and the nature of the development.

9.1 Identification of any areas that should be avoided

No dedicated buffer areas are recommended, other than staying out of pre-identified high ecological importance areas as identified per the EIA screening assessment.

9.2 Mitigation measures for inclusion in the EMPr and EIA

The following mitigation measures can be implemented as part of the EMPr to further reduce the risk of flooding on site and contribution to stormwater generation potential:

- Stormwater management should focus on the following before the work takes place:
  - **Assess the site constraints and any site-specific concerns, including:**
    - Specific vegetation that may need to be identified and/or isolated from the site disturbance.
    - Highly erodible soils may require additional erosion control measures.
    - The type of construction should consider landform. Avoid slab-on-ground construction on steep sites.
    - Up-slope drainage catchments that may need to be diverted around the work site.
    - Workspace limitations may require site-specific sediment control measures and/or the extensive use of skips or bins for material storage and waste management.
    - Expected rainfall intensity during the period of disturbance (wet season vs dry season).
  - **Stabilise the site entry/exit points:**

        - A stabilised site access must be established and if possible, limited to one point only. The access allows for the construction vehicles to enter the work area of goods while preventing the unnecessary tracking of sediment onto the nearby environment from multiple locations. A stabilised entry/exit point normally consists of a stabilised rock pad.

    - **<u>Prevent erosion & manage stockpiles:</u>**

        - Suitable material storage areas must be located up-slope of the main sediment barrier (e.g., sediment fence).

        - Stockpiles kept on site for more than two weeks will require an impervious cover (e.g., builder's plastic or geofabric) to protect against raindrop impact. Stockpiles of sandy material located behind a sediment fence will only need a protective cover if the stockpiles are likely to be exposed to strong winds.

        - On steep sites and sites with limited available space, erodible materials may need to be stored in commercial-sized bins or mini-skips before use.

    - **<u>Manage Site Waste</u>**

        - Adequate waste receptacles must be provided on-site and maintained in a way that potential and actual environmental harm resulting from such material waste is minimised.

        - Building activities must be carried out on a pervious surface, such as grass or open soil, or in such a manner that all sediment-laden runoff is prevented from discharging into a water body.

    - Based on the above mentioned, it is recommended that work take place in dry months, and don't leave excavations open or the area unrehabilitated before a rainfall month occurs. If work does commence in wet seasons, it is advised that the measures in this document be considered, as well as any means to prevent erosion and sediment runoff (i.e., temporary sandbags, reed beds, re-vegetation, temporary stilling basins, temporary berms etc.).

- Ensure a stormwater management plan is implemented, and that all stormwater systems are kept clean of any debris to reduce flooding risk.

- Ensure that eroded areas are re-vegetated, to ensure reduced sedimentation risk and reduced runoff volumes to the streams.

- Have fuel/oil spill kits on-site, for immediate clean-up of any hydrocarbons during the proposed activities. Park vehicles in dedicated areas, with drip trays to manage potential leakages.
- Conduct regular inspections and maintenance of the site to ensure that vegetation cover is adequate, and no rivulets are generated.

9.3 Reasoned opinion on whether the activity should be authorized

This hydrological assessment cannot find any grounds or identify high hydrological risks that do not proceed with the development. This is grounded on the assumption that the proposed mitigation measures (Section 7), CSWMP, EMPr and EIA recommendations are implemented during the construction and operational phase of the development.

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APPENDIX A: PEAK FLOW ESTIMATES – FLOOD LINES

HRU1

RATIONAL METHOD 3							
Description of catchment		HRU1					
River detail	Non-Perennial Reach of the Brak River						
Calculated by	Hendrik Botha				Date	Tuesday, 06 December 2022	
Physical characteristics							
Size of catchment (A)	405	km^2		Rainfall region		D6C	
Longest watercourse (L)	36.3	km		**Area distribution factors**			
Average slope (S_{av})	0.0038	m/m		Rural (α)	Urban (β)	Lakes (γ)	
Dolomite area (D%)	0	%		1	0	0	
Mean annual rainfall(MAR)	320	mm					
Rural				**URBAN**			
Surface slope	**%**	**Factor**	**C_s**	**Description**	**%**	**Factor**	**C2**
Vleis and pans (<3%)	70.61	0.01	0.71	**Lawns**			
Flat areas (3 - 10%)	22.05	0.06	1.32	Sandy,flat<2%	0	0.08	0
Hilly (10 - 30%)	5.42	0.12	0.65	Sandy,steep>7%	0	0.16	0
Steep Areas (>30%)	1.92	0.22	0.42	Heavy s,flat<2%	0	0.15	0
Total	100.00	0.41	3.10	Heavy s,steep>7%	0	0.3	0
Permeability	**%**	**Factor**	**C_p**	**Residential Areas**			
Very permeable	80	0.03	2.40	Houses	0	0.5	0
Permeable	20	0.06	1.20	Flats	0	0.6	0
Semi-permeable	0	0.12	0.00	Industry			
Impermeable	0	0.21	0.00	Light industry	0	0.6	0
Total	100	0.42	3.60	Heavy industry	0	0.7	0
Vegetation	**%**	**Factor**	**C_v**	**Business**			
Thick bush & plantation	70.9	0.03	2.13	City centre	0	0.8	0
Light bush & farm-lands	21.1	0.07	1.48	Suburban	0	0.65	0
Grasslands	1.42	0.17	0.24	Streets	0	0.75	0
No vegatation	6.65	0.26	1.73	Max flood	0	1	0
Total	100.07	0.53	5.57	Total (C2)	0		0
Time of concentration (TC)							
				Use Defined watercourse			
7.741 hours	9.008	hours					
Run-off coefficient							
Return Period (years)	2	5	10	20	50	100	PMF
Run-off coefficient, C_1	0.123	0.123	0.123	0.123	0.123	0.123	0.900
Adjusted for dolomitic areas, C_{1D}	0.123	0.123	0.123	0.123	0.123	0.123	0.900
dj factor for initial saturation, F	0.5	0.55	0.6	0.67	0.83	1	1.00
Adjusted run - off coefficient, C_{1T}	0.0613815	0.06751965	0.0736578	0.082	0.102	0.123	0.900
Combined run - off coefficient, C_T	0.0613815	0.06751965	0.0736578	0.082	0.102	0.123	0.900
Rainfall							
Return Period (years)	2	5	10	20	50	100	PMF
Point rainfall (mm), P_T	39.65	55.91	67.80	80.19	97.35	111.22	126.09
Point Intensity (mm/h), P_{iT}	4.40	6.21	7.53	8.90	10.81	12.35	14.00
Area reduction factor (%),ARF_T	0.891	0.891	0.891	0.891	0.891	0.891	0.891
Average intensity (mm/hour),I_T	3.923	5.532	6.709	7.934	9.632	11.005	12.476
Return Period (years)	2	5	10	20	50	100	PMF
Peak flow (m3/s)	27.092	42.021	55.595	73.420	110.414	151.98	1263.20

$$T_C = 0.604\left(\frac{rL}{\sqrt{S_{av}}}\right)^{0.467}$$

$$T_c = \left[\frac{0.87\,L^2}{1000\,S_{AV}}\right]^{0.385}$$

STANDARD DESIGN FLOOD (SDF) METHOD							
Description of catchment	HRU1						
River detail	Non-Perennial Reach of the Brak River						
Calculated by	Hendrik Botha			Date	06/12/2022		
Physical characteristics							
Size of catchment (A)	405	km^2		Days of thunder per year (R)		52	days
Longest watercourse (L)	36.3	km		Time of concentration, t		540.477	minutes
Average slope (S_{av})	0.004	m/m		Time of concentration, T_c	$T_c = \left[\frac{0.87\,L^2}{1000\,S_{AV}}\right]^{0.385}$		
SDF Basin	12						
2-year return period rainfall (M)	39	mm					9.0080
TR102 n-day rainfall data							
Weather Service Station				MAP		320	mm
Weather Service Station no.				Coordinates			
Duration	Return Period (years)						
	2	5	10	20	50	100	200
Rainfall							
Return Period (years), T	2	5	10	20	50	100	200
Point precipitation depth (mm) $P_{t,T}$	33.4	56.4	73.8	91.1	114.1	131.5	148.8
Area reduction factor (%),ARF_T	0.891	0.891	0.891	0.891	0.891	0.891	0.891
Average intensity (mm/hour),I_T	3.3	5.6	7.3	9.0	11.3	13.0	14.7
Run-off coefficient							
Calibration factors C_2 (%)	5		C_{100} (%)		30		
Return Period (years), T	2	5	10	20	50	100	200
Return period factors (Y_T)	0	0.84	1.28	1.64	2.05	2.33	2.58
Run-off coefficient, C_T	0.050	0.140	0.187	0.226	0.270	0.300	0.327
Peak flow (m3/s)	18.61	87.97	153.83	229.25	342.89	439.07	541.53

