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The development of a 400 MW Solar Photovoltaic (PV) facility on the Remainder of Farm Goede Hoop 26C and Portion 3 of Farm Goede Hoop 26C, between De Aar & Hanover, Emthanjeni Local Municipality, Pixley Ka Seme District Municipality, Northern Cape Province, South Africa

Hydrological Assessment

Version - Final 3

01 September 2022

Ecoleges Environmental Consultants

GCS Project Number: 22-0076

Client Reference: De Aar Solar Phase 3

HYDROLOGICAL ASSESSMENT SCOPING REPORT

Report
Version – Final 3

01 September 2022

Ecoleges Environmental Consultants

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	Name	**Signature**	**Date**
Author **(Principal Hydrogeologist)**	Hendrik Botha (MSc, PriSciNat)	01/09/2022 2:40:42 *Pr.Sci.Nat (400139/17)*	01 September 2022

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 compile a scoping report (the plan of study), in terms of hydrology, for the development of a 400 MW Solar Photovoltaic (PV) facility on the Remainder of Farm Goede Hoop 26C and Portion 3 of Farm Goede Hoop 26C (*hereafter referred to as "Phase 3 development"*), between De Aar & Hanover, Emthanjeni Local Municipality, Pixley Ka Seme District Municipality, Northern Cape Province, South Africa.

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 3 development.

This study found that three (3) hydrological response units (HRUs) were delineated for the project area, which entails numerous micro catchments which contribute to the overall drainage. Drainage for the general area is towards the northwest in the form of a multitude of non-perennial drainage lines, which drains towards the non-perennial Brak River, situated approximately 6.6km downstream west of the site. There are several in-stream water storage dams associated with the non-perennial streams in the study area. Three (3) small capacity surface water storage dams (capacity and license status currently unknown) fall within the proposed development area (in the non-perennial drainage lines).

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 impact on runoff rates and volumes indicates that solar panels do not have a significant impact on runoff volumes, peak rates or time to peak rates when the ground below the panels is vegetated. Accounting for changes in soil type, slope angle and rainfall intensity, ground cover beneath solar arrays was found to have the most significant impact on runoff rates. On this basis, if vegetation cover beneath the solar arrays is maintained, no significant increase in surface-water runoff is anticipated compared to greenfield runoff rates (WHS, 2022).

The conceptual stormwater management plan (CSWMP) indicates that (refer to Section 6):

- Due to the micro-catchment type drainage of the overall development areas, free drainage provides the best stormwater management option for the development (refer to Section 6).

- Based on the nature of the project (raised PV solar arrays on pipe stand, and vegetation kept intact during the construction and operational phase of the project) no dirty stormwater generation areas are anticipated. As all stormwaters will be subjected to micro-catchment style stormwater runoff, and concentrated rainfall volumes from the PV panels onto the soils, erosion and sediment transport will likely take place. However, this will depend on the density of the vegetation cover surrounding the PV arrays and stormwater peak flow.
- Efforts should be made in managing runoff from the PV panels and arrays onto the soils and then releasing the accumulated water back into the environment via free drainage.

The risk assessment for both construction and post-construction phases of the project is considered marginal, with mostly reversible and manageable impacts (Refer to Section 7). Potential runoff and stormwater discharge from the site into the surrounding may cause erosion of the soils in areas where PV panels are erected and in the surroundings. 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 and operational 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 (i.e., an assemblage of panels that are form factor).

A monitoring plan for both the proposed stormwater system (refer to Section 6) 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 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.

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

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

Requirements from Appendix 6 of GN 326 EIA Regulation 2017	Chapter
(a) Details of: (i) The specialist who prepare the reports; and (ii) the expertise of that specialist to compile a specialist report including a curriculum vitae	Document Issue (Page ii) Appendix C.
(b) Declaration that the specialist is independent in a form as may be specialities by the competent authority	Document Issue (Page ii) 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 9.4.
(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.*

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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
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 compile a scoping report (the plan of study), in terms of hydrology, for the development of a 400 MW Solar Photovoltaic (PV) facility on the Remainder of Farm Goede Hoop 26C and Portion 3 of Farm Goede Hoop 26C (*hereafter referred to as "Phase 3 development"*), between De Aar & Hanover, Emthanjeni Local Municipality, Pixley Ka Seme District Municipality, Northern Cape Province, South Africa (refer to Figure 1-6).

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 3 development.

1.1 Project background

The applicant driving this project is Soventix South Africa (Pty) Ltd, a multi-national renewable energy company with its head office in Germany. The property owner is Mr Willem Retief that has entered into a land-use agreement with Soventix.

The main access to the site is off the N10 between De Aar & Hanover. The current land use is sheep farming, which will continue within the solar PV plants to ensure minimal reduction (if any) on the agricultural potential of the land as well as a management tool to control vegetation growth.

The size of the proposed development footprint for the 400 MW solar PV facility is approximately 600 ha. This area includes four interconnected 100 MW solar PV plants (150 ha each), with associated infrastructure. The PV system will be connected via transmission lines to the authorised substation in Phase 1. The substation ties into the existing ESKOM 400KV overhead powerlines. Existing roads will be used for main access, which may need to be enlarged to allow large equipment to access the site during construction.

The Aquatic Biodiversity Sensitivity is "Very High" for the Phase 3 development due to the area falling within a "Strategic Water Source Area." Footprints 1 & 2 infringe on "Wetlands & Rivers". The real extent of the wetlands and watercourses is in the process of being confirmed.

The Phase 3 footprints would need to be connected to an on-site substation on Phase 2 using overhead powerlines (and an existing road network). Depending on the width of the watercourse, pylons may need to be placed inside a watercourse, and some existing road crossings may need to be widened, to allow for their refinement and possible reduction in surface area, based on specialist findings and recommendations.

The principal aims of the hydrology assessment will be to determine how this development (and its separate elements, e.g., solar PV panels, pylons, and road crossings) will impact the surface water hydrology of the area, compile a stormwater management plan for the solar PV facility, and inform the General Authorisation for S21(c) and (i) water uses associated with existing road crossings that need to be widened and potential transmission corridors through watercourses.

Those activities associated with the development which require an S21(c) and (i) Risk Assessment (to be undertaken by the Aquatic Specialist) which may directly affect hydrology, include:

1. Upgrading three existing road crossings (including installing culverts).
2. Erecting a perimeter fence (and creating a fire-break road) that may cross a watercourse in two potential locations.
3. Developing a solar PV system within 100m of a watercourse and/or 500 m from a wetland or pan (including the possible wetland system near Corner C).
4. Installing underground water pipes, aboveground storage tanks and a deionization plant in proximity to both boreholes (with pans).
5. Three potential watercourse crossings for underground cables (used to take electricity from the field transformers to the on-site substation); and
6. Increased evaporation (i.e., ambient temperature) and increased runoff from the solar panels during storm events.

The watercourse crossings are discussed below.

1.1.1 Underground Pipeline crossings (to deionization plants with water storage tanks)

Pipes will need to transfer the water from the wind pumps at Borehole No. 4 (in-channel) and Borehole No. 5 (in-channel) to their respective deionization plants and storage tanks, which will be located off-channel, but within 100 m from the edge of the watercourse or 500 m from the edge of a wetland/pan.

If a third borehole is drilled at sites T1 or T2, it will, unlike Boreholes No. 4 and 5, be located outside a watercourse. However, a pipeline will need to transport the water from the borehole pump to the PV block containing the operational area including the deionisation plant with water tanks. The pipeline will cross a watercourse whereas the deionisation plant and water tanks may be within 100 m from the edge of the watercourse or 500 m from the edge of a wetland/pan.

The proposed Underground Pipeline crossings to the deionization plants with water storage tanks are shown in Figure 1-1.

(light blue)	Ephemeral channel
(orange)	Seepage wetland
(yellow)	Ecological buffer (20 m)
(black)	'Corridors' indicate the permissible area for the alignment of the underground pipelines

GPS co-ordinates of Borehole No. 4	30°49'43.62"S and 24°20'55.07"E
GPS co-ordinates of Borehole No. 5	30°49'30.17"S and 24°22'5.58"E
GPS co-ordinates of T1 Proposed Borehole	-30.851 S and 24.35747 E
GPS co-ordinates of T2 Proposed Borehole	-30.8514 S and 24.35786 E
Approximate Centre of PV Block where the operational area, including deionisation plant and water tanks, will be located.	30°50'41.36"S and 24°21'50.46"E

Figure 1-1: Underground Pipeline crossings (to deionization plants with water storage tanks)

1.1.2 Underground Pipeline crossings (to livestock watering troughs)

Pipes will need to transfer the water from the wind pumps at Borehole No. 4 (in-channel) and Borehole No. 5 (in-channel) to livestock watering troughs in each of the adjacent fenced PV blocks (or camps). The livestock watering troughs will be located off-channel but within 100 m from the edge of the watercourse or 500 m from the edge of a wetland/pan.

If a third borehole is drilled at sites T1 or T2, it will, unlike Boreholes No. 4 and 5, be located outside a watercourse. However, a pipeline will need to transport the water from the borehole pump to the PV block containing the operational area including a livestock watering trough. The pipeline will cross a watercourse whereas the watering trough may be within 100 m from the edge of the watercourse or 500 m from the edge of a wetland/pan.

The proposed Underground Pipeline crossings to livestock watering troughs are shown in Figure 1-2.

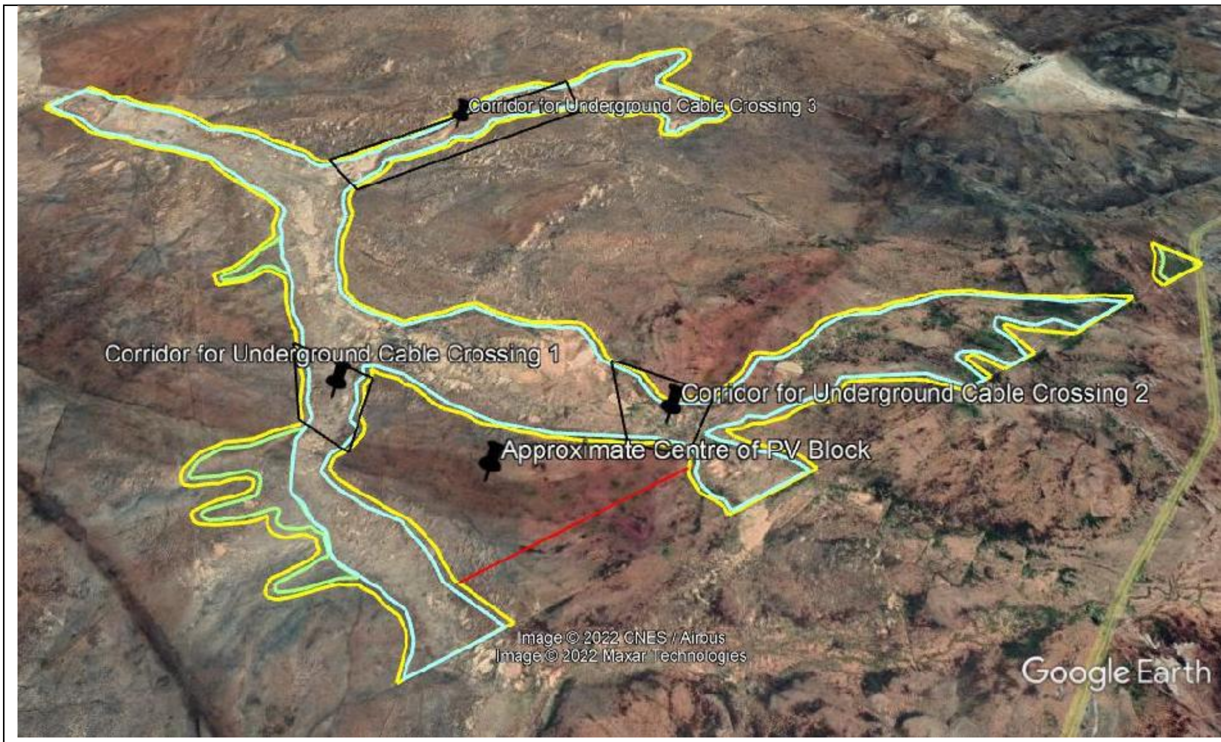
	Ephemeral channel
	Seepage wetland
	Ecological buffer (20 m)
	'Corridors' indicate the permissible area for the alignment of the underground pipelines

GPS co-ordinates of Borehole No. 4	30°49'43.62"S and 24°20'55.07"E
GPS co-ordinates of Borehole No. 5	30°49'30.17"S and 24°22'5.58"E
GPS co-ordinates of T1 Proposed Borehole	-30.851 S and 24.35747 E
GPS co-ordinates of T2 Proposed Borehole	-30.8514 S and 24.35786 E
Approximate Centre of PV Block where the on-site substation, operational area, construction camp, borrow pit, livestock watering trough, deionisation plant and water tanks will be located.	30°50'41.36"S and 24°21'50.46"E

Figure 1-2: Underground Pipeline crossings (to livestock watering troughs)

1.1.3 Underground Cable crossings

Underground cables from the field transformers to the on-site substation will cross the watercourse at three different locations. It is advised that the Engineers use the same crossings for the underground cables and roads. The proposed Underground cables from the field transformers are shown in Figure 1-2.



	Ephemeral channel
	Seepage wetland
	Ecological buffer (20 m)
	Visual sensitivity buffer (200 m) from the property boundary
	'Corridors' indicating the permissible area for the alignment of the underground cable crossings

GPS coordinates of the approximate centre of the corridor for Cable Crossing No. 1.	30°50'30.71"S and 24°21'31.35"E
GPS coordinates of the approximate centre of a corridor for Cable Crossing No. 2.	30°50'34.12"S and 24°22'10.38"E
GPS coordinates of the approximate centre of the corridor for Cable Crossing No. 3.	30°49'43.34"S and 24°21'40.04"E
Approximate Centre of PV Block where the on-site substation, operational area, construction camp and possibly a borrow pit, will be located.	30°50'41.36"S and 24°21'50.46"E

Figure 1-3: Proposed Underground cables from the field transformers

1.1.4 Distribution line

The planned 66 kV to 132 kV distribution line from the on-site substation on Phase 3 to Phase 2 will intersect a watercourse. The proposed planned 66 kV to 132 kV distribution line is shown in Figure 1-4.

(light blue)	Ephemeral channel
(peach)	Seepage wetland
(yellow)	Ecological buffer (20 m)
(red)	Visual sensitivity buffer (200 m) from the property boundary
(black)	'Corridor' indicates the permissible area for the alignment of the planned distribution line (66 kV to 132 kV) crossing

GPS coordinates of the approximate centre of the corridor for the planned distribution line (66 kV to 132 kV) crossing.	30°50'53.01"S and 24°21'45.53"E
Approximate Centre of PV Block where the on-site substation will be located.	30°50'41.36"S and 24°21'50.46"E

Figure 1-4: Planned 66 kV to 132 kV distribution

1.1.5 Road crossings

A total of six (6) road crossings will be required to access the different PV Blocks of the Solar PV facility, which is fragmented by the watercourse (refer to Figure 1-5). Existing two-track road crossings occur within the corridors demarcated for Road Crossing Numbers 1, 2, 3 and 6 but (except for No. 6) they are at oblique angles to the principal direction of flow within the watercourse, making them longer than necessary. Consequently, it is advised that the Engineers realign those crossings, effectively designing new (shorter) crossings (as opposed to upgrading existing two-track roads) to reduce the physical footprint and scale of the ecological impact. Pre-cast box culverts or pipes will also be required for the road crossings.