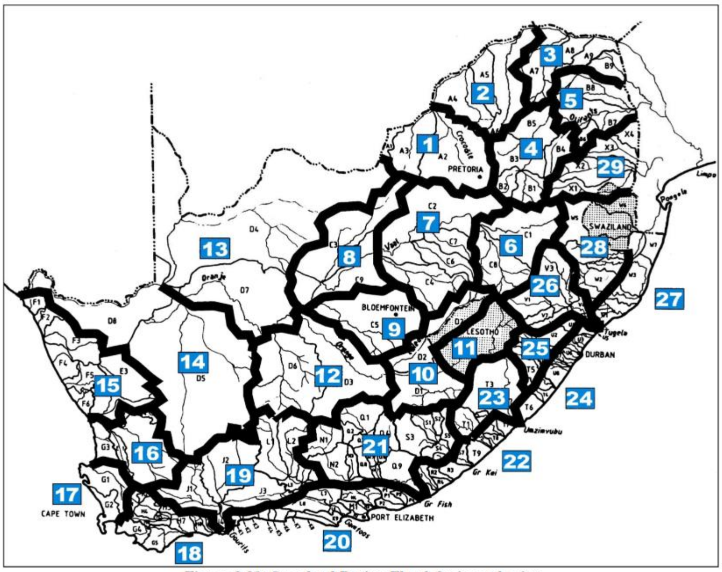


Figure 3.30: Standard Design Flood drainage basins

MIDGLEY & PITMAN (MIPI) METHOD														
River Detail	Catchment Area	MAP	S	L	Lc	Constant K_T				Catchment Parameter	Peak Flows			
	(km^2)	(mm)	m/m	km	km	1:10 year	1:20 Year	1: 50 year	1: 100 year	(Dimensionless)	1:10 year	1:20 Year	1: 50 year	1: 100 year
HRU1	405	320	0.0038	36.3	17.1	0.59	0.8	1.11	1.4	0.0402	137.31	186.18	258.33	325.82

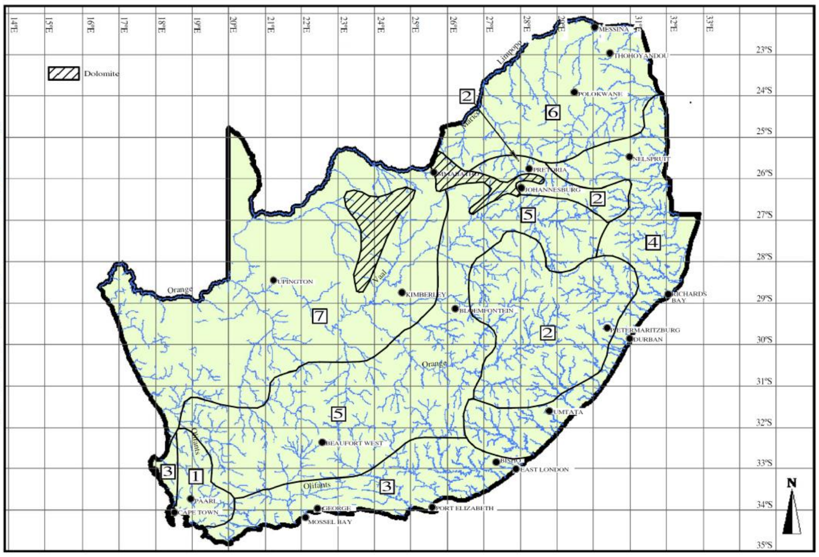


Figure 3.35: Homogeneous flood regions in South Africa

HRU2

RATIONAL METHOD 3							
Description of catchment		HRU2					
River detail	Non-Perennial Reach of the Brak River						
Calculated by	Hendrik Botha				Date	Tuesday, 06 December 2022	
Physical characteristics							
Size of catchment (A)	40.471	km^2		Rainfall region		D6C	
Longest watercourse (L)	10.58	km		**Area distribution factors**			
Average slope (S_{av})	0.0062	m/m		Rural (α)	Urban (β)	Lakes (γ)	
Dolomite area (D%)	0	%		1	0	0	
Mean annual rainfall(MAR)	320	mm					
Rural				**URBAN**			
Surface slope	**%**	**Factor**	**C_s**	**Description**	**%**	**Factor**	**C2**
Vleis and pans (<3%)	65.20	0.01	0.65	**Lawns**			
Flat areas (3 - 10%)	30.61	0.06	1.84	Sandy,flat<2%	0	0.08	0
Hilly (10 - 30%)	4.09	0.12	0.49	Sandy,steep>7%	0	0.16	0
Steep Areas (>30%)	0.10	0.22	0.02	Heavy s,flat<2%	0	0.15	0
Total	100.00	0.41	3.00	Heavy s,steep>7%	0	0.3	0
Permeability	**%**	**Factor**	**C_p**	**Residential Areas**			
Very permeable	80	0.03	2.40	Houses	0	0.5	0
Permeable	20	0.06	1.20	Flats	0	0.6	0
Semi-permeable	0	0.12	0.00	Industry			
Impermeable	0	0.21	0.00	Light industry	0	0.6	0
Total	100	0.42	3.60	Heavy industry	0	0.7	0
Vegetation	**%**	**Factor**	**C_v**	**Business**			
Thick bush & plantation	74.95	0.03	2.25	City centre	0	0.8	0
Light bush & farm-lands	17.37	0.07	1.22	Suburban	0	0.65	0
Grasslands	1.63	0.17	0.28	Streets	0	0.75	0
No vegatation	6.15	0.26	1.60	Max flood	0	1	0
Total	100.1	0.53	5.34	Total (C2)	0		0
Time of concentration (TC)							
$T_C = 0.604\left(\frac{rL}{\sqrt{S_{av}}}\right)^{0.467}$		$T_c = \left[\frac{0.87\,L^2}{1000\,S_{AV}}\right]^{0.385}$		Use Defined watercourse			
3.882 hours		2.887	hours				
Run-off coefficient							
Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**	**PMF**
Run-off coefficient, C_1	0.119	0.119	0.119	0.119	0.119	0.119	0.900
Adjusted for dolomitic areas, C_{1D}	0.119	0.119	0.119	0.119	0.119	0.119	0.900
dj factor for initial saturation, F	0.5	0.55	0.6	0.67	0.83	1	1.00
Adjusted run - off coefficient, C_{1T}	0.0597095	0.06568045	0.0716514	0.080	0.099	0.119	0.900
Combined run - off coefficient, C_T	0.0597095	0.06568045	0.0716514	0.080	0.099	0.119	0.900
Rainfall							
Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**	**PMF**
Point rainfall (mm), P_T	33.39	47.26	57.27	67.68	82.14	93.93	106.42
Point Intensity (mm/h), P_{it}	11.57	16.37	19.84	23.44	28.45	32.53	36.86
Area reduction factor (%),ARF_T	0.973	0.973	0.973	0.973	0.973	0.973	0.973
Average intensity (mm/hour),I_T	11.250	15.920	19.293	22.798	27.671	31.642	35.849
Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**	**PMF**
Peak flow (m3/s)	7.551	11.755	15.540	20.507	30.833	42.48	362.71

STANDARD DESIGN FLOOD (SDF) METHOD							
Description of catchment	HRU2						
River detail	Non-Perennial Reach of the Brak River						
Calculated by	Hendrik Botha			Date	06/12/2022		
Physical characteristics							
Size of catchment (A)	40.471	km^2		Days of thunder per year (R)		52	days
Longest watercourse (L)	10.58	km		Time of concentration, t		173.240	minutes
Average slope (S_{av})	0.006	m/m		Time of concentration, T_c	$T_c = \left[\frac{0.87 L^2}{1000 S_{AV}}\right]^{0.385}$		2.8873
SDF Basin	12						
2-year return period rainfall (M)	39	mm					
TR102 n-day rainfall data							
Weather Service Station				MAP		320	mm
Weather Service Station no.				Coordinates			
Duration	Return Period (years)						
	2	5	10	20	50	100	200
Rainfall							
Return Period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**200**
Point precipitation depth (mm) $P_{t,T}$	27.0	45.5	59.5	73.5	92.0	106.1	120.1
Area reduction factor (%),ARF_T	0.973	0.973	0.973	0.973	0.973	0.973	0.973
Average intensity (mm/hour),I_T	9.1	15.3	20.0	24.8	31.0	35.7	40.4
Run-off coefficient							
Calibration factors / C_2 (%)	5		C_{100} (%)		30		
Return Period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**200**
Return period factors (Y_T)	0	0.84	1.28	1.64	2.05	2.33	2.58
Run-off coefficient, C_T	0.050	0.140	0.187	0.226	0.270	0.300	0.327
Peak flow (m3/s)	5.11	24.14	42.22	62.91	94.10	120.49	148.61

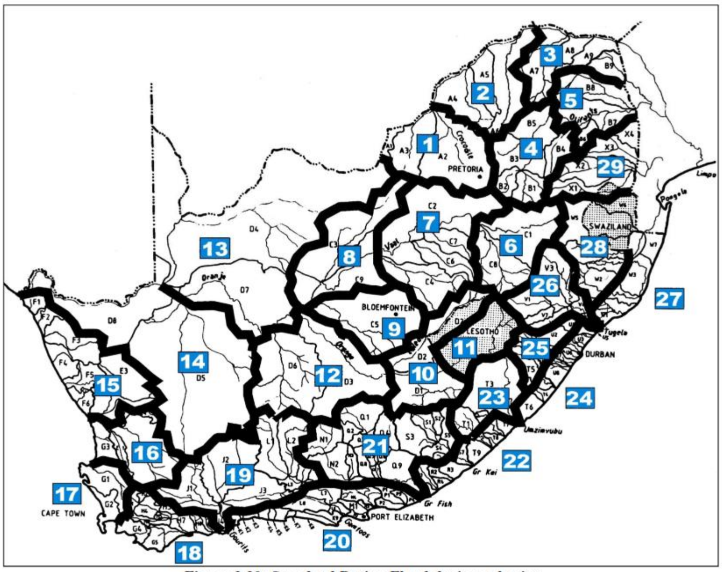


Figure 3.30: Standard Design Flood drainage basins

MIDGLEY & PITMAN (MIPI) METHOD														
River Detail	Catchment Area	MAP	S	L	Lc	Constant K_T				Catchment Parameter	Peak Flows			
	(km^2)	(mm)	m/m	km	km	1:10 year	1:20 Year	1: 50 year	1: 100 year	(Dimensionless)	1:10 year	1:20 Year	1: 50 year	1: 100 year
HRU2	40.471	320	0.0062	10.6	7.7	0.59	0.8	1.11	1.4	0.0391	34.28	46.49	64.50	81.35