(light blue)	Ephemeral channel
(orange)	Seepage wetland
(yellow)	Ecological buffer (20 m)
(red)	Visual sensitivity buffer (200 m) from the property boundary
(black)	'Corridors' indicate the permissible area for the alignment of the road crossings

GPS coordinates of the approximate centre of the corridor for Road Crossing No. 1.	30°49'44.71"S and 24°20'58.69"E
GPS coordinates of the approximate centre of the corridor for Road Crossing No. 2.	30°50'12.56"S and 24°21'24.97"E
GPS coordinates of the approximate centre of the corridor for Road Crossing No. 3.	30°50'34.12"S and 24°22'10.38"E
GPS coordinates of the approximate centre of the corridor for Road Crossing No. 4.	30°50'30.71"S and 24°21'31.35"E
GPS coordinates of the approximate centre of the corridor for Road Crossing No. 5.	30°49'43.34"S and 24°21'40.04"E
GPS coordinates of the approximate centre of the corridor for Road Crossing No. 6.	30°50'54.60"S and 24°21'45.87"E

Figure 1-5: Proposed road crossings

1.2 The objective of this report

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.

1.3 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. Indication 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.

1.4 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.

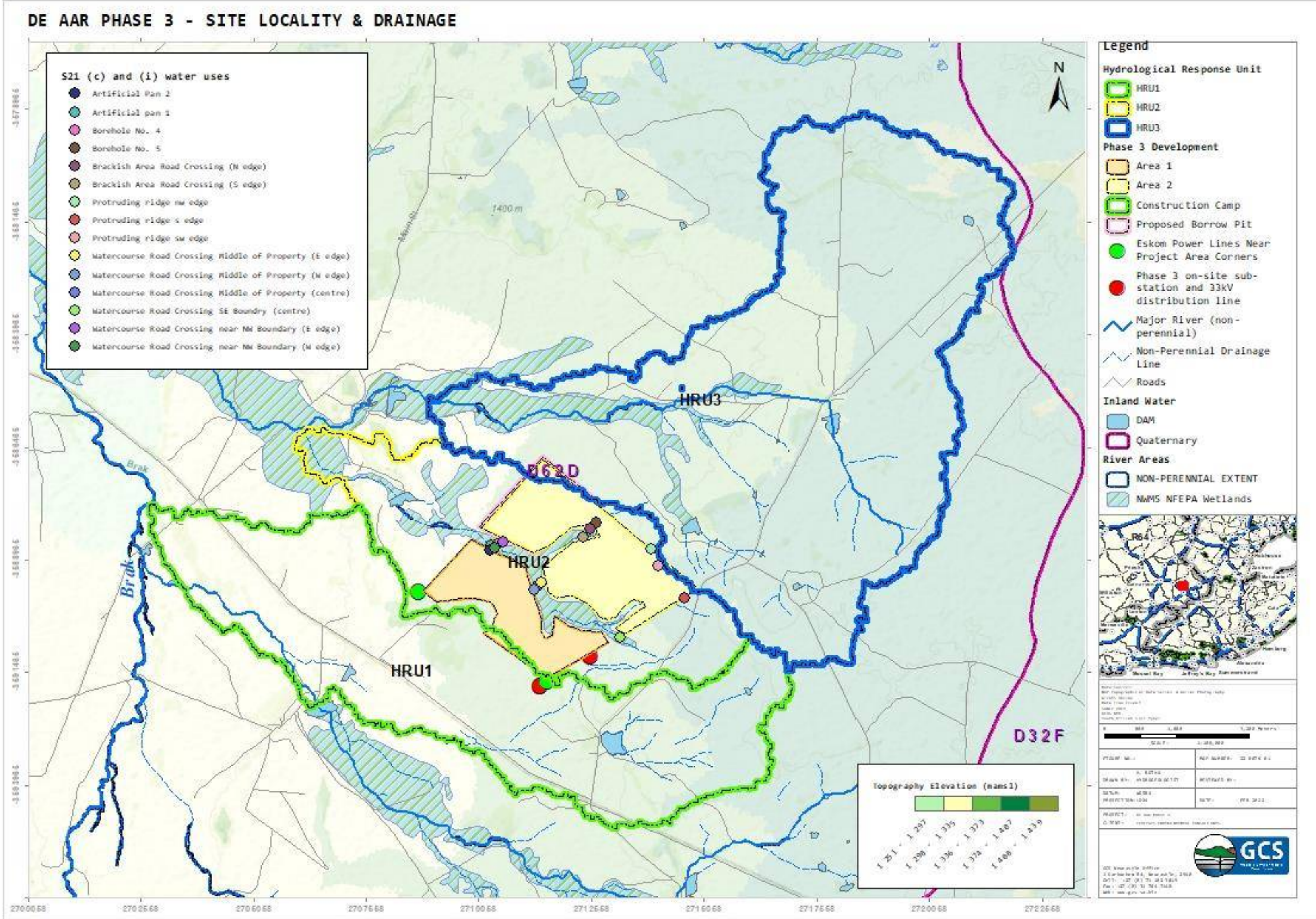


Figure 1-6: Site locality and drainage

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 specialities by the competent authority

(c) Indication of the scope of, and purpose for which, the report was prepared

(cA) Indication of the quality and age of base data used for the specialist report

(cB) A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change

(d) Duration, Date and seasons of the site investigation and the relevance of the season to the outcome of the assessment

(e) Description of the methodology adopted in preparing the report or carrying out the specialised process include of equipment and modelling used

(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

(g) Identification of any areas to be avoided, including buffers

(h) Map superimposing the activity and associated structures and infrastructure on environmental sensitivities of the site including areas to be avoided, including buffers

(i) Description of any assumptions made and uncertainties or gaps in knowledge

(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

(k) Mitigation measures for inclusion in the EMPr

(l) Conditions for inclusion in the environmental authorisation

(m) Monitoring requirements for inclusion in the EMPr or environmental authorisation

(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

(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 or stormwater modelling.

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

2.2.2 Design rainfall and peak flow

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

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

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

Table 2-1: Summary of peak flow methods

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 the Manning's n coefficients along the river/streamlines. The 1:50 and 1:100-year flood lines were generated and mapped in Global Mapper and ArcGIS (ESRI, 2018).

2.4 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 <15km^2)

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

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

2.6 Surface water monitoring plan

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

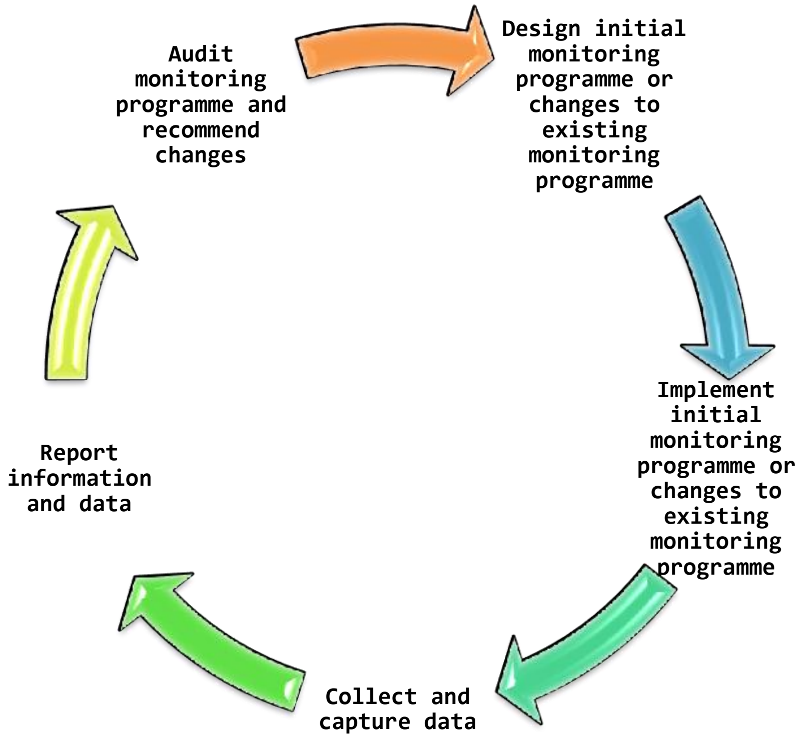


Figure 2-1: Monitoring Process

A surface water monitoring 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 1335 to 1370 metres above mean sea level (mamsl).

3.1 Sub-catchments / hydrological response units (HRUs)

Three (3) hydrological response units (HRUs) describe the natural drainage for the study area (using a 1:10 000 stream count and 20m DTM fill) – refer to Figure 1-6 and Figure 3-1. The HRUs delineated correspond well to known non-perennial rivers and drainage lines associated with the site.

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, situated approximately 6.6km downstream west of the site. There are several in-stream water storage dams associated with the non-perennial streams in the study area. Three (3) small capacity surface water storage dams (capacity and license status currently unknown) fall within the proposed development area (in the non-perennial drainage lines).

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. The following was noted:

- Three (3) surface water storage dams were noted in the Phase 3 area, capacities estimated at 2500 m^3, 8 200 m^3 and 2 984 m^3 (downstream to upstream in the non-perennial drainage stream).
- Two (2) windmills were noted in the project area. The windmills are used for livestock watering. Both windmills pump to an artificial pond, respective to the windmill positions. The landowner estimates a yield of 1000 l/hour for both windmills.
- 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 majority of the Phase 3 development (both Area 1 and 2) fall within HRU2 (about 96% of the total development area) with the northern extent of Area 2 falling in HRU3 (about 2%) and a small portion of Area 1 falls in HRU1 (about 2%).

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 3-1. The slope rise (%) for each HRU was determined using an ALOS 30mDTM and can be seen in Figure 3-2.

Table 3-1: Sub-catchments and summary of land cover types

Sub-Catchment		HRU1	HRU2	HRU3
Area (km^2)		30.08	21.738	53.932
Longest Drainage Line (km)		9.92	4.87	9.47
Average Slope (%)		0.46%	0.56%	0.45%
Slope (%)	<3	78.56%	82.01%	80.17%
	3-10	19.88%	16.51%	19.02%
	10-30	1.49%	1.48%	0.81%
	>30	0.07%	0.00%	0.00%
Land Cover	Thick bush & plantation	0.02%	0.00%	0.01%
	Light bush & farmlands	93.67%	97.25%	94.66%
	Grasslands	1.48%	0.00%	2.44%
	No Vegetation	4.84%	2.75%	2.89%

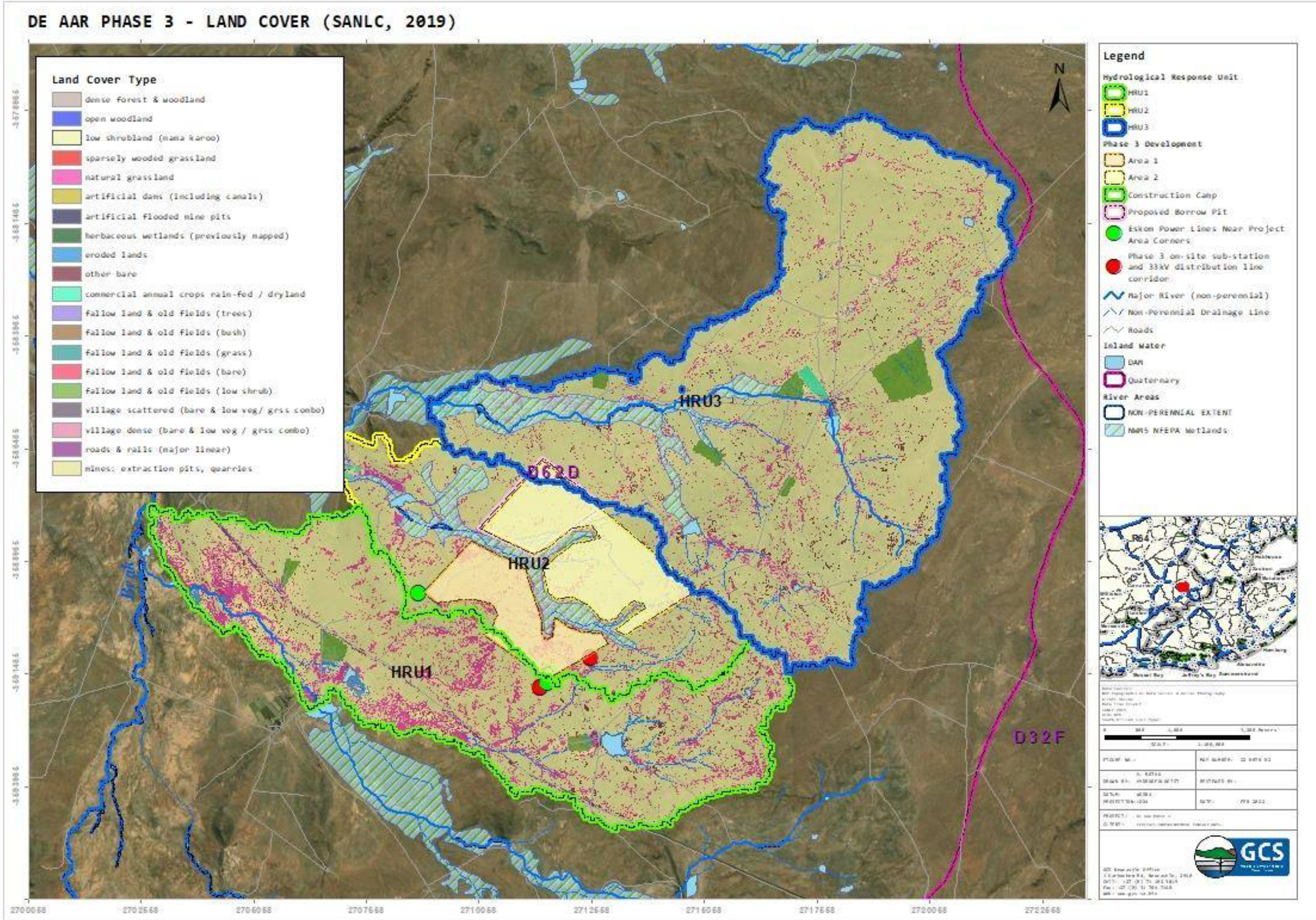


Figure 3-1: Sub-catchment land cover types (SANLC, 2019)