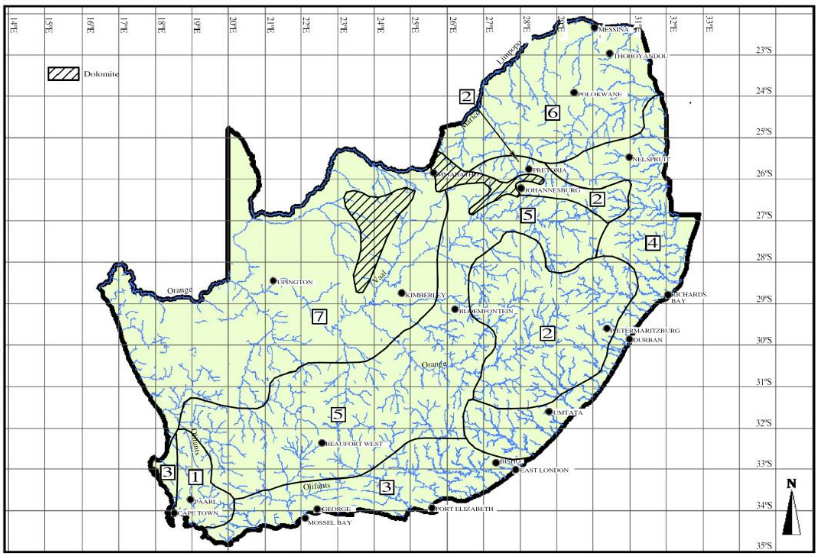


Figure 3.35: Homogeneous flood regions in South Africa

HRU3

RATIONAL METHOD 3							
Description of catchment		HRU3					
River detail	Non-Perennial Reach of the Brak River						
Calculated by	Hendrik Botha			Date	Tuesday, 06 December 2022		
Physical characteristics							
Size of catchment (A)	48.329	km^2		Rainfall region	D6C		
Longest watercourse (L)	10.05	km		Area distribution factors			
Average slope (S_{av})	0.0049	m/m		Rural (α)	Urban (β)	Lakes (γ)	
Dolomite area (D%)	0	%		1	0	0	
Mean annual rainfall(MAR)	320	mm					
Rural				URBAN			
Surface slope	%	Factor	C_s	Description	%	Factor	C2
Vleis and pans (<3%)	74.73	0.01	0.75	Lawns			
Flat areas (3 - 10%)	21.97	0.06	1.32	Sandy,flat<2%	0	0.08	0
Hilly (10 - 30%)	2.67	0.12	0.32	Sandy,steep>7%	0	0.16	0
Steep Areas (>30%)	0.62	0.22	0.14	Heavy s,flat<2%	0	0.15	0
Total	99.99	0.41	2.52	Heavy s,steep>7%	0	0.3	0
Permeability	%	Factor	C_p	Residential Areas			
Very permeable	80	0.03	2.40	Houses	0	0.5	0
Permeable	20	0.06	1.20	Flats	0	0.6	0
Semi-permeable	0	0.12	0.00	Industry			
Impermeable	0	0.21	0.00	Light industry	0	0.6	0
Total	100	0.42	3.60	Heavy industry	0	0.7	0
Vegetation	%	Factor	C_v	Business			
Thick bush & plantation	70.31	0.03	2.11	City centre	0	0.8	0
Light bush & farm-lands	20.93	0.07	1.47	Suburban	0	0.65	0
Grasslands	4.19	0.17	0.71	Streets	0	0.75	0
No vegatation	4.69	0.26	1.22	Max flood	0	1	0
Total	100.12	0.53	5.51	Total (C2)	0		0

Time of concentration (TC)

$$T_C = 0.604\left(\frac{rL}{\sqrt{S_{av}}}\right)^{0.467}$$

$$T_c = \left[\frac{0.87\,L^2}{1000\,S_{AV}}\right]^{0.385}$$

Use Defined watercourse

4.005	hours	3.038	hours

Run-off coefficient							
Return Period (years)	2	5	10	20	50	100	PMF
Run-off coefficient, C_1	0.116	0.116	0.116	0.116	0.116	0.116	0.900
Adjusted for dolomitic areas, C_{1D}	0.116	0.116	0.116	0.116	0.116	0.116	0.900
dj factor for initial saturation, F	0.5	0.55	0.6	0.67	0.83	1	1.00
Adjusted run - off coefficient, C_{1T}	0.058142	0.0639562	0.0697704	0.078	0.097	0.116	0.900
Combined run - off coefficient, C_T	0.058142	0.0639562	0.0697704	0.078	0.097	0.116	0.900

Rainfall							
Return Period (years)	2	5	10	20	50	100	PMF
Point rainfall (mm), P_T	33.71	47.71	57.81	68.32	82.92	94.82	107.43
Point Intensity (mm/h), P_{it}	11.09	15.70	19.03	22.48	27.29	31.21	35.35
Area reduction factor (%),ARF_T	0.965	0.965	0.965	0.965	0.965	0.965	0.965
Average intensity (mm/hour),I_T	10.708	15.156	18.366	21.702	26.341	30.122	34.126
Return Period (years)	2	5	10	20	50	100	PMF
Peak flow (m3/s)	8.358	13.013	17.202	22.698	34.130	47.02	412.31

STANDARD DESIGN FLOOD (SDF) METHOD							
Description of catchment		HRU3					
River detail	Non-Perennial Reach of the Brak River						
Calculated by	Hendrik Botha			Date	06/12/2022		
Physical characteristics							
Size of catchment (A)	48.329	km^2		Days of thunder per year (R)		52	days
Longest watercourse (L)	10.05	km		Time of concentration, t		182.309	minutes
Average slope (S_{av})	0.005	m/m		Time of concentration, T_c	$T_c = \left[\frac{0.87\,L^2}{1000\,S_{AV}}\right]^{0.385}$		3.0385
SDF Basin	12						
2-year return period rainfall (M)	39	mm					
TR102 n-day rainfall data							
Weather Service Station				MAP		320	mm
Weather Service Station no.				Coordinates			
Duration	Return Period (years)						
	2	5	10	20	50	100	200
Rainfall							
Return Period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**200**
Point precipitation depth (mm) $P_{t,T}$	27.3	46.0	60.1	74.3	93.0	107.2	121.4
Area reduction factor (%),ARF_T	0.965	0.965	0.965	0.965	0.965	0.965	0.965
Average intensity (mm/hour),I_T	8.7	14.6	19.1	23.6	29.6	34.1	38.6
Run-off coefficient							
Calibration factors — C_2 (%)	5		C_{100} (%)		30		
Return Period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**200**
Return period factors (Y_T)	0	0.84	1.28	1.64	2.05	2.33	2.58
Run-off coefficient, C_T	0.050	0.140	0.187	0.226	0.270	0.300	0.327
Peak flow (m3/s)	5.81	27.48	48.05	71.61	107.11	137.15	169.15

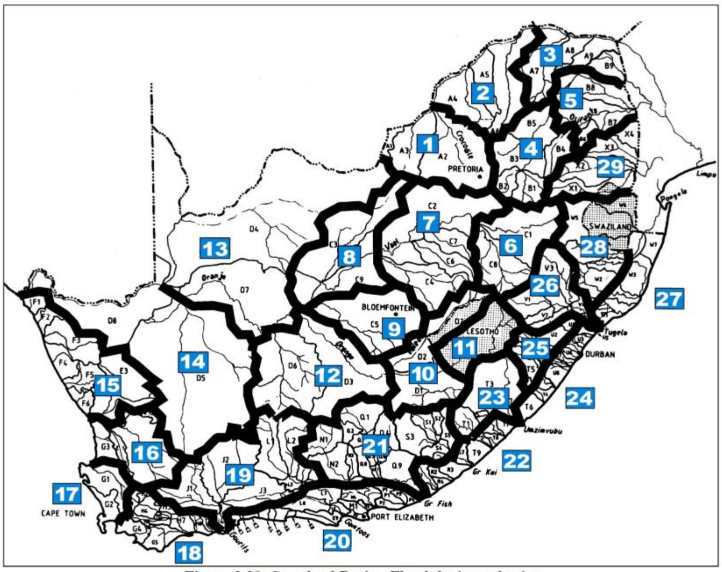


Figure 3.30: Standard Design Flood drainage basins

MIDGLEY & PITMAN (MIPI) METHOD														
River Detail	Catchment Area	MAP	S	L	Lc	Constant K_T				Catchment Parameter	Peak Flows			
	(km^2)	(mm)	m/m	km	km	1:10 year	1:20 Year	1: 50 year	1: 100 year	(Dimensionless)	1:10 year	1:20 Year	1: 50 year	1: 100 year
HRU3	48.329	320	0.0049	10.1	8.6	0.59	0.8	1.11	1.4	0.0391	38.14	51.72	71.76	90.50