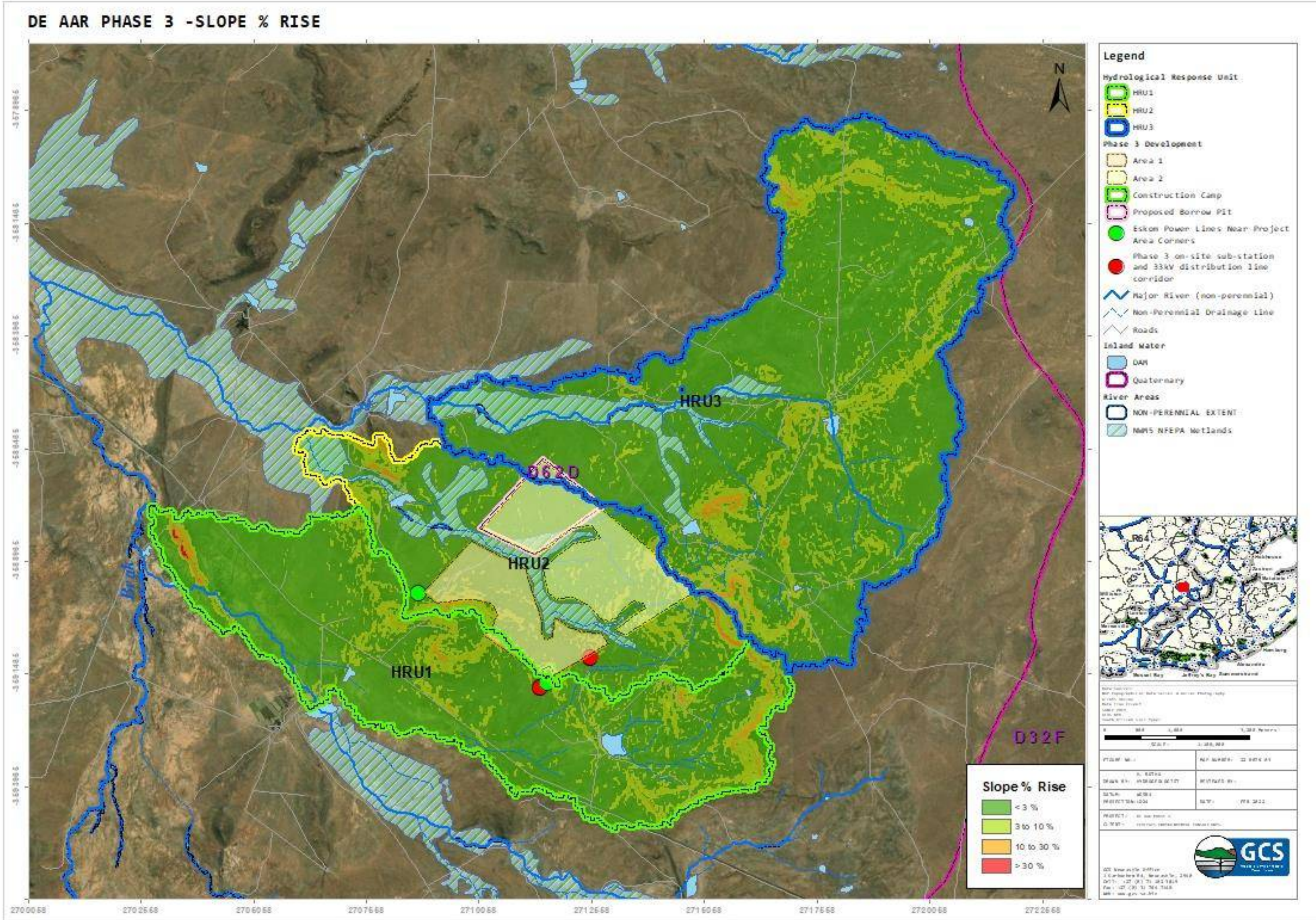


Figure 3-2: Sub-catchment slope rise (%)

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 36 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 spring-to-summer rainfall area.

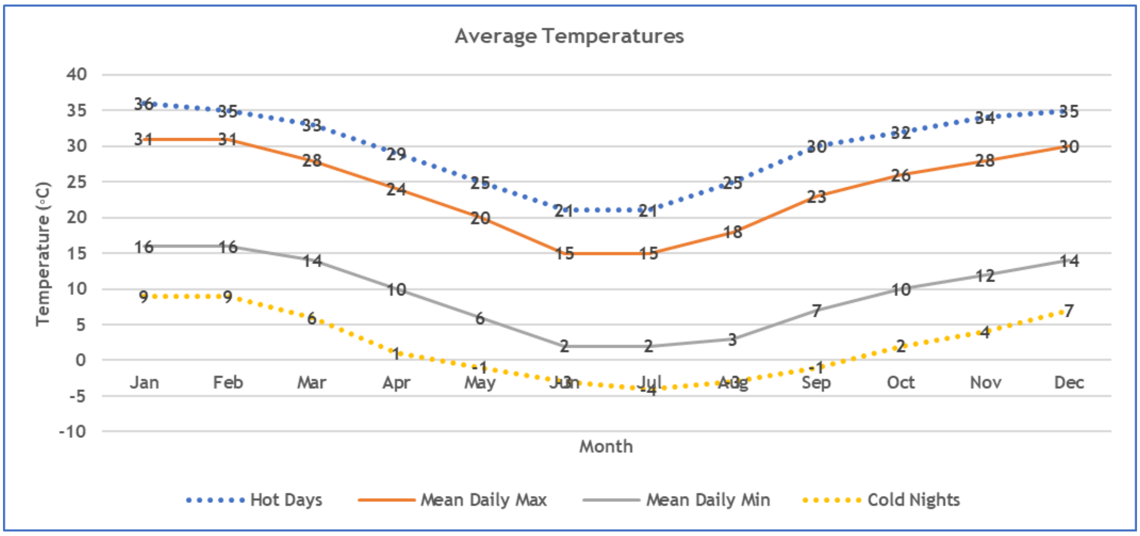


Figure 3-3: Average yearly temperatures (Meteoblue, 2021)

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. Precipitation intensity during wind will likely cause intensity changes on slopes perpendicular to the wind direction, throughout the year.

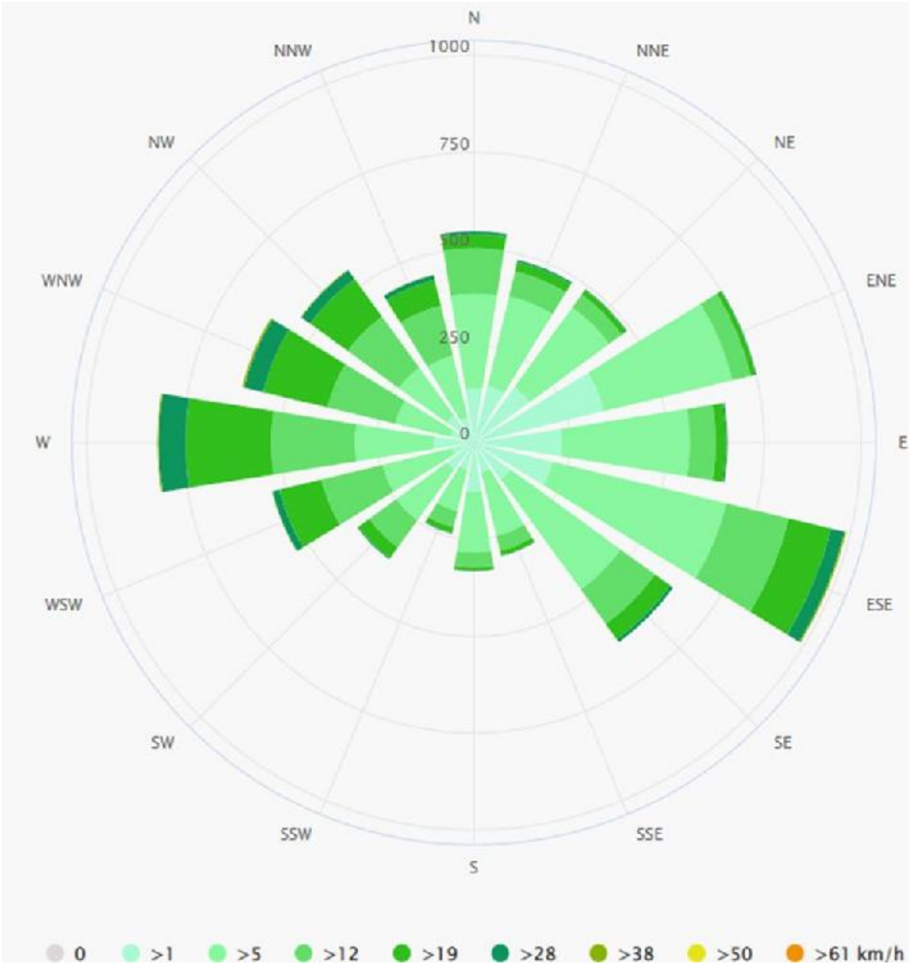
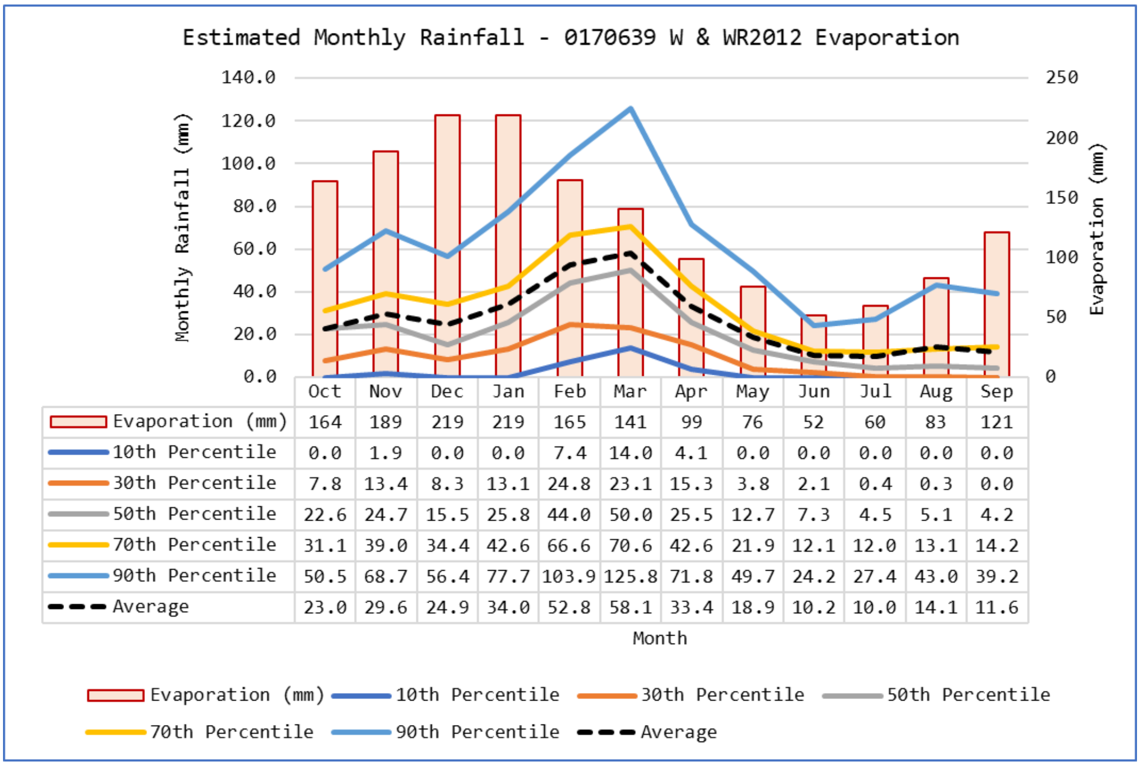


Figure 3-4: Wind rose (Meteoblue, 2021)

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 12km 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.

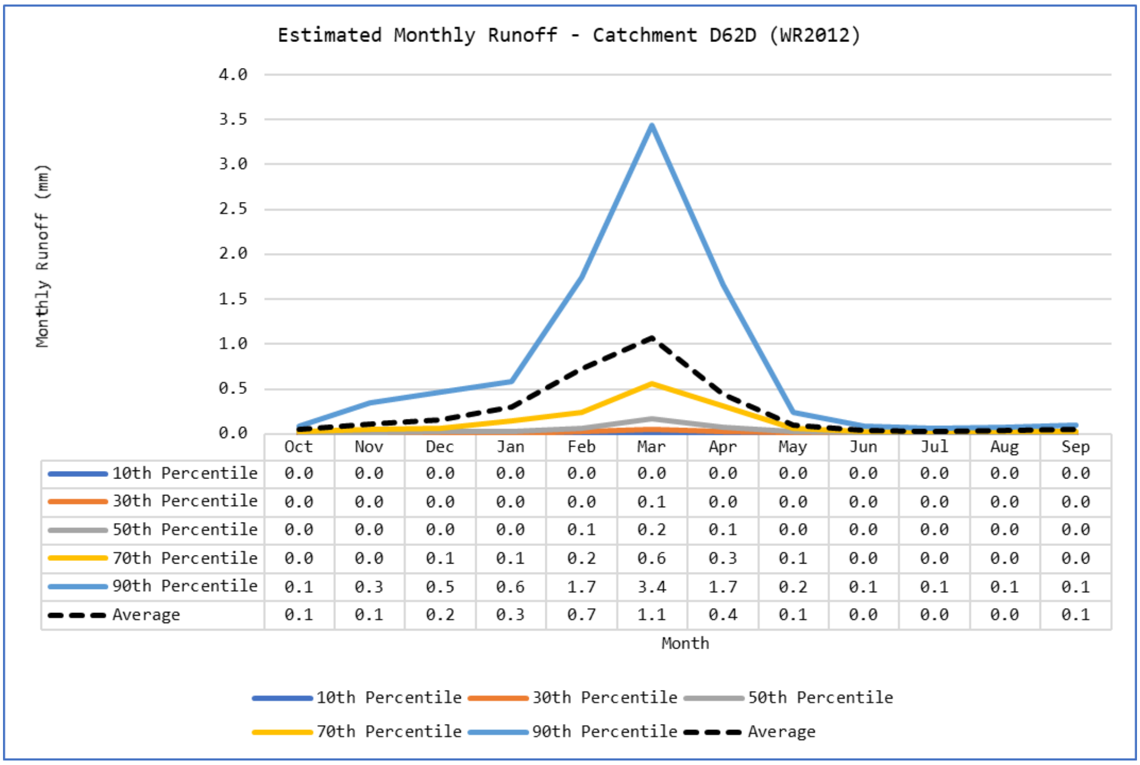


	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Evaporation (mm)	164	189	219	219	165	141	99	76	52	60	83	121
10th Percentile	0.0	1.9	0.0	0.0	7.4	14.0	4.1	0.0	0.0	0.0	0.0	0.0
30th Percentile	7.8	13.4	8.3	13.1	24.8	23.1	15.3	3.8	2.1	0.4	0.3	0.0
50th Percentile	22.6	24.7	15.5	25.8	44.0	50.0	25.5	12.7	7.3	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)

3.1 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 (median yields of 0.5 to 2 l/sec). 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).

3.2 Wetland and ecological areas

Based on available National Wetland Freshwater Ecosystem Priority Areas (NFEPA) (Van Deventer, 2018) the non-perennial drainage streams associated with the site are classified as riverine wetland systems (to be confirmed by the wetland assessment report – not part of this study). The screening assessment also indicates that the footprint for Area 1 and Area 2 infringe on the wetlands and non-perennial rivers, and the aquatic biodiversity rating is very high (refer to Figure 3-7). It is understood that the footprints will further be refined after a dedicated aquatic and wetland study has been undertaken.