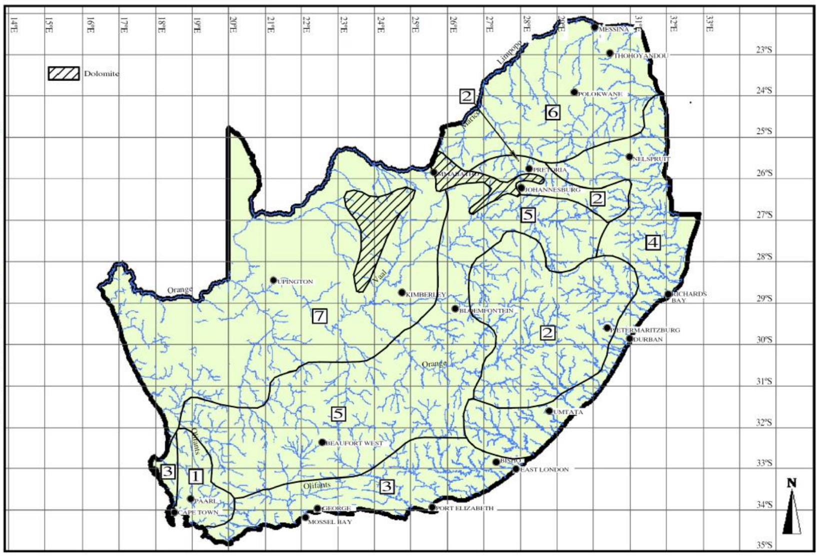


Figure 3.35: Homogeneous flood regions in South Africa

HRU4

RATIONAL METHOD 3							
Description of catchment		HRU4					
River detail	Non-Perennial Reach of the Brak River						
Calculated by	Hendrik Botha			Date	Tuesday, 06 December 2022		
Physical characteristics							
Size of catchment (A)	9.4	km^2		Rainfall region		D6C	
Longest watercourse (L)	1.9	km		Area distribution factors			
Average slope (S_{av})	0.0021	m/m		Rural (α)	Urban (β)	Lakes (γ)	
Dolomite area (D%)	0	%		1	0	0	
Mean annual rainfall(MAR)	320	mm					
Rural				URBAN			
Surface slope	%	Factor	C_s	Description	%	Factor	C2
Vleis and pans (<3%)	88.49	0.01	0.88	Lawns			
Flat areas (3 - 10%)	8.97	0.06	0.54	Sandy,flat<2%	0	0.08	0
Hilly (10 - 30%)	1.85	0.12	0.22	Sandy,steep>7%	0	0.16	0
Steep Areas (>30%)	0.69	0.22	0.15	Heavy s,flat<2%	0	0.15	0
Total	100.00	0.41	1.80	Heavy s,steep>7%	0	0.3	0
Permeability	%	Factor	C_p	Residential Areas			
Very permeable	80	0.03	2.40	Houses	0	0.5	0
Permeable	20	0.06	1.20	Flats	0	0.6	0
Semi-permeable	0	0.12	0.00	Industry			
Impermeable	0	0.21	0.00	Light industry	0	0.6	0
Total	100	0.42	3.60	Heavy industry	0	0.7	0
Vegetation	%	Factor	C_v	Business			
Thick bush & plantation	77.73	0.03	2.33	City centre	0	0.8	0
Light bush & farm-lands	20	0.07	1.40	Suburban	0	0.65	0
Grasslands	0.19	0.17	0.03	Streets	0	0.75	0
No vegatation	2.08	0.26	0.54	Max flood	0	1	0
Total	100	0.53	4.31	Total (C2)	0		0

$$T_C = 0.604\left(\frac{rL}{\sqrt{S_{av}}}\right)^{0.467}$$

$$T_c = \left[\frac{0.87\,L^2}{1000\,S_{AV}}\right]^{0.385}$$

Use Defined watercourse

2.242	hours	1.168	hours

Run-off coefficient							
Return Period (years)	2	5	10	20	50	100	PMF
Run-off coefficient, C_1	0.097	0.097	0.097	0.097	0.097	0.097	0.900
Adjusted for dolomitic areas, C_{1D}	0.097	0.097	0.097	0.097	0.097	0.097	0.900
dj factor for initial saturation, F	0.5	0.55	0.6	0.67	0.83	1	1.00
Adjusted run - off coefficient, C_{1T}	0.0485095	0.05336045	0.0582114	0.065	0.081	0.097	0.900
Combined run - off coefficient, C_T	0.0485095	0.05336045	0.0582114	0.065	0.081	0.097	0.900
Rainfall							
Return Period (years)	2	5	10	20	50	100	PMF
Point rainfall (mm), P_T	29.13	41.11	49.89	58.98	71.56	81.79	92.72
Point Intensity (mm/h), P_{it}	24.95	35.21	42.73	50.52	61.29	70.05	79.41
Area reduction factor (%),ARF_T	1.012	1.012	1.012	1.012	1.012	1.012	1.012
Average intensity (mm/hour),I_T	25.253	35.637	43.250	51.134	62.039	70.907	80.383
Return Period (years)	2	5	10	20	50	100	PMF
Peak flow (m3/s)	3.199	4.965	6.574	8.679	13.044	17.96	188.90

STANDARD DESIGN FLOOD (SDF) METHOD							
Description of catchment		HRU4					
River detail	Non-Perennial Reach of the Brak River						
Calculated by	Hendrik Botha			Date	06/12/2022		
Physical characteristics							
Size of catchment (A)	9.4	km^2		Days of thunder per year (R)		52	days
Longest watercourse (L)	1.9	km		Time of concentration, t		70.057	minutes
Average slope (S_{av})	0.002	m/m		Time of concentration, T_c	$T_c = \left[\frac{0.87 L^2}{1000 S_{AV}}\right]^{0.385}$		1.1676
SDF Basin	12						
2-year return period rainfall (M)	39	mm					
TR102 n-day rainfall data							
Weather Service Station				MAP		320	mm
Weather Service Station no.				Coordinates			
Duration	Return Period (years)						
	2	5	10	20	50	100	200
Rainfall							
Return Period (years), T	2	5	10	20	50	100	200
Point precipitation depth (mm) $P_{t,T}$	21.8	36.8	48.2	59.5	74.5	85.8	97.2
Area reduction factor (%),ARF_T	1.012	1.012	1.012	1.012	1.012	1.012	1.012
Average intensity (mm/hour),I_T	18.9	31.9	41.7	51.6	64.6	74.4	84.2
Run-off coefficient							
Calibration factors C_2 (%)	5		C_{100} (%)		30		
Return Period (years), T	2	5	10	20	50	100	200
Return period factors (Y_T)	0	0.84	1.28	1.64	2.05	2.33	2.58
Run-off coefficient, C_T	0.050	0.140	0.187	0.226	0.270	0.300	0.327
Peak flow (m3/s)	2.47	11.68	20.42	30.43	45.52	58.29	71.89

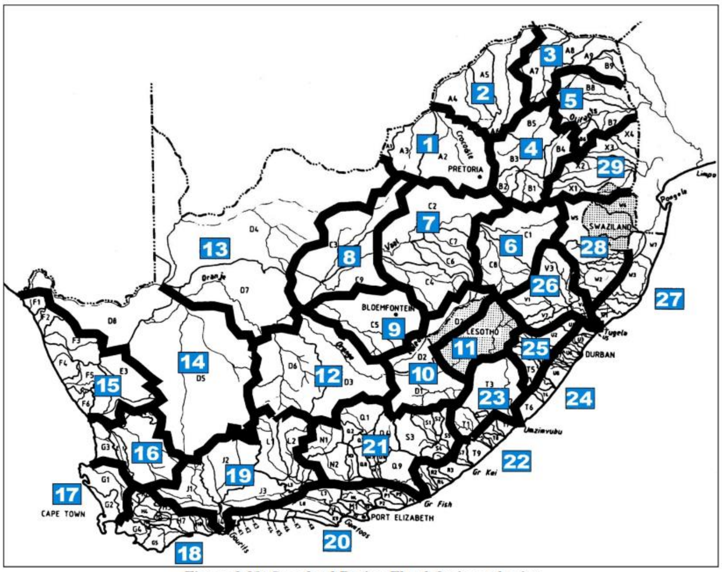
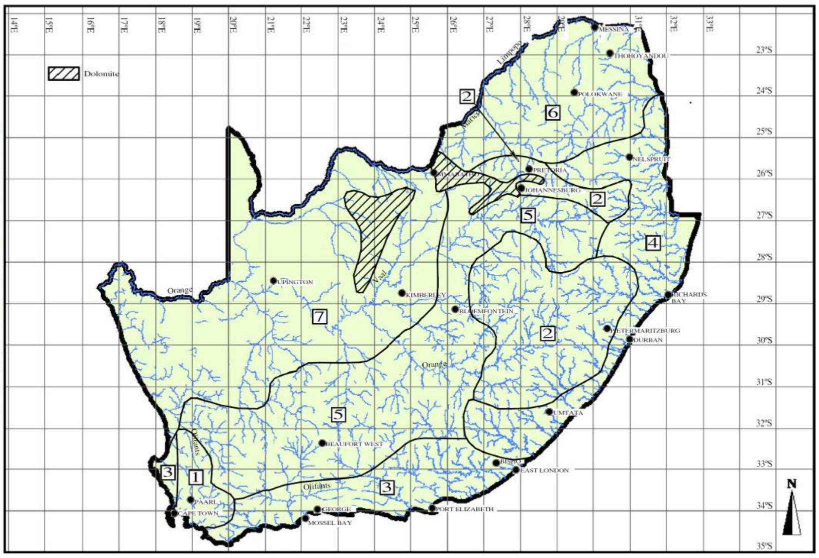


Figure 3.30: Standard Design Flood drainage basins

MIDGLEY & PITMAN (MIPI) METHOD														
River Detail	Catchment Area	MAP	S	L	Lc	Constant K_T				Catchment Parameter	Peak Flows			
	(km^2)	(mm)	m/m	km	km	1:10 year	1:20 Year	1: 50 year	1: 100 year	(Dimensionless)	1:10 year	1:20 Year	1: 50 year	1: 100 year
HRU4	9.4	320	0.0021	1.9	3.9	0.59	0.8	1.11	1.4	0.0581	15.46	20.96	29.08	36.68

Figure 3.35: Homogeneous flood regions in South Africa



HRU5

RATIONAL METHOD 3							
Description of catchment		HRU5					
River detail	Non-Perennial Reach of the Brak River						
Calculated by	Hendrik Botha			Date	Tuesday, 06 December 2022		
Physical characteristics							
Size of catchment (A)	6.99	km^2		Rainfall region		D6C	
Longest watercourse (L)	5.24	km		Area distribution factors			
Average slope (S_{av})	0.0034	m/m		Rural (α)	Urban (β)	Lakes (γ)	
Dolomite area (D%)	0	%		1	0	0	
Mean annual rainfall(MAR)	320	mm					
Rural				URBAN			
Surface slope	%	Factor	C_s	Description	%	Factor	C2
Vleis and pans (<3%)	87.46	0.01	0.87	Lawns			
Flat areas (3 - 10%)	9.37	0.06	0.56	Sandy,flat<2%	0	0.08	0
Hilly (10 - 30%)	2.30	0.12	0.28	Sandy,steep>7%	0	0.16	0
Steep Areas (>30%)	0.87	0.22	0.19	Heavy s,flat<2%	0	0.15	0
Total	100.00	0.41	1.90	Heavy s,steep>7%	0	0.3	0
Permeability	%	Factor	C_p	Residential Areas			
Very permeable	80	0.03	2.40	Houses	0	0.5	0
Permeable	20	0.06	1.20	Flats	0	0.6	0
Semi-permeable	0	0.12	0.00	Industry			
Impermeable	0	0.21	0.00	Light industry	0	0.6	0
Total	100	0.42	3.60	Heavy industry	0	0.7	0
Vegetation	%	Factor	C_v	Business			
Thick bush & plantation	73.28	0.03	2.20	City centre	0	0.8	0
Light bush & farm-lands	20.85	0.07	1.46	Suburban	0	0.65	0
Grasslands	0	0.17	0.00	Streets	0	0.75	0
No vegatation	5.88	0.26	1.53	Max flood	0	1	0
Total	100.01	0.53	5.19	Total (C2)	0		0
Time of concentration (TC)							
$T_C = 0.604\left(\frac{rL}{\sqrt{S_{av}}}\right)^{0.467}$		$T_c = \left[\frac{0.87\,L^2}{1000\,S_{AV}}\right]^{0.385}$		Use Defined watercourse			
3.218 hours		2.118 hours					
Run-off coefficient							
Return Period (years)	2	5	10	20	50	100	PMF
Run-off coefficient, C_1	0.107	0.107	0.107	0.107	0.107	0.107	0.900
Adjusted for dolomitic areas, C_{1D}	0.107	0.107	0.107	0.107	0.107	0.107	0.900
dj factor for initial saturation, F	0.5	0.55	0.6	0.67	0.83	1	1.00
Adjusted run - off coefficient, C_{1T}	0.0534545	0.05879995	0.0641454	0.072	0.089	0.107	0.900
Combined run - off coefficient, C_T	0.0534545	0.05879995	0.0641454	0.072	0.089	0.107	0.900
Rainfall							
Return Period (years)	2	5	10	20	50	100	PMF
Point rainfall (mm), P_T	31.67	44.77	54.28	64.15	77.85	89.01	100.87
Point Intensity (mm/h), P_{it}	14.95	21.13	25.62	30.29	36.75	42.02	47.62
Area reduction factor (%),ARF_T	1.049	1.049	1.049	1.049	1.049	1.049	1.049
Average intensity (mm/hour),I_T	15.683	22.171	26.883	31.773	38.559	44.084	49.957
Return Period (years)	2	5	10	20	50	100	PMF
Peak flow (m3/s)	1.628	2.531	3.348	4.419	6.643	9.15	87.30

STANDARD DESIGN FLOOD (SDF) METHOD							
Description of catchment		HRU5					
River detail	Non-Perennial Reach of the Brak River						
Calculated by	Hendrik Botha			Date	06/12/2022		
Physical characteristics							
Size of catchment (A)	6.99	km^2		Days of thunder per year (R)		52	days
Longest watercourse (L)	5.24	km		Time of concentration, t		127.096	minutes
Average slope (S_{av})	0.003	m/m		Time of concentration, T_c	$T_c = \left[\frac{0.87 L^2}{1000 S_{AV}}\right]^{0.385}$		2.1183
SDF Basin	12						
2-year return period rainfall (M)	39	mm					
TR102 n-day rainfall data							
Weather Service Station				MAP		320	mm
Weather Service Station no.				Coordinates			
Duration	Return Period (years)						
	2	5	10	20	50	100	200
Rainfall							
Return Period (years), T	2	5	10	20	50	100	200
Point precipitation depth (mm) $P_{t,T}$	25.2	42.5	55.6	68.7	86.0	99.1	112.2
Area reduction factor (%),ARF_T	1.049	1.049	1.049	1.049	1.049	1.049	1.049
Average intensity (mm/hour),I_T	12.5	21.1	27.5	34.0	42.6	49.1	55.6
Run-off coefficient							
Calibration factors C_2 (%)	5		C_{100} (%)		30		
Return Period (years), T	2	5	10	20	50	100	200
Return period factors (Y_T)	0	0.84	1.28	1.64	2.05	2.33	2.58
Run-off coefficient, C_T	0.050	0.140	0.187	0.226	0.270	0.300	0.327
Peak flow (m3/s)	1.21	5.73	10.02	14.93	22.34	28.60	35.28

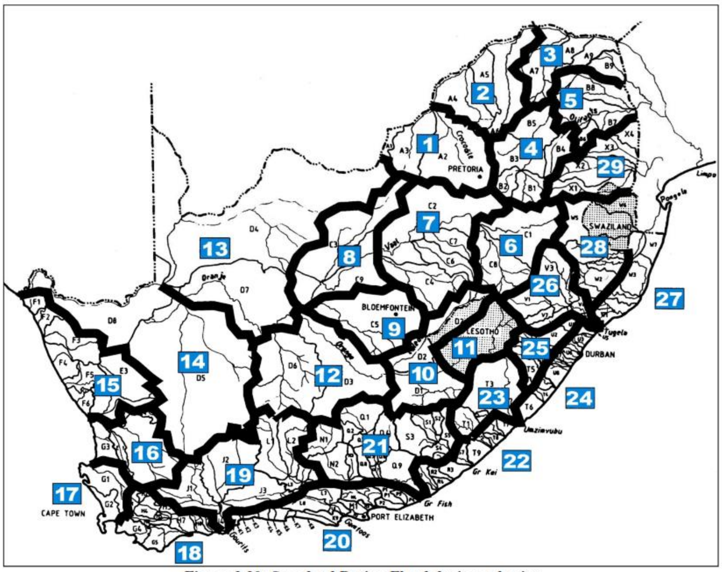


Figure 3.30: Standard Design Flood drainage basins

MIDGLEY & PITMAN (MIPI) METHOD														
River Detail	Catchment Area	MAP	S	L	Lc	Constant K_T				Catchment Parameter	Peak Flows			
	(km^2)	(mm)	m/m	km	km	1:10 year	1:20 Year	1: 50 year	1: 100 year	(Dimensionless)	1:10 year	1:20 Year	1: 50 year	1: 100 year
HRU5	6.99	320	0.0034	5.24	3.07	0.59	0.8	1.11	1.4	0.0253	10.96	14.86	20.62	26.00