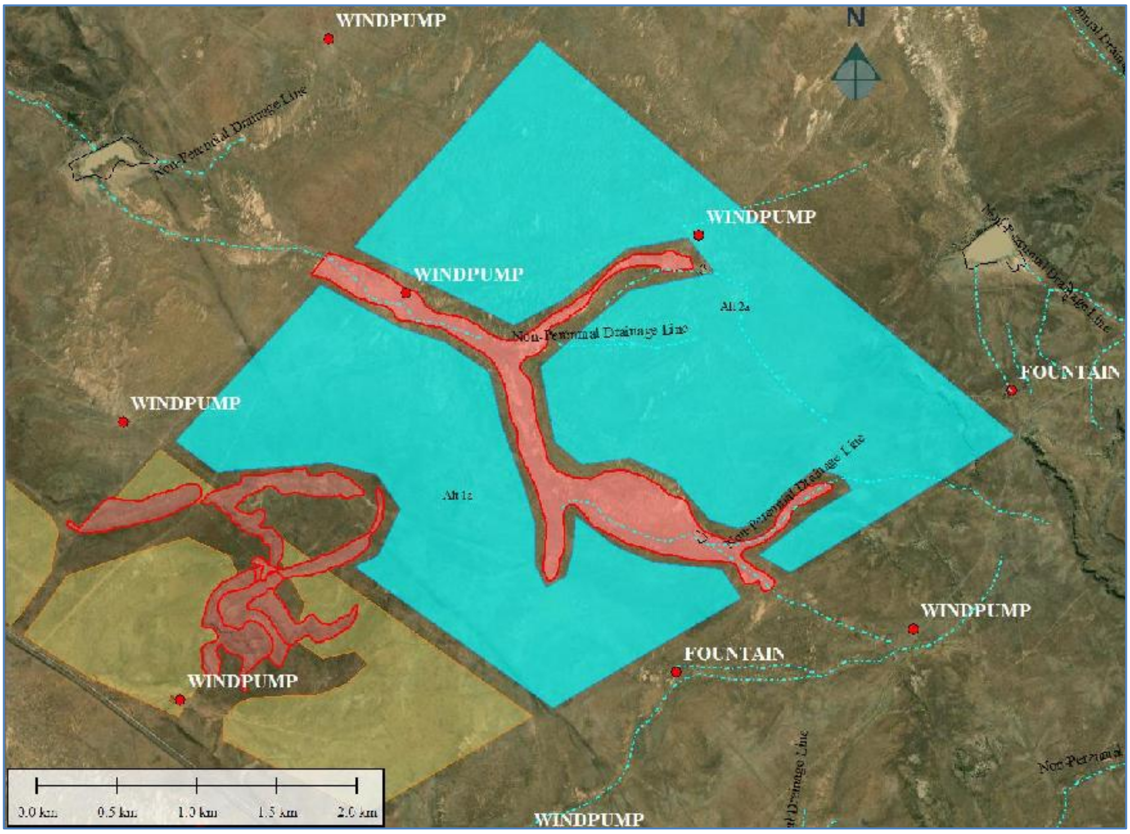


Figure 3-7: Ecological no-go areas (red) (Ecoleges, 2022)

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

Table 3-2 provides a summary of the PES, EIS and EWR (as a percentage of the MAR) for the quaternary catchments.

Table 3-2: 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)

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).

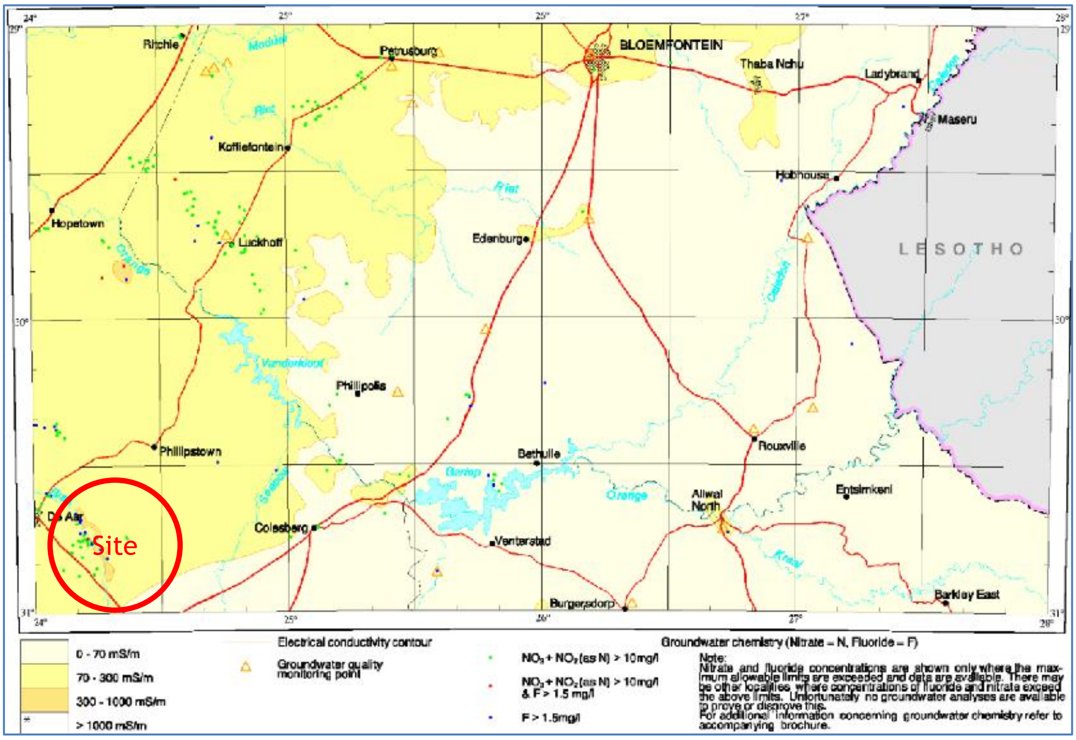


Figure 4-1: Groundwater quality (Meyer, P.S., Chetty, T., Jonk, F., 2002)

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. The only surface water bodies in the area that had water were the storage dams (which had some water after the rain a couple of days before this investigation), constructed in the non-perennial stream between Phase 3 Area 1 and Area 2. pH for screening sites ranged from 7.1 to 7.5, and EC ranged from 10 to 15 mS/m.

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 C**). Design rainfall was retrieved from station 0170639W [station Rooiwal situated 12km 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 rational method (RM3), SDF and MIPI methods produced peak flows in the same order of magnitude. 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 (m^3/s) - Pre-Development

Catchment	Method											
	RM (3)			SDF			MIPI			Geometric Mean		
	1:20 yr	1:50 yr	1:100 yr	1:20 yr	1:50 yr	1:100 yr	1:20 yr	1:50 yr	1:100 yr	1:20yr	1:50 yr	1:100 yr
	(m^3/s)											
HRU1	17.0	25.6	35.3	45.2	67.7	86.6	36.9	51.2	64.5	31	45	58
HRU2	19.5	27.4	37.8	50.6	75.7	96.9	43.2	59.9	75.6	34	50	65
HRU3	29.4	30.7	42.3	52.8	79.0	101.1	45.6	63.2	79.8	37	54	70

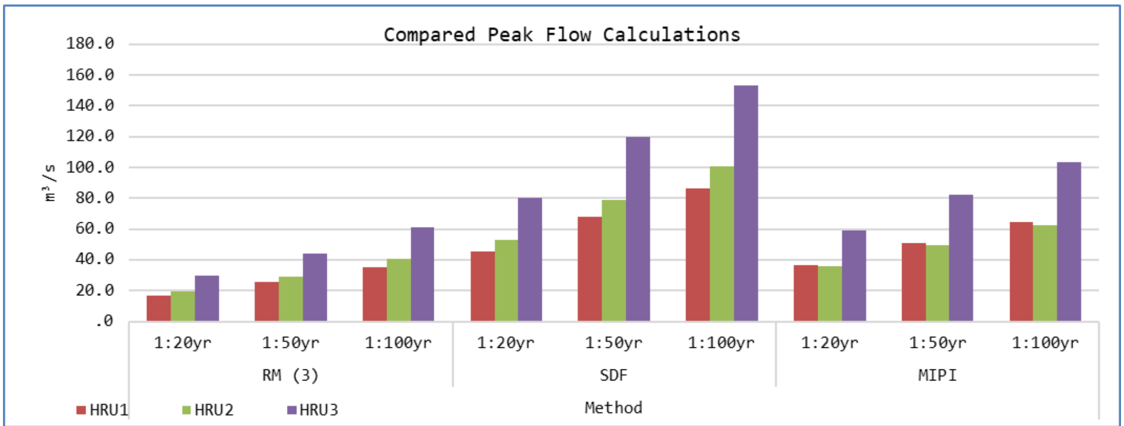


Figure 5-1: Calculated peak flows - pre-development

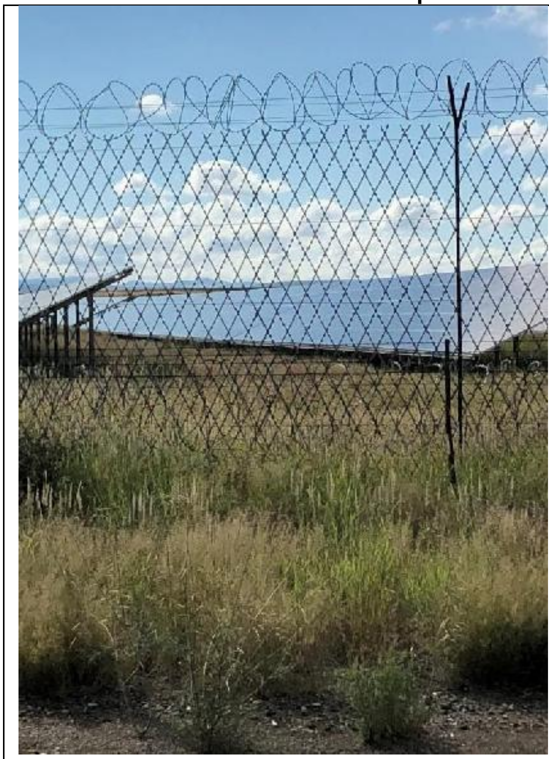
5.2 Post-development peak flows

Due to the project type (i.e., installation of solar arrays which will likely promote runoff from the PV panels onto the surrounding land), there may be an increase in stormwater peak flows that may contribute to increased flooding potential. However, visiting other solar farms in the project area (refer to Table 5-3) suggest that vegetation on the land surface will remain fairly similar even after PV panels are installed (i.e., natural vegetation will be kept, and panels will be mounted on 1.5 to 3 m standpipes).

Research into the impact of solar-farm panels on runoff rates and volumes indicates that solar panels do not have a significant impact on runoff volumes, peak rates or time to peak rates when the ground below the panels is vegetated. Accounting for changes in soil type, slope angle and rainfall intensity, ground cover beneath solar arrays was found to have the most significant impact on runoff rates. On this basis, if vegetation cover beneath the solar arrays is maintained, no significant increase in surface-water runoff is anticipated compared to greenfield runoff rates (WHS, 2022).

It is therefore anticipated, that maintaining natural vegetation cover will assist in preventing increases in peak flow to the non-perennial streams/rivers. Hence, a marginal impact in terms of post-development peak flows on a sub-catchment scale is anticipated. There may be some local flooding/ponding due to the many topographical depressions in the study area. However, on-site stormwater management will help to prevent erosion from areas where panels are installed, and the water that flows from the panels onto the land surface would need to be controlled per solar array. It is predicted that there may only be an impact on the sub-catchment flood peak flows, if severe erosion and vegetation clearing activities take place, with inadequate stormwater management.

Table 5-3: Example of nearby solar farms and configurations

	
Photograph 1 – De Aar Solar	Photograph 2 – De Aar Solar

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

5.3.3 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 three (3) 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

No hydraulic structures were identified in the study area, other than weirs in known non-perennial drainage areas (which form dams) and railway box culverts along the railway 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 30m 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 topographic data provided was of sufficient accuracy and coverage to enable hydraulic modelling at a suitable level of detail.
- The Manning's 'n' values used are considered suitable for use in the flooding events modelled, representing all the channels and floodplains.
- No abstractions or discharges into the stream sections were considered during the modelling.
- Hydraulic structures, other than the water storage dams, were not entered into the model due to the resolution of available topography data.
- Steady-state hydraulic modelling was undertaken, which assumes the flow is continuous at the peak rate; and
- A mixed flow regime that is tailored to both subcritical and supercritical flows was selected for running the steady-state model.

5.4 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.

However, 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.

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, the manning 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.

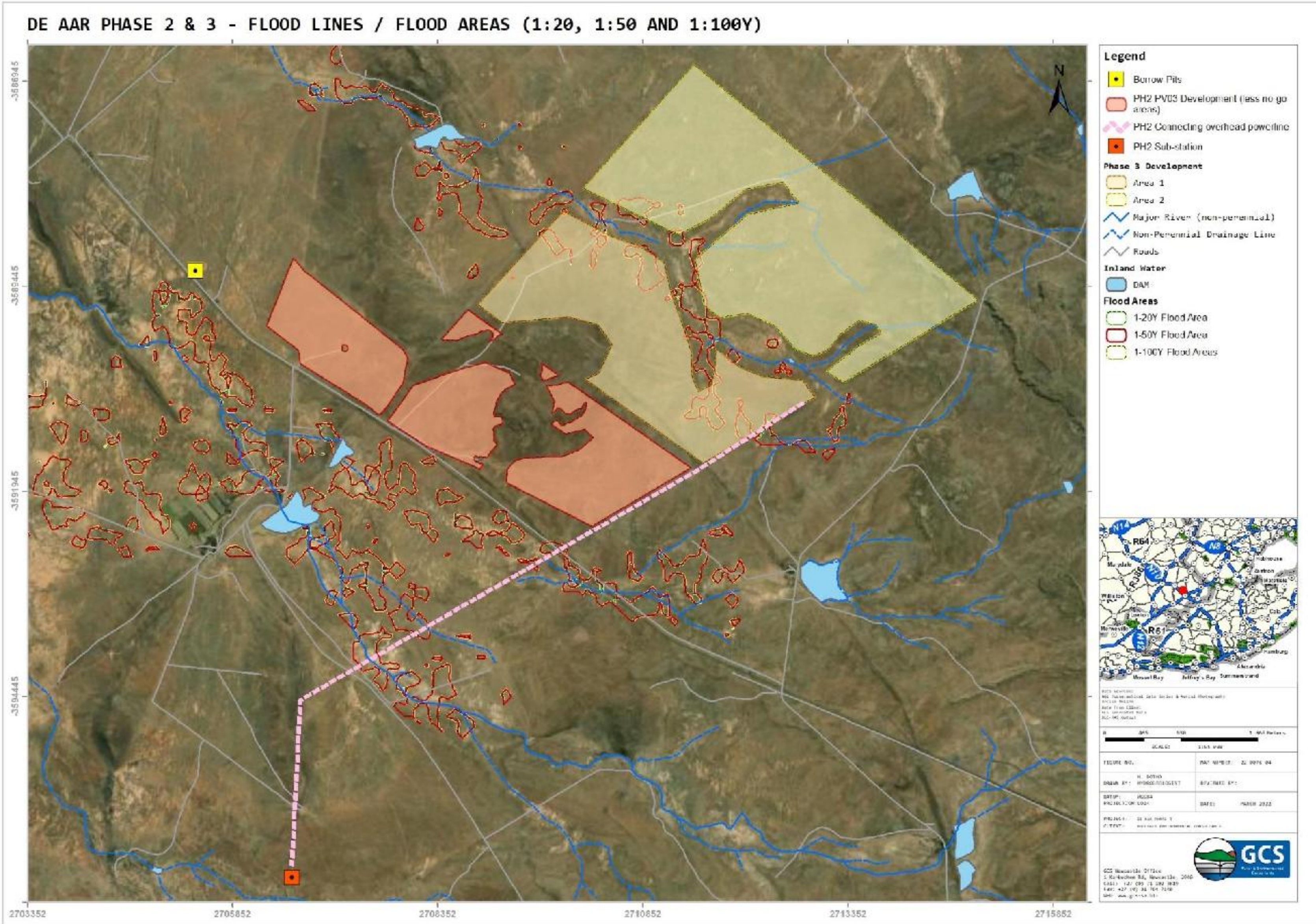


Figure 5-2: **1:20, 1:50 and 1:100-year flood areas**

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.