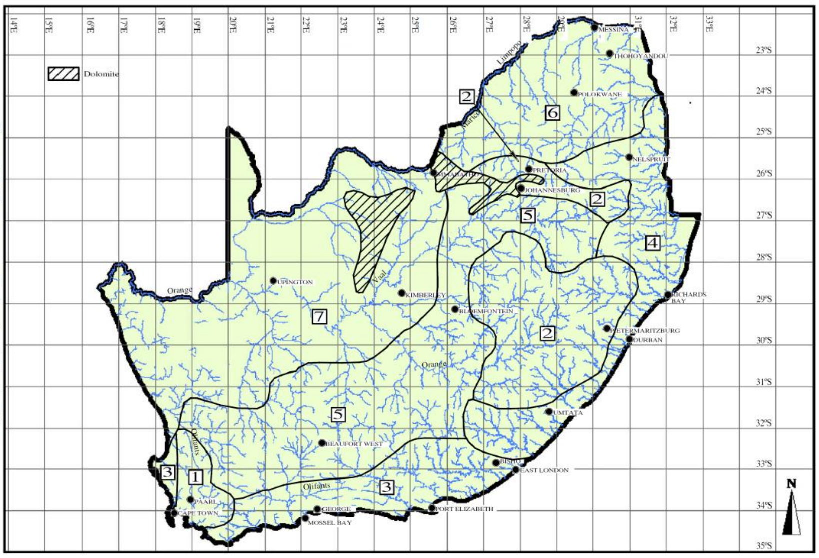


Figure 3.35: Homogeneous flood regions in South Africa

HRU6

RATIONAL METHOD 3							
Description of catchment		HRU6					
River detail	Non-Perennial Reach of the Brak River						
Calculated by	Hendrik Botha			Date	Tuesday, 06 December 2022		
Physical characteristics							
Size of catchment (A)	0.21	km^2		Rainfall region		D6C	
Longest watercourse (L)	0.79	km		**Area distribution factors**			
Average slope (S_{av})	0.2300	m/m		Rural (α)	Urban (β)	Lakes (γ)	
Dolomite area (D%)	0	%		1	0	0	
Mean annual rainfall(MAR)	320	mm					
Rural				**URBAN**			
Surface slope	**%**	**Factor**	**C_s**	**Description**	**%**	**Factor**	**C2**
Vleis and pans (<3%)	100.00	0.01	1.00	**Lawns**			
Flat areas (3 - 10%)	0.00	0.06	0.00	Sandy,flat<2%	0	0.08	0
Hilly (10 - 30%)	0.00	0.12	0.00	Sandy,steep>7%	0	0.16	0
Steep Areas (>30%)	0.00	0.22	0.00	Heavy s,flat<2%	0	0.15	0
Total	100.00	0.41	1.00	Heavy s,steep>7%	0	0.3	0
Permeability	**%**	**Factor**	**C_p**	**Residential Areas**			
Very permeable	80	0.03	2.40	Houses	0	0.5	0
Permeable	20	0.06	1.20	Flats	0	0.6	0
Semi-permeable	0	0.12	0.00	Industry			
Impermeable	0	0.21	0.00	Light industry	0	0.6	0
Total	100	0.42	3.60	Heavy industry	0	0.7	0
Vegetation	**%**	**Factor**	**C_v**	**Business**			
Thick bush & plantation	81.8	0.03	2.45	City centre	0	0.8	0
Light bush & farm-lands	17.63	0.07	1.23	Suburban	0	0.65	0
Grasslands	0	0.17	0.00	Streets	0	0.75	0
No vegatation	0.49	0.26	0.13	Max flood	0	1	0
Total	99.92	0.53	3.82	Total (C2)	0		0
Time of concentration (TC)							
$T_C = 0.604\left(\frac{rL}{\sqrt{S_{av}}}\right)^{0.467}$		$T_c = \left[\frac{0.87\,L^2}{1000\,S_{AV}}\right]^{0.385}$		Use Defined watercourse			
0.497	hours	0.097	hours				
Run-off coefficient							
Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**	**PMF**
Run-off coefficient, C_1	0.084	0.084	0.084	0.084	0.084	0.084	0.900
Adjusted for dolomitic areas, C_{1D}	0.084	0.084	0.084	0.084	0.084	0.084	0.900
dj factor for initial saturation, F	0.5	0.55	0.6	0.67	0.83	1	1.00
Adjusted run - off coefficient, C_{1T}	0.0420775	0.04628525	0.050493	0.056	0.070	0.084	0.900
Combined run - off coefficient, C_T	0.0420775	0.04628525	0.050493	0.056	0.070	0.084	0.900
Rainfall							
Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**	**PMF**
Point rainfall (mm), P_T	18.76	26.54	32.13	38.02	46.10	52.68	59.67
Point Intensity (mm/h), P_{it}	192.57	272.46	329.82	390.25	473.22	540.83	612.53
Area reduction factor (%),ARF_T	1.101	1.101	1.101	1.101	1.101	1.101	1.101
Average intensity (mm/hour),I_T	212.112	300.109	363.284	429.851	521.241	595.709	674.687
Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**	**PMF**
Peak flow (m3/s)	0.521	0.810	1.070	1.414	2.124	2.92	35.42

STANDARD DESIGN FLOOD (SDF) METHOD							
Description of catchment		HRU6					
River detail	Non-Perennial Reach of the Brak River						
Calculated by	Hendrik Botha				Date	06/12/2022	
Physical characteristics							
Size of catchment (A)	0.21	km^2		Days of thunder per year (R)		52	days
Longest watercourse (L)	0.79	km		Time of concentration, t		5.845	minutes
Average slope (S_{av})	0.230	m/m		Time of concentration, T_c	$T_c = \left[\frac{0.87 L^2}{1000 S_{AV}}\right]^{0.385}$		
SDF Basin	12						
2-year return period rainfall (M)	39	mm					0.0974
TR102 n-day rainfall data							
Weather Service Station				MAP		320	mm
Weather Service Station no.				Coordinates			
Duration	Return Period (years)						
	2	5	10	20	50	100	200
Rainfall							
Return Period (years), T	2	5	10	20	50	100	200
Point precipitation depth (mm) $P_{t,T}$	7.7	13.0	17.0	21.0	26.3	30.3	34.4
Area reduction factor (%),ARF_T	1.101	1.101	1.101	1.101	1.101	1.101	1.101
Average intensity (mm/hour),I_T	87.2	147.2	192.5	237.8	297.7	343.1	388.4
Run-off coefficient							
Calibration factors C_2 (%)	5		C_{100} (%)		30		
Return Period (years), T	2	5	10	20	50	100	200
Return period factors (Y_T)	0	0.84	1.28	1.64	2.05	2.33	2.58
Run-off coefficient, C_T	0.050	0.140	0.187	0.226	0.270	0.300	0.327
Peak flow (m3/s)	0.25	1.20	2.10	3.13	4.69	6.00	7.41

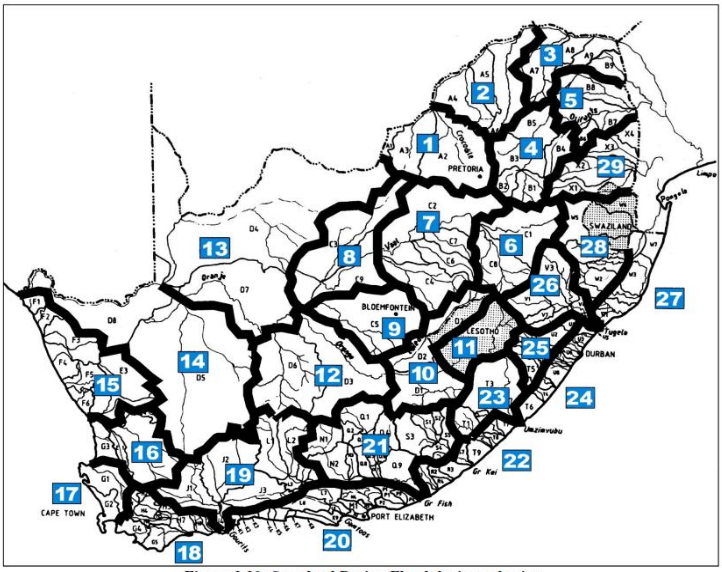


Figure 3.30: Standard Design Flood drainage basins

MIDGLEY & PITMAN (MIPI) METHOD															
River Detail	Catchment Area	MAP	S	L	Lc	Constant K_T				Catchment Parameter	Peak Flows			
	(km^2)	(mm)	m/m	km	km	1:10 year	1:20 Year	1: 50 year	1: 100 year	(Dimensionless)	1:10 year	1:20 Year	1: 50 year	1: 100 year
HRU6	0.21	320	0.2300	0.79	0.46	0.59	0.8	1.11	1.4	0.2771	2.16	2.93	4.06	5.12