6.3 Delineation of clean and dirty water areas

Based on the nature of the project (raised PV solar arrays on pipe stand, and vegetation kept intact during the construction and operational phase of the project) no dirty stormwater generation areas are anticipated. As all stormwaters will be subjected to micro-catchment style stormwater runoff, and concentrated rainfall volumes from the PV panels onto the soils, erosion and sediment transport will likely take place. However, this will depend on the density of the vegetation cover surrounding the PV arrays and stormwater peak flow.

Efforts should be made in managing runoff from the PV panels and arrays onto the soils, and then manage the distribution of the accumulated water back to the environment.

6.4 Assumptions

The following assumptions pertain to the CSWMP:

- The ALOS DTM used to delicate the sub-catchments are of sufficient resolution to accurately describe the runoff from the site(s).

6.5 Stormwater peak flows

Based on the operation philosophy of the proposed solar farm (which entails maintaining vegetation cover and pre-construction land capabilities) and supporting literature data for impacts on runoff from solar arrays (WHS, 2022, and PDEP, 2019), the soils & vegetation cover around the solar arrays govern stormwater runoff and sedimentation.

The rational method was used to calculate the stormwater peak flows for the areas designated for the solar arrays. 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 0.09 (9%). 1:2, 1:10, 1:50 and 1:100 yr return periods are presented and are tabulated in Table 6-1.

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

Table 6-1: Stormwater return period estimates for the development areas

PV Area	Q2 -m³/s	Q10 -m³/s	Q50 -m³/s	Q100 -m³/s
PH3a	1.47	2.53	3.62	4.14
PH3b	0.90	1.55	2.22	2.54

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 the winter 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 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 development aims to maintain sheet flow into the watercourse and not create distinct discharge points or outlets, which would require additional invasive and often destructive implementation measures (i.e. the digging of a trench, installation of a swale or digging and placing berms. Refer to Figure 6-1 for a conceptualisation of the preferred stormwater management system at the site.

6.6.3 Mitigative stormwater management measures that can be considered, but may not be required

If a storm event does occur and free drainage back to the environment shows evidence of erosion and sedimentation, then the following should be considered as mitigative stormwater measures (refer to Figure 6-2 and numbers assigned to the SW system):

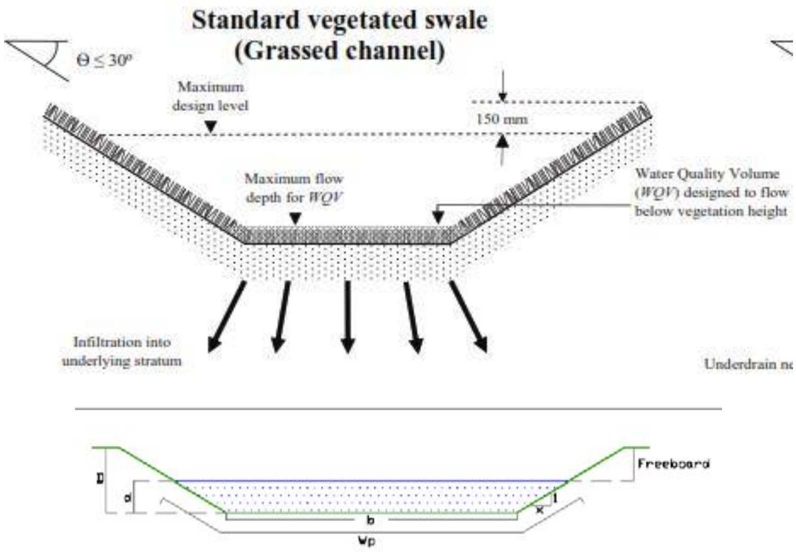
1. It is proposed that vegetated swales be installed downstream of the PV array areas (along the downstream side of the developments). Depending on the final layout of the PV array assemblages, vegetated swales can be installed on the bottom sloped side of the array to further decrease peak runoff volumes from the panels and divert the water to the lower-lying swales for each area. Connecting vegetated swales as a type of herringbone system to the final discharge area (i.e., the lowest point associated with the site) will help to slowly divert any runoff back to the environment which is generated by the solar panels.
2. At the lowest positions in a given vegetated swale system, an outfall to the environment should be constructed. It is proposed that for an outfall a vegetated swale changes into a vegetated discharge area. For additional stormwater control at the outfall, rock riprap can be considered, along with vegetation cover.
3. In other areas, free drainage to the environment is recommended, with no installation of any stormwater systems. In these areas, vegetation cover should be sufficient to manage stormwater runoff.

To circumvent potential erosion and sedimentation in open and unvegetated areas associated with the site native species of vegetation in the area should be planted and maintained. The expansive root systems of these plants provide support to the soil and decrease runoff potential.

<u>Proposed stormwater system sizing</u>

The stormwater systems were sized based on the calculated storm peak flows (refer to Section 6.5) and consider at least 150mm freeboard (refer to Table 6-2). <u>The proposed systems are subjected to changes if detailed stormwater modelling is undertaken.</u>

Table 6-2: Proposed stormwater systems

ID	Type	Material	Proposed Dimensions
1	Vegetated/grassed lined surface swale (or V-drain equivalent)	Earth and local vegetation	 D = 0.6 m, d (design level) = 0.3 m, b =0.4 m x = 30 º

6.7 Other stormwater considerations

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

- Minimise vegetation disturbance during construction.
- Re-vegetate as soon as possible to establish and maintain good ground cover across the site.
- Conduct regular inspections and maintenance of the site to ensure that vegetation cover is adequate, and no rivulets are generated.

6.8 Proposed stormwater monitoring requirements

It is advised that stormwater monitoring take place to ensure that the proposed stormwater system functions correctly. The following is proposed:

1. Routine hydraulic monitoring (i.e., observations of any blockages in the swale system) and cleaning out of the stormwater systems.
2. Routine re-vegetation of the swales, to ensure optimum operation.
3. As the stormwater from the site will only be rainfall runoff from the solar panels, and the sub-stations at the site, no quality monitoring is recommended (i.e., a runoff will highly likely be clean).

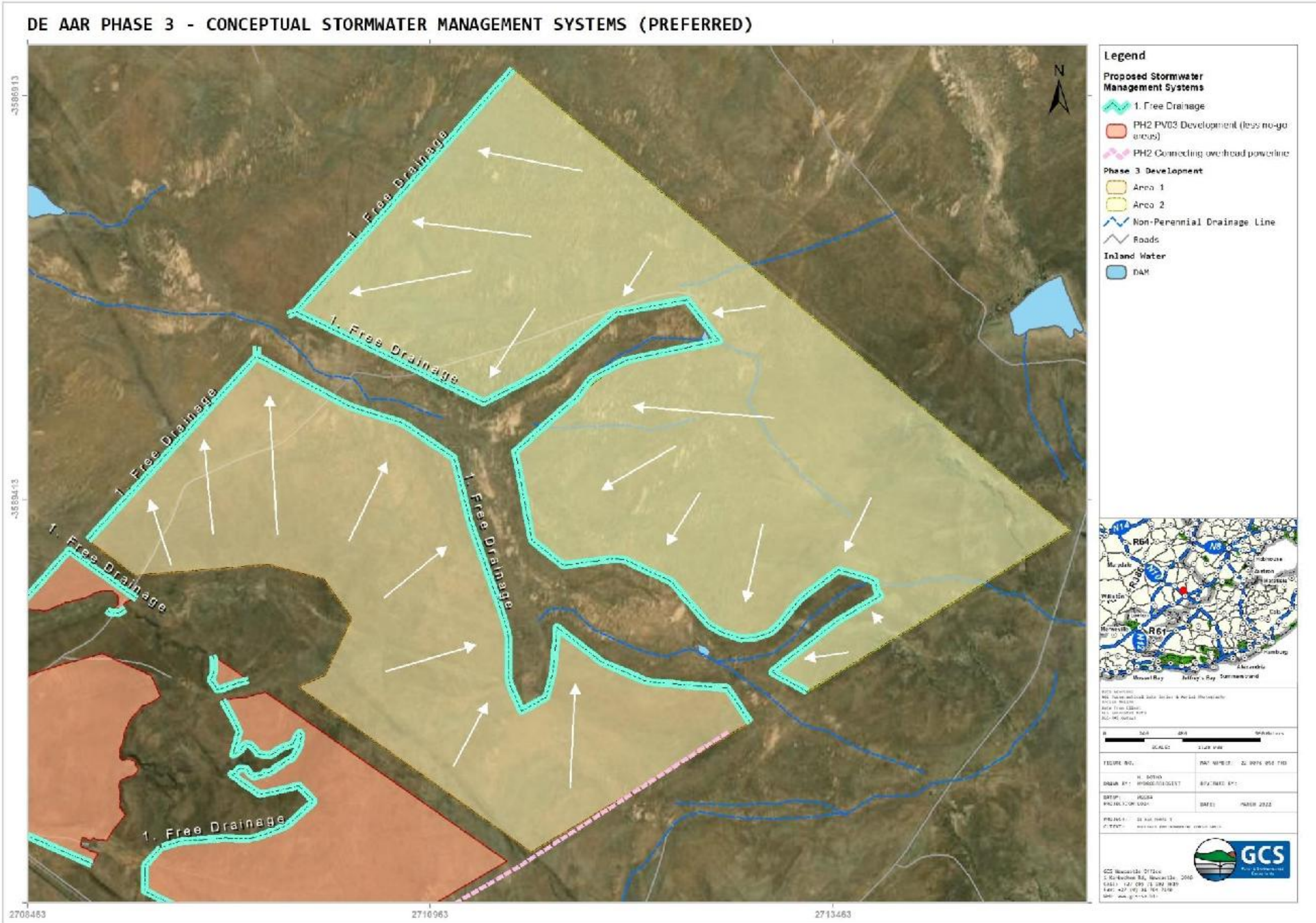


Figure 6-1: Conceptual stormwater management system (preferred – free drainage)

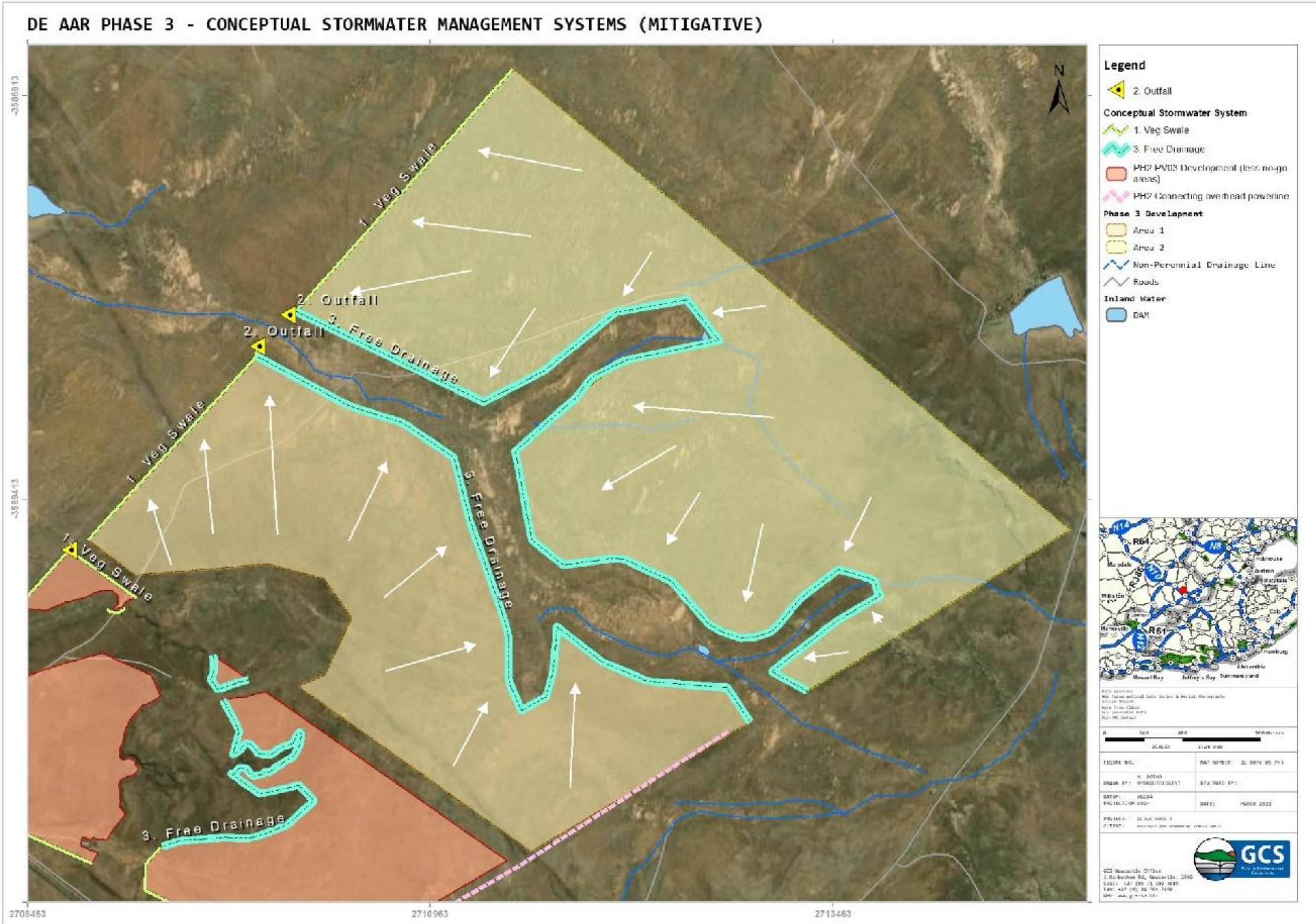


Figure 6-2: **Conceptual stormwater management system**

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.

In terms of the proposed development, several hydrological risks during the construction and operational phase of the development were identified. The potential impacts identified and environmental significance for the construction and operational phase are listed in Table 7-1 and Table 7-2. 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 (construction of standpipes and arrays for PV panels, construction of sub-stations, 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.
  - Excavation of borrow-pits for road building material may cause temporary sedimentation during storm events.
  - Disturbing sediments associated with streams to install dedicated stream crossings and road culverts may promote sediment runoff.
- The operational phase of the PV farm:
  - Oil spillage from parked vehicles (service vehicles).
  - Sedimentation runoff from areas where no stormwater management measures are implemented; or where vegetation is not maintained.

The risk assessment for both construction and post-construction phases 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 of the soils in areas where PV panels are erected and in the surroundings. 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 and operational 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 (i.e., the assemblage of panels that are form factor).

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

As all activities will take place on the same property, and close to other solar development (i.e., Phase 1 and Phase 2) there will be cumulative impacts (however limited due to the project type). Figure 7-1 shows the sub-catchments associated with this project, boreholes identified as part of the hydrocensus, and other solar development within a 30km radius of the project.

Among the most prominent cumulative impacts will be associated with the stream crossings (both underground and above-ground infrastructure). The cumulative impacts from a surface water perspective are limited in that small areas will be disturbed, and disturbed areas will likely only show temporary impacts in terms of water quality (i.e. sedimentation if flooding takes place). No impacts in terms of quantity are predicated, as a result of the streams and rivers being ephemeral. No dedicated surface water pollution sources will be created (i.e., landfills, oil or fuel storage areas, mining, etc.). Moreover, the other proposed solar developments are situated in different drainage areas, rendering the likely impact associated with this project zero. Any hydrological risk for this project will be confined to the delineated sub-catchments (worst case). The operational phase risk table includes cumulative risk about the site, and activities thereon.

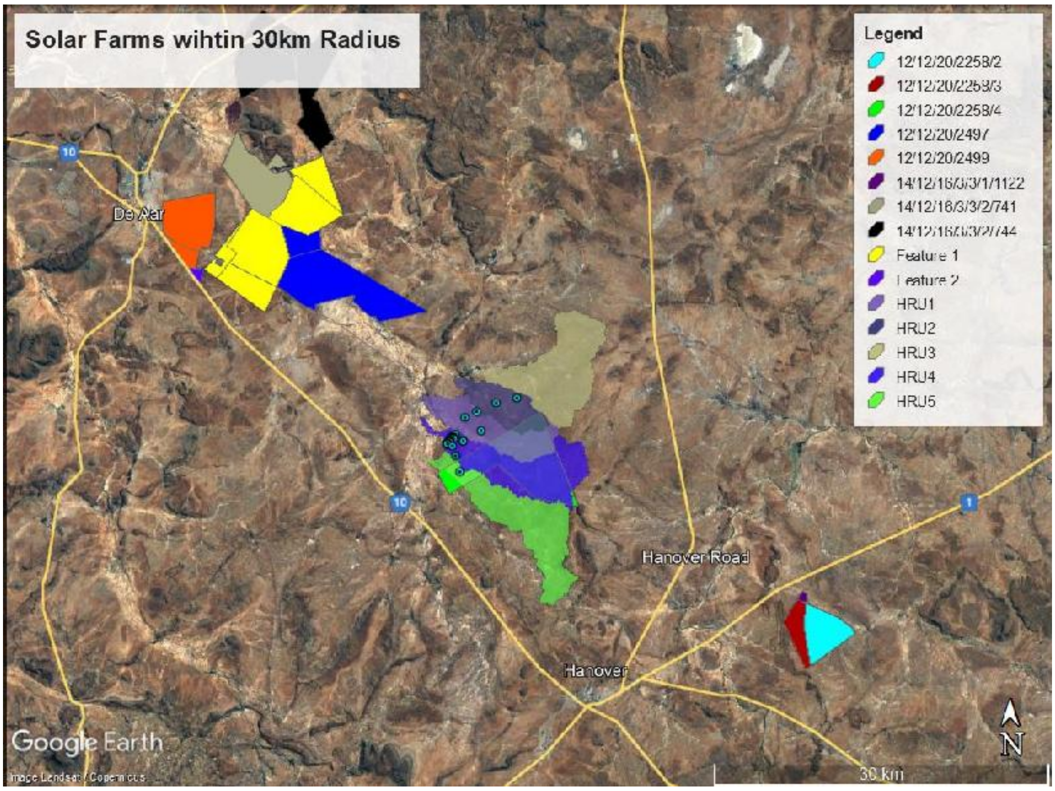


Figure 7-1: Other solar farms within a 30km radius & sub-catchments associated with this project

Table 7-1: Construction (preparation and development) phase hydrological risk

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 PV array assemblage	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 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)	Very Low (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 PV array assemblage	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 box culverts are used for any dedicated stream crossings. Box culverts should be sized to accommodate at least 1:100y flood events.	Short-term (2)	Site (2)	Yes (1)	Low (1)	Negligible (0 to -6) (-5)	Definite (2)	Very Low (0 to -12) (-10)	Medium

Table 7-2: Operational phase hydrological risk

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	***Soil quality*** Fuel or oil leakages from tractors/vehicles entering the site may also cause soil quality degradation.	The net result of the development and activities at the site.	Short-term (2)	Site (2)	Yes (1)	Low (-1)	Negligible (0 to -6) (-5)	Definite (2)	Very Low (0 to -12) (-10)	• Ensure all vehicles entering the site are parked in designated areas, with drip trays, and that vehicles are in good order (i.e., don't let an observed leaking vehicle enter the site or service it on-site).	Short-term (2)	Site (2)	Yes (1)	Low (-1)	Negligible (0 to -6) (-5)	Improbable (0)	Negligible (0 to -12) (0)	Medium
Primary Surface Water Receivers – > Non-perennial streams	***Runoff and sedimentation*** Sedimentation of the non-perennial streams if storm events take place and insufficient vegetation cover is present. This is likely only to take place during severe storm events (i.e., 1:2 to 1:100y events). Accidental rainfall will likely not cause sedimentation.	The net result of the development and activities at the site.	Short-term (2)	Site (2)	Yes (1)	Low (-1)	Negligible (0 to -6) (-5)	Definite (2)	Very Low (0 to -12) (-10)	• Install swales as per the CSWMP for stormwater drainage at the site. • Re-vegetate areas where erosion is noted or where vegetation is required to reduce stormwater peak flows.	Short-term (2)	Site (2)	Yes (1)	Low (-1)	Negligible (0 to -6) (-5)	Improbable (0)	Negligible (0 to -12) (0)	Medium
	Impact on water quality Hydrocarbon spills from vehicles accessing the site, or leakages from sub-stations transformers.	The net result of the development and activities at the site.	Short-term (2)	Site (2)	Yes (1)	Low (-1)	Negligible (0 to -6) (-5)	Definite (2)	Very Low (0 to -12) (-10)	• Ensure all vehicles entering the site are parked in designated areas, with drip trays, and that vehicles are in good order (i.e., don't let an observed leaking vehicle enter the site or service it on-site). • Regular inspections (monthly) and maintenance of sub-stations.	Short-term (2)	Site (2)	Yes (1)	Low (-1)	Negligible (0 to -6) (-5)	Improbable (0)	Negligible (0 to -12) (0)	Medium
Cumulative Impact	*No impacts in terms of quantity are predicated, as a result of the streams and rivers being ephemeral.* *No dedicated surface water pollution sources will be created (i.e., landfills, oil or fuel storage areas, mining, etc.).* *Other proposed solar developments are situated in different drainage areas, rendering the likely impact associated with*	PV arrays and post-stream crossing activities	Short-term (2)	Site (2)	Yes (1)	Low (1)	Negligible (0 to -6) (-5)	Improbable (0)	Very low (0 to -12) (0 - ZERO)	The cumulative impacts from a surface water perspective are limited in that small areas will be disturbed, and disturbed areas will likely only show temporary impacts in terms of water quality (i.e. sedimentation if flooding takes place). Not much can be done in terms of mitigation of overall cumulative impacts. However, implementing the mitigation measures mentioned above	Short-term (2)	Site (2)	Yes (1)	Low (1)	Negligible (0 to -6) (-5)	Improbable (0)	Very low (0 to -12) (0 - ZERO)	Medium

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	
	this project zero. Any hydrological risk for this project will be confined to the delineated sub-catchments (worst case). The operational phase risk table includes cumulative risk about the site, and activities thereon.									(construction and operational phase) will help determine the overall probability of an impact on water quality if storm events occur. Furthermore, stormwater management protocols and recommendations should be considered to prevent cumulative impacts.								

8 SURFACE WATER MONITORING

Currently, no surface water monitoring is taking place. It is proposed that a proper monitoring programme be implemented to monitor both the water quality and quantity at the site (when there is water in the area to monitor). The monitoring programme is divided into two phases:

- Phase 1: Monitoring during any construction activities (temporary monitoring); and
- Phase 2: Monitoring after development is complete (long term or for a period after the activity).

8.1 Phase 1 monitoring

During the construction phase, it is recommended that all vehicles are in good working order when entering the site (i.e., visual observations of any leakages that may emanate from the vehicle accessing the site) and parked in designated areas with drip trays.

As part of Phase 1 monitoring, visual observations (i.e., monthly inspections and inspections shortly after rainfall events) of the banks associated with the non-perennial streams and rivers and the general conditions of the areas cleared, should be adequate to determine if there is any sediment runoff taking place or erosion.

8.2 Phase 2 monitoring

From the risk assessment undertaken, it is anticipated that soils downstream of the proposed development, and the non-perennial streams (feeding into temporary livestock watering dams) are the receivers of any sediment runoff or poor-quality runoff from the site.

It is proposed that four (4) bi-annual water monitoring points be established in the non-perennial stream and temporary dams constructed by the landowner. These are the only areas where there will likely be sufficient water to sample and monitor the impact of the development (i.e., the rivers are ephemeral and only have water shortly after storm events). The proposed monitoring points are shown in Figure 8-1).

For groundwater monitoring aspects relating to the construction and operational phase of the project, we refer the reader to the GCS Groundwater Assessment Report (Project Number 22-0401 Date: 10 August 2022).

8.3 Stormwater management

As per Section 6, the following is proposed in terms of stormwater monitoring:

1. Routine hydraulic monitoring (i.e., observations of any blockages in the system) and cleaning out of the stormwater systems.
2. Routine re-vegetation of the swales, to ensure optimum operation.
3. As the stormwater from the site will only be rainfall runoff from the solar panels, and the sub-stations at the site, no quality monitoring is recommended (i.e., a runoff will highly likely be clean).

8.4 Monitoring duration

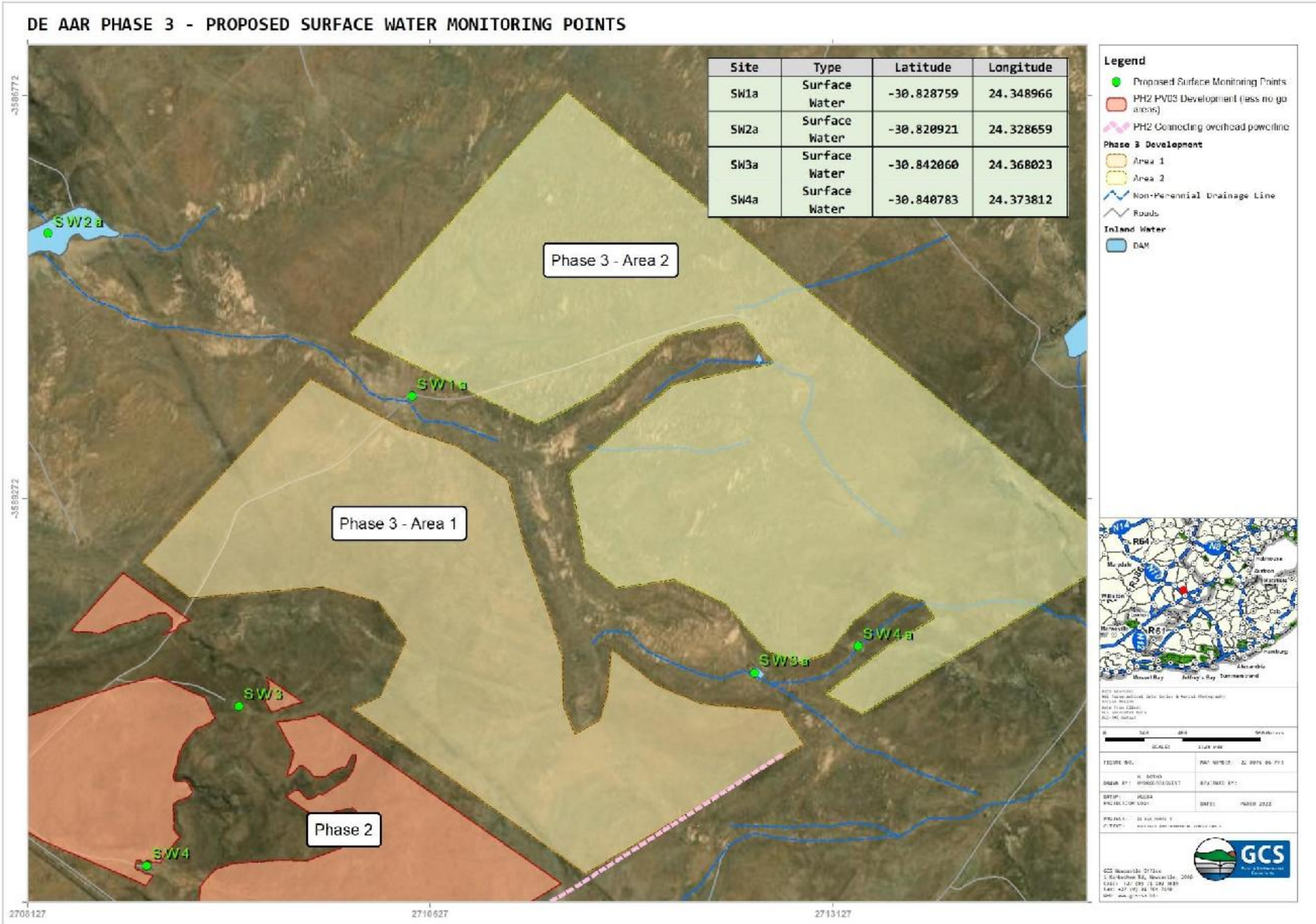
In terms of monitoring duration, it is proposed that monitoring take place up to 2 years after the completion of the development. The need for further monitoring of the site can be evaluated by the local environmental authorities or DWS representative.

8.5 Monitoring responsibility

It is proposed that the applicant be responsible for Phase 1 and Phase 2 monitoring. The proposed monitoring type, frequencies and constituents to monitor are listed in Table 8-1 below. Preliminary monitoring positions are indicated in Figure 8-1.

Table 8-1: Proposed monitoring points, frequencies and sample analyses

Site Type	Frequency	Type	Field Measurements
Non-perennial streams draining the site (in-situ / field measurements should be suitable).	Bi-Annually	Field assessment and laboratory (if required).	pH. Electrical Conductivity (EC) / Total Dissolved Solids (TDS). Temp.