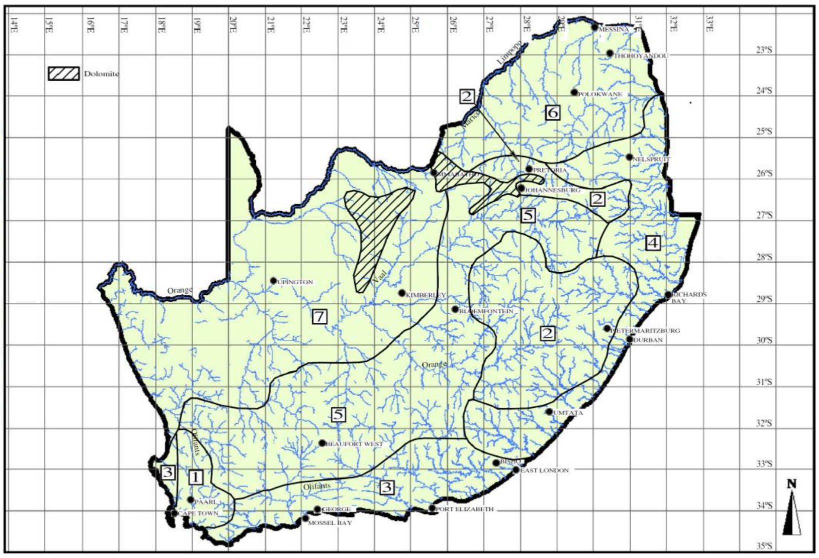


Figure 3.35: Homogeneous flood regions in South Africa

HRU7

RATIONAL METHOD 3							
Description of catchment		HRU7					
River detail	Non-Perennial Reach of the Brak River						
Calculated by	Hendrik Botha			Date	Tuesday, 06 December 2022		
Physical characteristics							
Size of catchment (A)	12.63	km^2		Rainfall region		D6C	
Longest watercourse (L)	4.14	km		**Area distribution factors**			
Average slope (S_{av})	0.0021	m/m		Rural (α)	Urban (β)	Lakes (γ)	
Dolomite area (D%)	0	%		1	0	0	
Mean annual rainfall(MAR)	320	mm					
Rural				**URBAN**			
Surface slope	**%**	**Factor**	**C_s**	**Description**	**%**	**Factor**	**C2**
Vleis and pans (<3%)	91.80	0.01	0.92	**Lawns**			
Flat areas (3 - 10%)	7.72	0.06	0.46	Sandy,flat<2%	0	0.08	0
Hilly (10 - 30%)	0.48	0.12	0.06	Sandy,steep>7%	0	0.16	0
Steep Areas (>30%)	0.00	0.22	0.00	Heavy s,flat<2%	0	0.15	0
Total	100.00	0.41	1.44	Heavy s,steep>7%	0	0.3	0
Permeability	**%**	**Factor**	**C_p**	**Residential Areas**			
Very permeable	80	0.03	2.40	Houses	0	0.5	0
Permeable	20	0.06	1.20	Flats	0	0.6	0
Semi-permeable	0	0.12	0.00	Industry			
Impermeable	0	0.21	0.00	Light industry	0	0.6	0
Total	100	0.42	3.60	Heavy industry	0	0.7	0
Vegetation	**%**	**Factor**	**C_v**	**Business**			
Thick bush & plantation	68.28	0.03	2.05	City centre	0	0.8	0
Light bush & farm-lands	19.88	0.07	1.39	Suburban	0	0.65	0
Grasslands	1.19	0.17	0.20	Streets	0	0.75	0
No vegatation	11.71	0.26	3.04	Max flood	0	1	0
Total	101.06	0.53	6.69	Total (C2)	0		0

$$T_C = 0.604\left(\frac{rL}{\sqrt{S_{av}}}\right)^{0.467}$$

$$T_c = \left[\frac{0.87\,L^2}{1000\,S_{AV}}\right]^{0.385}$$

Use Defined watercourse

3.226 hours	2.127	hours					
Run-off coefficient							
Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**	**PMF**
Run-off coefficient, C_1	0.117	0.117	0.117	0.117	0.117	0.117	0.900
Adjusted for dolomitic areas, C_{1D}	0.117	0.117	0.117	0.117	0.117	0.117	0.900
dj factor for initial saturation, F	0.5	0.55	0.6	0.67	0.83	1	1.00
Adjusted run - off coefficient, C_{1T}	0.0586285	0.06449135	0.0703542	0.079	0.097	0.117	0.900
Combined run - off coefficient, C_T	0.0586285	0.06449135	0.0703542	0.079	0.097	0.117	0.900
Rainfall							
Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**	**PMF**
Point rainfall (mm), P_T	31.69	44.80	54.31	64.20	77.90	89.07	100.93
Point Intensity (mm/h), P_{it}	14.90	21.06	25.54	30.18	36.63	41.88	47.46
Area reduction factor (%),ARF_T	1.021	1.021	1.021	1.021	1.021	1.021	1.021
Average intensity (mm/hour),I_T	15.203	21.493	26.060	30.801	37.379	42.735	48.428
Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**	**PMF**
Peak flow (m3/s)	3.127	4.863	6.432	8.489	12.763	17.58	152.91

STANDARD DESIGN FLOOD (SDF) METHOD							
Description of catchment		HRU7					
River detail	Non-Perennial Reach of the Brak River						
Calculated by	Hendrik Botha			Date	06/12/2022		
Physical characteristics							
Size of catchment (A)	12.63	km^2	Days of thunder per year (R)		52	days	
Longest watercourse (L)	4.14	km	Time of concentration, t		127.615	minutes	
Average slope (S_{av})	0.002	m/m	Time of concentration, T_c	$T_c = \left[\frac{0.87\, L^2}{1000\, S_{AV}} \right]^{0.385}$		2.1269	
SDF Basin	12						
2-year return period rainfall (M)	39	mm					
TR102 n-day rainfall data							
Weather Service Station			MAP		320	mm	
Weather Service Station no.			Coordinates				
Duration	Return Period (years)						
	2	5	10	20	50	100	200
Rainfall							
Return Period (years), T	2	5	10	20	50	100	200
Point precipitation depth (mm) $P_{t,T}$	25.2	42.6	55.7	68.8	86.1	99.2	112.3
Area reduction factor (%),ARF_T	1.021	1.021	1.021	1.021	1.021	1.021	1.021
Average intensity (mm/hour),I_T	12.1	20.4	26.7	33.0	41.3	47.6	53.9
Run-off coefficient							
Calibration factors C_2 (%)	5		C_{100} (%)		30		
Return Period (years), T	2	5	10	20	50	100	200
Return period factors (Y_T)	0	0.84	1.28	1.64	2.05	2.33	2.58
Run-off coefficient, C_T	0.050	0.140	0.187	0.226	0.270	0.300	0.327
Peak flow (m3/s)	2.12	10.04	17.56	26.16	39.13	50.11	61.80

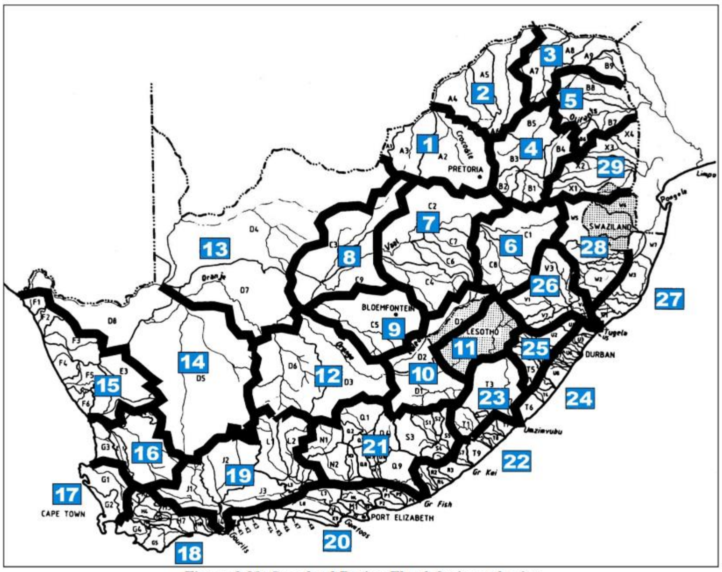


Figure 3.30: Standard Design Flood drainage basins

MIDGLEY & PITMAN (MIPI) METHOD														
River Detail	Catchment Area	MAP	S	L	Lc	Constant K_T				Catchment Parameter	Peak Flows			
	(km^2)	(mm)	m/m	km	km	1:10 year	1:20 Year	1: 50 year	1: 100 year	(Dimensionless)	1:10 year	1:20 Year	1: 50 year	1: 100 year
HRU7	12.63	320	0.0021	4.14	3.49	0.59	0.8	1.11	1.4	0.0401	17.13	23.23	32.23	40.64