Site	Type	Latitude	Longitude
SW1a	Surface Water	-30.828759	24.348966
SW2a	Surface Water	-30.820921	24.328659
SW3a	Surface Water	-30.842060	24.368023
SW4a	Surface Water	-30.840783	24.373812

Figure 8-1: Proposed monitoring points

9 CONCLUSIONS

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).
- Three (3) hydrological response units (HRUs) were delineated for the project area, which entails numerous micro catchments which contribute to the overall drainage. Drainage for the general area is towards the northwest in the form of a multitude of non-perennial drainage lines, which drains towards the non-perennial Brak River, situated approximately 6.6km downstream west of the site. There are several in-stream water storage dams associated with the non-perennial streams in the study area. Three (3) small capacity surface water storage dams (capacity and license status currently unknown) fall within the proposed development area (in the non-perennial drainage lines).
- 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. The following was noted:
    - Three (3) surface water storage dams were noted in the Phase 3 area, capacities estimated at 2500 m^3, 8 200 m^3 and 2 984 m^3 (downstream to upstream in the non-perennial drainage stream).
    - Two (2) windmills were noted in the project area. The windmills are used for livestock watering. Both windmills pump to an artificial pond, respective to the windmill positions. The landowner estimates a yield of 1000 l/hour for both windmills.
    - 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 impact on runoff rates and volumes indicates that solar panels do not have a significant impact on runoff volumes, peak rates or time to peak rates when the ground below the panels is vegetated. Accounting for changes in soil type, slope angle and rainfall intensity, ground cover beneath solar arrays was found to have the most significant impact on runoff rates. On this basis, if vegetation cover beneath the solar arrays is maintained, no significant increase in surface-water runoff is anticipated compared to greenfield runoff rates (WHS, 2022).
- The CSWMP indicates that:
    - Due to the micro-catchment type drainage of the overall development areas, free drainage provides the best stormwater management option for the development (refer to Section 6).
    - Based on the nature of the project (raised PV solar arrays on pipe stand, and vegetation kept intact during the construction and operational phase of the project) no dirty stormwater generation areas are anticipated. As all stormwaters will be subjected to micro-catchment style stormwater runoff, and concentrated rainfall volumes from the PV panels onto the soils, erosion and sediment transport will likely take place. However, this will depend on the density of the vegetation cover surrounding the PV arrays and stormwater peak flow.
    - Efforts should be made in managing runoff from the PV panels and arrays onto the soils and then releasing the accumulated water back into the environment via free drainage.
- The risk assessment for both construction and post-construction phases 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 of the soils in areas where PV panels are erected and in the surroundings. 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 and operational 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 (i.e., an assemblage of panels that are form factor).

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. Construction within probable non-perennial drainage areas should be avoided, wherever the drainage lines can be confirmed in the field (difficult given the micro-catchment style drainage for the area). No alternative development sites are proposed.

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:

- 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 the winter 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.
- 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.
- To prevent erosion and deposition during construction use:
  - Minimise vegetation disturbance during construction.
  - Re-vegetate as soon as possible to establish and maintain good ground cover across the site.
  - Conduct regular inspections and maintenance of the site to ensure that vegetation cover is adequate, and no rivulets are generated.
- If PV panels and array assemblages are proposed in areas of higher flood risk, the depth of flooding should be predicted for those areas (e.g. depth of surface-water flooding predicted during the 1 in 50-year flood event).
- All electrical connectors and other items vulnerable to floodwater should be located at a minimum level of the maximum flood depth plus a 0.3m freeboard above ground level to ensure that they are protected from the design flood event.

9.3 Monitoring requirements, specifically related to stormwater management & surface water

During the construction phase, it is recommended that all vehicles are in good working order when entering the site (i.e., visual observations of any leakages that may emanate from the vehicle accessing the site) and parked in designated areas with drip trays. Visual observations (i.e., monthly inspections and inspections shortly after rainfall events) of the banks associated with the non-perennial streams and rivers and the general conditions of the areas cleared, should be adequate to determine if there is any sediment runoff taking place or erosion.

It is proposed that four (4) bi-annual water monitoring points be established in the non-perennial stream and temporary dams constructed by the landowner. These are the only areas where there will likely be sufficient water to sample and monitor the impact of the development (i.e., the rivers are ephemeral and only have water shortly after storm events). The proposed monitoring points are shown in Section 8.

It is also advised that all groundwater boreholes (4 identified within proximity of the solar farm) be monitored for the decline in water levels/yields, as well as water quality. It is known that the boreholes are used as the main water supply for livestock / domestic use.

It is advised that stormwater monitoring take place to ensure that the proposed stormwater system functions correctly. The following is proposed:

1. Routine hydraulic monitoring (i.e., observations of any blockages in the swale system) and cleaning out of the stormwater systems.
2. Routine re-vegetation of the swales, to ensure optimum operation.
3. As the stormwater from the site will only be rainfall runoff from the solar panels, and the sub-stations at the site, no quality monitoring is recommended (i.e., the runoff will highly likely be clean).

From the risk assessment undertaken, it is anticipated that soils downstream of the proposed development, and the non-perennial streams (feeding into temporary livestock watering dams) are the receivers of any sediment runoff or poor-quality runoff from the site.

9.4 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	Monday, 14 March 2022	
Physical characteristics							
Size of catchment (A)	30.08	km^2		Rainfall region		D6C	
Longest watercourse (L)	9.92	km		Area distribution factors			
Average slope (S_{av})	0.0046	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%)	78.56	0.01	0.79	Lawns			
Flat areas (3 - 10%)	19.88	0.06	1.19	Sandy,flat<2%	0	0.08	0
Hilly (10 - 30%)	1.49	0.12	0.18	Sandy,steep>7%	0	0.16	0
Steep Areas (>30%)	0.07	0.22	0.02	Heavy s,flat<2%	0	0.15	0
Total	100.00	0.41	2.17	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	0.02	0.03	0.00	City centre	0	0.8	0
Light bush & farm-lands	93.67	0.07	6.56	Suburban	0	0.65	0
Grasslands	1.48	0.17	0.25	Streets	0	0.75	0
No vegatation	4.84	0.26	1.26	Max flood	0	1	0
Total	100.01	0.53	8.07	Total (C2)	0		0
Time of concentration (TC)							
Overland flow	Defined watercourse						
$T_C = 0.604\left(\frac{rL}{\sqrt{S_{av}}}\right)^{0.467}$	$T_c = \left[\frac{0.87 L^2}{1000 S_{AV}}\right]^{0.385}$			Use Defined watercourse			
4.039 hours	3.082	hours					
Run-off coefficient							
Return Period (years)	2	5	10	20	50	100	PMF
Run-off coefficient, C_1	0.138	0.138	0.138	0.138	0.138	0.138	0.900
Adjusted for dolomitic areas, C_{1D}	0.138	0.138	0.138	0.138	0.138	0.138	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}	0.0692005	0.07612055	0.0830406	0.093	0.115	0.138	0.900
Combined run - off coefficient, C_T	0.0692005	0.07612055	0.0830406	0.093	0.115	0.138	0.900
Rainfall							
Return Period (years)	2	5	10	20	50	100	PMF
Point rainfall (mm), P_T	33.77	47.80	57.92	68.44	83.07	94.99	107.62
Point Intensity (mm/h), P_{it}	10.96	15.51	18.79	22.20	26.95	30.82	34.92
Area reduction factor (%),ARF_T	0.991	0.991	0.991	0.991	0.991	0.991	0.991
Average intensity (mm/hour),I_T	10.857	15.366	18.620	22.003	26.707	30.539	34.599
Return Period (years)	2	5	10	20	50	100	PMF
Peak flow (m3/s)	6.278	9.773	12.920	17.048	25.634	35.32	260.18

STANDARD DESIGN FLOOD (SDF) METHOD							
Description of catchment		HRU1					
River detail	Non-Perennial Reach of the Brak River						
Calculated by	Hendrik Botha				Date	14/03/2022	
Physical characteristics							
Size of catchment (A)	30.08	km^2		Days of thunder per year (R)		52	days
Longest watercourse (L)	9.92	km		Time of concentration, t		184.935	minutes
Average slope (S_{av})	0.005	m/m		Time of concentration, T_c	$T_c = \left[\frac{0.87\,L^2}{1000\,S_{AV}}\right]^{0.385}$		
SDF Basin	12						
2-year return period rainfall (M)	39	mm					3.0822
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	46.1	60.3	74.5	93.3	107.5	121.7
Area reduction factor (%),ARF_T	0.991	0.991	0.991	0.991	0.991	0.991	0.991
Average intensity (mm/hour),I_T	8.8	14.8	19.4	24.0	30.0	34.6	39.1
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)	3.67	17.36	30.36	45.24	67.67	86.64	106.86

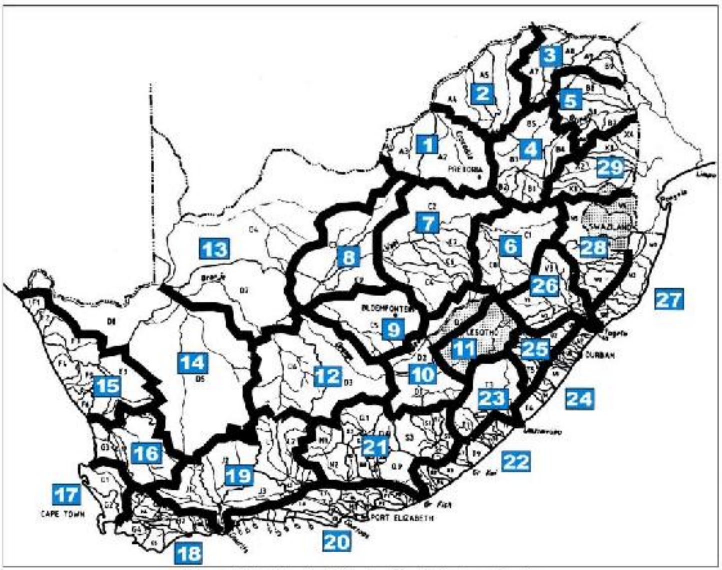


Figure 3.30: Standard Design Flood drainage basins

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	30.08	320	0.0046	9.92	6.88	0.59	0.8	1.11	1.4	0.0299	27.19	36.87	51.16	64.52

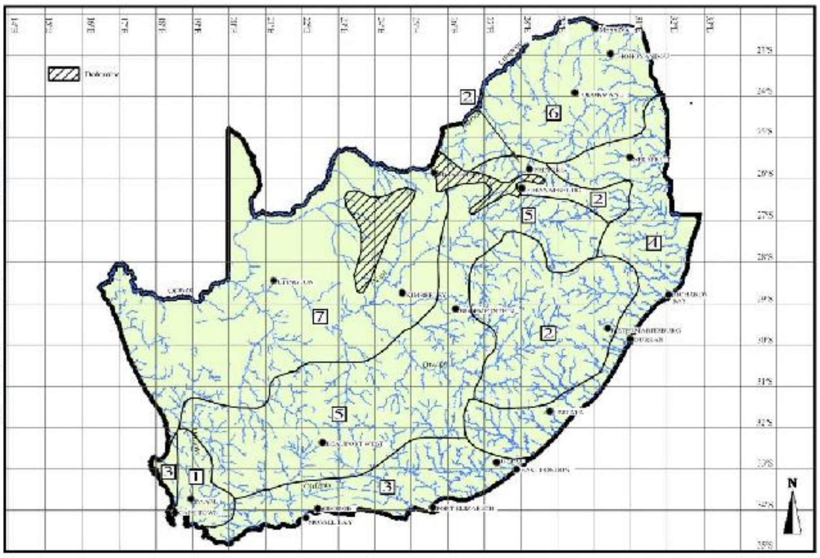


Figure 3.35: Homogeneous flood regions in South Africa

HRU2

RATIONAL METHOD 3							
Description of catchment		HRU2					
River detail	Non-Perennial Reach of the Brak River						
Calculated by	Hendrik Botha			Date	Monday, 14 March 2022		
Physical characteristics							
Size of catchment (A)	21.738	km^2		Rainfall region		D6C	
Longest watercourse (L)	4.87	km		**Area distribution factors**			
Average slope (S_{av})	0.0056	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%)	82.01	0.01	0.82	**Lawns**			
Flat areas (3 - 10%)	16.51	0.06	0.99	Sandy,flat<2%	0	0.08	0
Hilly (10 - 30%)	1.48	0.12	0.18	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	1.99	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	0	0.03	0.00	City centre	0	0.8	0
Light bush & farm-lands	97.25	0.07	6.81	Suburban	0	0.65	0
Grasslands	0	0.17	0.00	Streets	0	0.75	0
No vegatation	2.75	0.26	0.72	Max flood	0	1	0
Total	100	0.53	7.52	Total (C2)	0		0
Time of concentration (TC)							
Overland flow	Defined watercourse						
$T_C = 0.604\left(\frac{rL}{\sqrt{S_{av}}}\right)^{0.467}$	$T_c = \left[\frac{0.87\,L^2}{1000\,S_{AV}}\right]^{0.385}$			Use Defined watercourse			
2.767 hours	1.652	hours					
Run-off coefficient							
Return Period (years)	2	5	10	20	50	100	PMF
Run-off coefficient, C_1	0.131	0.131	0.131	0.131	0.131	0.131	0.900
Adjusted for dolomitic areas, C_{1D}	0.131	0.131	0.131	0.131	0.131	0.131	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}	0.065554	0.0721094	0.0786648	0.088	0.109	0.131	0.900
Combined run - off coefficient, C_T	0.065554	0.0721094	0.0786648	0.088	0.109	0.131	0.900
Rainfall							
Return Period (years)	2	5	10	20	50	100	PMF
Point rainfall (mm), P_T	30.50	43.08	52.25	61.77	74.95	85.68	97.11
Point Intensity (mm/h), P_{it}	18.46	26.07	31.63	37.39	45.36	51.86	58.78
Area reduction factor (%),ARF_T	0.983	0.983	0.983	0.983	0.983	0.983	0.983
Average intensity (mm/hour),I_T	18.141	25.626	31.085	36.744	44.587	50.969	57.768
Return Period (years)	2	5	10	20	50	100	PMF
Peak flow (m3/s)	7.181	11.158	14.765	19.490	29.297	40.35	313.94

STANDARD DESIGN FLOOD (SDF) METHOD							
Description of catchment		HRU2					
River detail	Non-Perennial Reach of the Brak River						
Calculated by	Hendrik Botha			Date	14/03/2022		
Physical characteristics							
Size of catchment (A)	21.738	km^2	Days of thunder per year (R)		52	days	
Longest watercourse (L)	4.87	km	Time of concentration, t		99.131	minutes	
Average slope (S_{av})	0.006	m/m	Time of concentration, T_c	$T_c = \left[\frac{0.87 L^2}{1000 S_{AV}}\right]^{0.385}$		1.6522	
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) $P_{t,T}$	23.8	40.1	52.5	64.9	81.2	93.6	106.0
Area reduction factor (%),ARF_T	0.983	0.983	0.983	0.983	0.983	0.983	0.983
Average intensity (mm/hour),I_T	14.2	23.9	31.2	38.6	48.3	55.7	63.0
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)	4.27	20.21	35.33	52.66	78.76	100.85	124.39