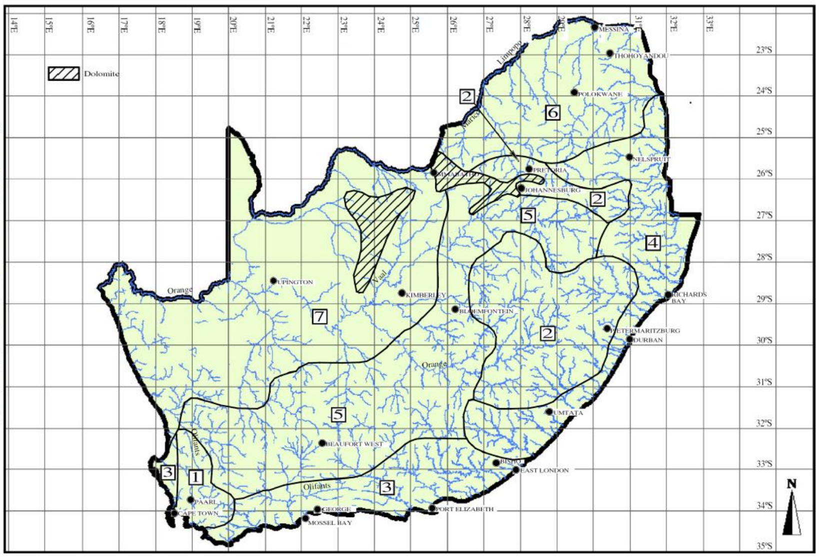


Figure 3.35: Homogeneous flood regions in South Africa

HRU8

RATIONAL METHOD 3							
Description of catchment		HRU8					
River detail	Non-Perennial Reach of the Brak River						
Calculated by	Hendrik Botha				Date	Tuesday, 06 December 2022	
Physical characteristics							
Size of catchment (A)	77.34	km^2		Rainfall region		D6C	
Longest watercourse (L)	22.32	km		Area distribution factors			
Average slope (S_{av})	0.0048	m/m		Rural (α)	Urban (β)	Lakes (γ)	
Dolomite area (D%)	0	%		1	0	0	
Mean annual rainfall(MAR)	320	mm					
Rural				URBAN			
Surface slope	%	Factor	C_s	Description	%	Factor	C2
Vleis and pans (<3%)	81.24	0.01	0.81	Lawns			
Flat areas (3 - 10%)	16.20	0.06	0.97	Sandy,flat<2%	0	0.08	0
Hilly (10 - 30%)	2.28	0.12	0.27	Sandy,steep>7%	0	0.16	0
Steep Areas (>30%)	0.27	0.22	0.06	Heavy s,flat<2%	0	0.15	0
Total	99.99	0.41	2.12	Heavy s,steep>7%	0	0.3	0
Permeability	%	Factor	C_p	Residential Areas			
Very permeable	80	0.03	2.40	Houses	0	0.5	0
Permeable	20	0.06	1.20	Flats	0	0.6	0
Semi-permeable	0	0.12	0.00	Industry			
Impermeable	0	0.21	0.00	Light industry	0	0.6	0
Total	100	0.42	3.60	Heavy industry	0	0.7	0
Vegetation	%	Factor	C_v	Business			
Thick bush & plantation	81.91	0.03	2.46	City centre	0	0.8	0
Light bush & farm-lands	13.04	0.07	0.91	Suburban	0	0.65	0
Grasslands	1.26	0.17	0.21	Streets	0	0.75	0
No vegatation	3.79	0.26	0.99	Max flood	0	1	0
Total	100	0.53	4.57	Total (C2)	0		0
Time of concentration (TC)							
Overland flow		Defined watercourse					
$T_C = 0.604\left(\frac{rL}{\sqrt{S_{av}}}\right)^{0.467}$		$T_c = \left[\frac{0.87\,L^2}{1000\,S_{AV}}\right]^{0.385}$		Use Defined watercourse			
5.841	hours	5.662	hours				
Run-off coefficient							
Return Period (years)	2	5	10	20	50	100	PMF
Run-off coefficient, C_1	0.103	0.103	0.103	0.103	0.103	0.103	0.900
Adjusted for dolomitic areas, C_{1D}	0.103	0.103	0.103	0.103	0.103	0.103	0.900
dj factor for initial saturation, F	0.5	0.55	0.6	0.67	0.83	1	1.00
Adjusted run - off coefficient, C_{1T}	0.0514355	0.05657905	0.0617226	0.069	0.085	0.103	0.900
Combined run - off coefficient, C_T	0.0514355	0.05657905	0.0617226	0.069	0.085	0.103	0.900
Rainfall							
Return Period (years)	2	5	10	20	50	100	PMF
Point rainfall (mm), P_T	37.01	52.21	63.32	74.83	90.91	103.82	117.71
Point Intensity (mm/h), P_{it}	6.54	9.22	11.18	13.22	16.06	18.34	20.79
Area reduction factor (%),ARF_T	0.966	0.966	0.966	0.966	0.966	0.966	0.966
Average intensity (mm/hour),I_T	6.313	8.905	10.801	12.764	15.506	17.708	20.077
Return Period (years)	2	5	10	20	50	100	PMF
Peak flow (m3/s)	6.976	10.824	14.322	18.900	28.442	39.13	388.19

STANDARD DESIGN FLOOD (SDF) METHOD							
Description of catchment		HRU8					
River detail	Non-Perennial Reach of the Brak River						
Calculated by	Hendrik Botha				Date	06/12/2022	
Physical characteristics							
Size of catchment (A)	77.34	km^2		Days of thunder per year (R)		52	days
Longest watercourse (L)	22.32	km		Time of concentration, t		339.690	minutes
Average slope (S_{av})	0.005	m/m		Time of concentration, T_c	$T_c = \left[\frac{0.87\ L^2}{1000\ S_{AV}}\right]^{0.385}$		5.6615
SDF Basin	12						
2-year return period rainfall (M)	39	mm					
TR102 n-day rainfall data							
Weather Service Station				MAP		320	mm
Weather Service Station no.				Coordinates			
Duration	Return Period (years)						
	2	5	10	20	50	100	200
Rainfall							
Return Period (years), T	2	5	10	20	50	100	200
Point precipitation depth (mm) $P_{t,T}$	30.8	51.9	67.9	83.9	105.1	121.1	137.1
Area reduction factor (%),ARF_T	0.966	0.966	0.966	0.966	0.966	0.966	0.966
Average intensity (mm/hour),I_T	5.3	8.9	11.6	14.3	17.9	20.7	23.4
Run-off coefficient							
Calibration factors C_2 (%)	5		C_{100} (%)		30		
Return Period (years), T	2	5	10	20	50	100	200
Return period factors (Y_T)	0	0.84	1.28	1.64	2.05	2.33	2.58
Run-off coefficient, C_T	0.050	0.140	0.187	0.226	0.270	0.300	0.327
Peak flow (m3/s)	5.64	26.67	46.64	69.51	103.96	133.12	164.19

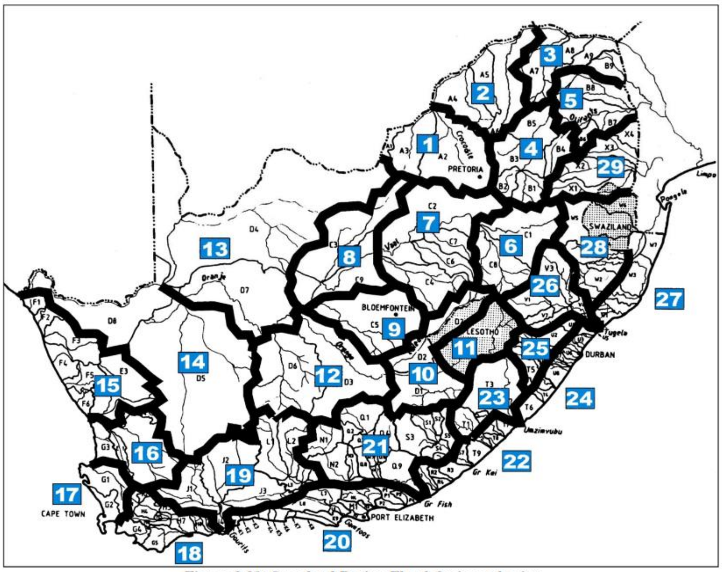


Figure 3.30: Standard Design Flood drainage basins

MIDGLEY & PITMAN (MIPI) METHOD														
River Detail	Catchment Area	MAP	S	L	Lc	Constant K_T				Catchment Parameter	Peak Flows			
	(km^2)	(mm)	m/m	km	km	1:10 year	1:20 Year	1: 50 year	1: 100 year	(Dimensionless)	1:10 year	1:20 Year	1: 50 year	1: 100 year
HRU8	77.34	320	0.0048	22.3	10.8	0.59	0.8	1.11	1.4	0.0222	45.16	61.24	84.96	107.16

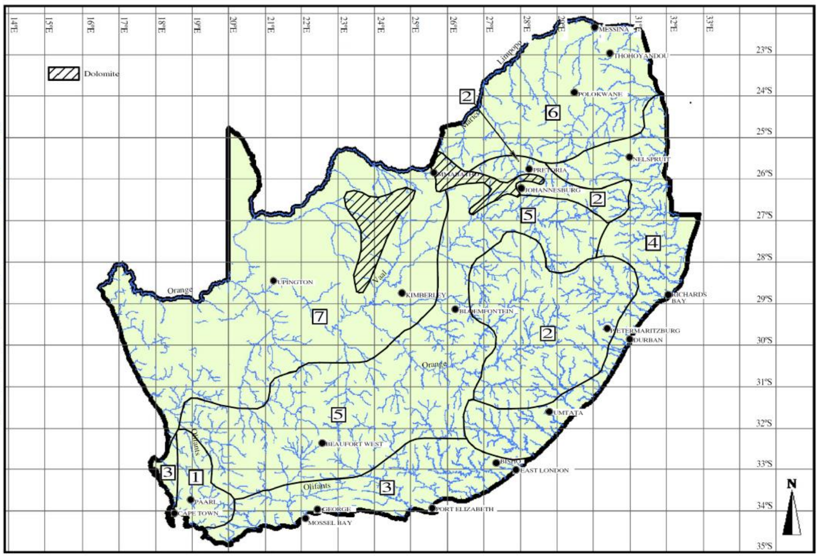


Figure 3.35: Homogeneous flood regions in South Africa

APPENDIX B: DISCLAIMER AND DECELERATION OF INDEPENDENCE

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

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

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

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

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

PROJECT TITLE

Hydrological Assessment for additional listed activities and water uses relating to the development of the Sun Central Cluster 1 300 MW Solar PV facility (previously known as Phase 1) in the Northern Cape.

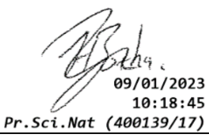
SPECIALIST INFORMATION

Specialist Company Name:	GCS Water and Environment Pty Ltd			
B-BBEE	Contribution level (indicate 1 to 8 or non-compliant)	4	Percentage Procurement Recognition	
Specialist name:	Hendrik Botha			
Specialist Qualifications:	MSc Environmental Sciences (Geohydrology & Geochemistry) BSc Hons. Environmental Sciences (Hydrology) BSc. Chemistry & Geology			
Professional affiliation/registration:	PR SCI NAT 400139/17			
Physical address:	1 Karbochem Road, Newcastle, KZN			
Postal address:				
Postal code:	2940	Cell:		
Telephone:	071 102 3819	Fax:		
E-mail:	hendrikb@gcs-sa.biz			

DECLARATION BY THE SPECIALIST

I, _Hendrik Botha, declare that –

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



Signature of the Specialist

GCS

Name of Company:

09 January 2023

Date

APPENDIX D: CV OF SPECIALIST

GCS Water & Environmental Consultants

Hendrik Botha

Technical Director

LinkedIn:

CORE SKILLS

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

DETAILS

Qualifications

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

Membership

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

Languages

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

Projects undertaken in

- South Africa
- Nigeria
- Namibia
- Liberia

PROFILE

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

Professional Affiliations:

SACNASP Professional Natural Scientist (400139/17)

Areas of Expertise:

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

SCAN ME
PROJECT RECORD

Page 1 of 8