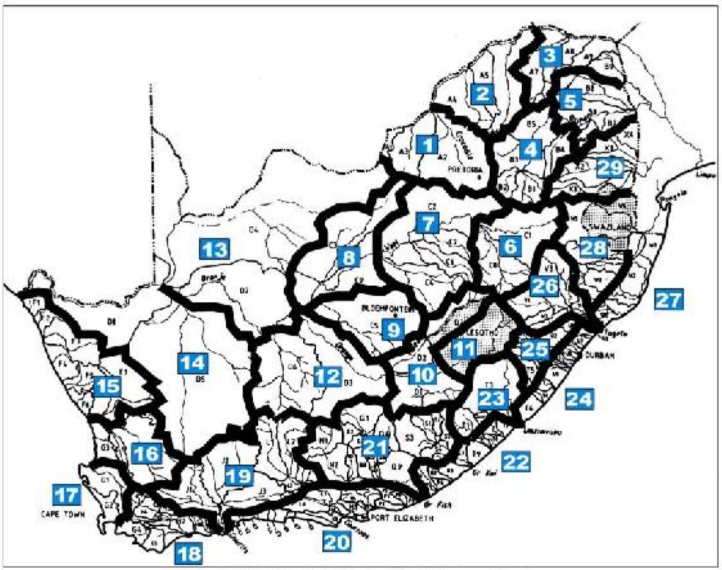


Figure 3.30: Standard Design Flood drainage basins

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	21.738	320	0.0056	4.87	4.99	0.59	0.8	1.11	1.4	0.0669	26.29	35.65	49.46	62.39

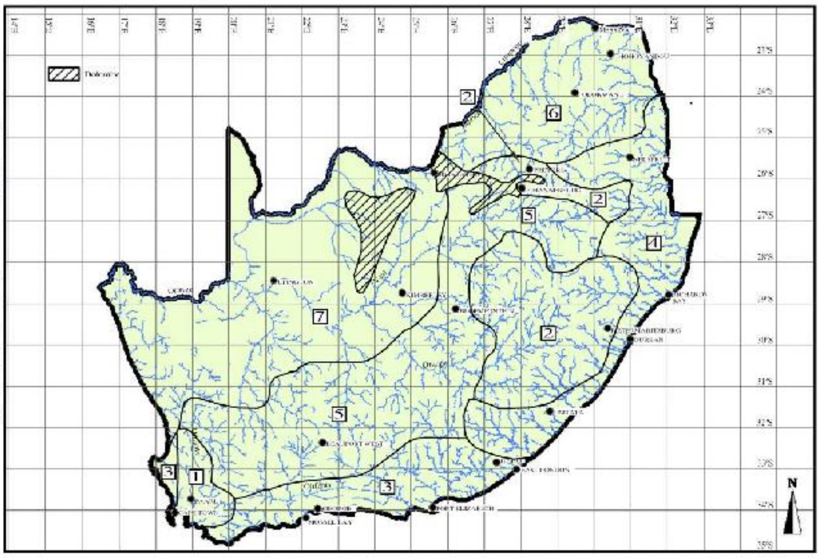


Figure 3.35: Homogeneous flood regions in South Africa

HRU3

RATIONAL METHOD 3							
Description of catchment		HRU3					
River detail	Non-Perennial Reach of the Brak River						
Calculated by	Hendrik Botha				Date	Monday, 14 March 2022	
Physical characteristics							
Size of catchment (A)	53.932	km^2		Rainfall region		D6C	
Longest watercourse (L)	9.47	km		Area distribution factors			
Average slope (S_{av})	0.0045	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%)	80.17	0.01	0.80	**Lawns**			
Flat areas (3 - 10%)	19.02	0.06	1.14	Sandy,flat<2%	0	0.08	0
Hilly (10 - 30%)	0.81	0.12	0.10	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	2.04	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	0.01	0.03	0.00	City centre	0	0.8	0
Light bush & farm-lands	94.66	0.07	6.63	Suburban	0	0.65	0
Grasslands	2.44	0.17	0.41	Streets	0	0.75	0
No vegatation	2.89	0.26	0.75	Max flood	0	1	0
Total	100	0.53	7.79	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			
3.973 hours	2.999	hours					
Run-off coefficient							
Return Period (years)	2	5	10	20	50	100	PMF
Run-off coefficient, C_1	0.134	0.134	0.134	0.134	0.134	0.134	0.900
Adjusted for dolomitic areas, C_{1D}	0.134	0.134	0.134	0.134	0.134	0.134	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}	0.067164	0.0738804	0.0805968	0.090	0.111	0.134	0.900
Combined run - off coefficient, C_T	0.067164	0.0738804	0.0805968	0.090	0.111	0.134	0.900
Rainfall							
Return Period (years)	2	5	10	20	50	100	PMF
Point rainfall (mm), P_T	33.63	47.60	57.68	68.16	82.73	94.60	107.18
Point Intensity (mm/h), P_{it}	11.21	15.87	19.23	22.72	27.58	31.54	35.73
Area reduction factor (%),ARF_T	0.959	0.959	0.959	0.959	0.959	0.959	0.959
Average intensity (mm/hour),I_T	10.750	15.215	18.437	21.787	26.444	30.240	34.259
Return Period (years)	2	5	10	20	50	100	PMF
Peak flow (m3/s)	10.817	16.840	22.262	29.375	44.169	60.85	461.92

STANDARD DESIGN FLOOD (SDF) METHOD							
Description of catchment		HRU3					
River detail	Non-Perennial Reach of the Brak River						
Calculated by	Hendrik Botha			Date	14/03/2022		
Physical characteristics							
Size of catchment (A)	53.932	km^2	Days of thunder per year (R)		52	days	
Longest watercourse (L)	9.47	km	Time of concentration, t		179.957	minutes	
Average slope (S_{av})	0.005	m/m	Time of concentration, T_c	$T_c = \left[\frac{0.87 L^2}{1000 S_{AV}} \right]^{0.385}$		2.9993	
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) $P_{t,T}$	27.2	45.9	60.0	74.1	92.8	106.9	121.0
Area reduction factor (%),ARF_T	0.959	0.959	0.959	0.959	0.959	0.959	0.959
Average intensity (mm/hour),I_T	8.7	14.7	19.2	23.7	29.7	34.2	38.7
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)	6.51	30.77	53.81	80.19	119.94	153.59	189.43

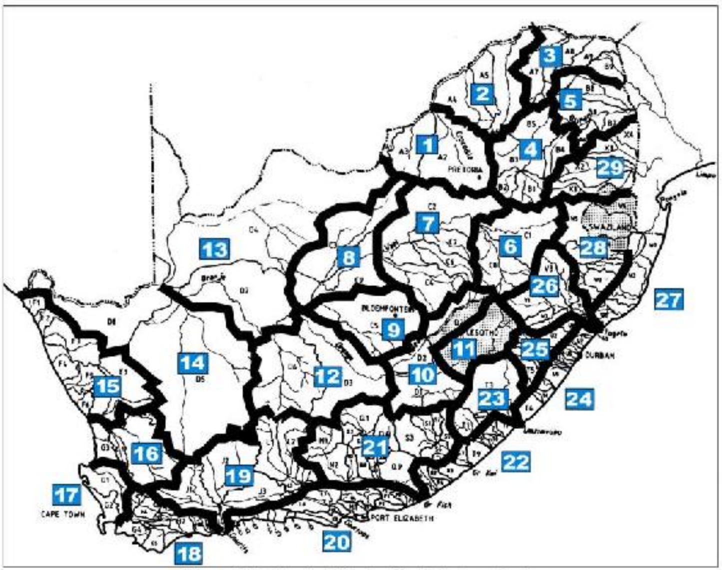


Figure 3.30: Standard Design Flood drainage basins

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	53.932	320	0.0045	9.47	6.87	0.59	0.8	1.11	1.4	0.0556	43.70	59.25	82.22	103.69

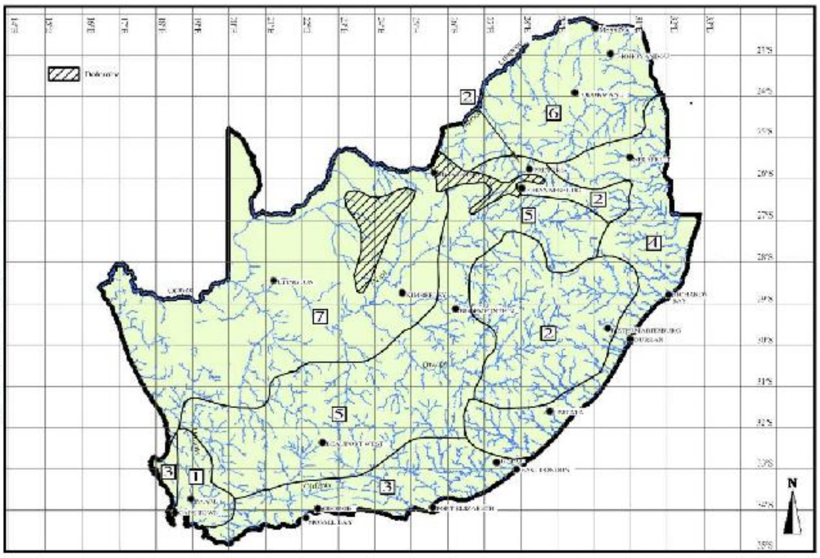


Figure 3.35: Homogeneous flood regions in South Africa

APPENDIX B: HYDROLOGICAL RISK ASSESSMENT RATING

Due to the hydrological 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 10-1 provides a summary of the criteria used to assess the significance of the potential impacts identified. An explanation of these impact criteria is provided in Table 10-2.

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 with probability.

Table 10-1: Proposed Criteria and Rating Scales to be used in the Assessment of the Potential Impacts

Criteria	Rating Scales	Notes
Nature	Positive (+)	An evaluation of the effect of the impact related to the proposed development.
	Negative (-)	
Extent	Footprint (1)	The impact only affects the area in which the proposed activity will occur.
	Site (2)	The impact will affect only the development area.
	Local (3)	The impact affects the development area and adjacent properties.
	Regional (4)	The effect of the impact extends beyond municipal boundaries.
	National (5)	The effect of the impact extends beyond more than 2 regional/ provincial boundaries.
	International (6)	The effect of the impact extends beyond country borders.
Duration	Temporary (1)	The duration of the activity associated with the impact will last 0-6 months.
	Short term (2)	The duration of the activity associated with the impact will last 6-18 months.
	Medium-term (3)	The duration of the activity associated with the impact will last 18 months-5 years.
	Long term (4)	The duration of the activity associated with the impact will last more than 5 years.
Severity	Low (1)	Where the impact affects the environment in such a way that natural, cultural and social functions and processes are minimally affected.
	Moderate (2)	Where the affected environment is altered but natural, cultural and social functions and processes continue albeit in a modified way; and valued, important, sensitive, or vulnerable systems or communities are negatively affected.

Criteria	Rating Scales	Notes
	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 it is definite that 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)	
	Very low (0 to -12)	
	Low – positive (0 to 12)	

Criteria	Rating Scales	Notes
	Moderate – positive (13 to 24)	
	High–positive (37 to 48)	
	Very high – positive (49 to 66)	

Table 10-2: Explanation of Assessment Criteria

Criteria	Explanation
Nature	This is an evaluation of the type of effect the construction, operation, and management of the proposed development would have on the affected environment. Will the impact change in 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 of 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.

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

APPENDIX C: DISCLAIMER AND DECELERATION OF INDEPENDENCE

The opinions expressed in this Report have been based on site /project information supplied to GCS (Pty) Ltd (GCS) by Ecoleges and is 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.

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

The development of a 400 MW Solar Photovoltaic (PV) facility on the Remainder of Farm Goede Hoop 26C and Portion 3 of Farm Goede Hoop 26C, between De Aar & Hanover, Emthanjeni Local Municipality, Pixley Ka Seme District Municipality, Northern Cape Province, South Africa Hydrological Assessment

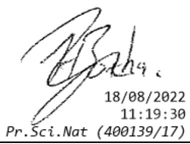
SPECIALIST INFORMATION

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)			
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:

01 September 2022

Date

CV OF SPECIALIST

Hendrik Botha

Snr. Hydro-geologist / Modeller

CORE SKILLS

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

DETAILS

Qualifications

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

Membership

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

Languages

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

Countries Worked In

- South Africa

PROFILE

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

Professional Affiliations:

SACNASP Professional Natural Scientist (400139/17)

Areas of Expertise:

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

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Work Experience

Period	Employer	Position	Role/ Responsibility
2014 - Current	GCS (Pty) Ltd	Snr. Hydrogeologist	Client liaison, client management, hydrology, geohydrology, hydropedology and geochemistry related work GCS Newcastle Office manager since July 2020.
2013	Centre for Water Science and Management at North-West University	Modeller	Hydrological rainfall-runoff modelling with EPA SWMM
2013	Chemistry Department at North-West University	Demonstrator	▫ Preparation of chemical agents used during experiments ▫ Demonstration of some chemistry principles to undergraduate students ▫ Helped students during experiments

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PROFESSIONAL EXPERIENCE

Scan here for full record

PROFESSIONAL EXPERIENCE - EARTH SCIENCES FIELD

Year	*Client*	*Project Description*	*Role / Responsibility*
Geochemistry, Waste Classification, Geochemical Modelling, Soil Chemistry and Water Chemistry Assessments			
2021	Modikwa Platinum	Modikwa Platinum Soil Study	Project Manager, Field Specialist, Reporting, Client liaison
2020	Tendele Coal (Pty)ltd	Somkhele Water & Geochemical Report	Project Manager, Field Specialist, Reporting, Client liaison
2019	Thalo Environmental	Waste Classification for the Fortuna WTW	Project Manager, Assessor, Reporting, Client liaison
2019-2020	Tendele Coal (Pty) Ltd	Area 9 (KwaQubuka Pit) Waste Evaluation & Risk-Based Approach Geohydrological Closure Assessment	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2019	Tendele Coal (Pty) Ltd	Geochemical Model Update for Somkhele Anthracite Mine	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2019	Buffalo Coal (Pty) Ltd	Aviemore Colliery Decant and Stream Loss Assessment	Project Manager, Modler, Analyst, Reporting, Client liaison
2019	Buffalo Coal (Pty) Ltd	Aviemore Colliery AMD Treatment Strategy	Project Manager, Modler, Analyst, Reporting, Client liaison
2018	Tendele Coal (Pty) Ltd	Geochemical Model Development for the Somkhele Anthracite Mine	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2016	Tendele Coal (Pty) Ltd	Somkhele Co-Disposal Assessment	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison

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GCS Water & Environmental Consultants

PROFESSIONAL EXPERIENCE

Scan here for full record

Year	Client	Project Description	Role / Responsibility
2015	Crest Choice Chicken	Potchefstroom Bottling Facility WQ Analysis	Interpretation and Analysis, Reporting
2015	Total Coal South Africa (TCSA)	Springbok Siding Soil Analyses	Interpretation and Analysis, Reporting
2015	Exxaro	(Malta Mine) Water Chemistry Analysis	Interpretation and Analysis, Reporting
2015	Tendele	AdHoc: Somkhele Sample Water Quality	Interpretation and Analysis, Reporting
2015	Hatch Goba	Mukulu Soil Analysis	Interpretation and Analysis, Reporting
2015	Northam Platinum	Soil Chemistry Interpretation	Interpretation and Analysis, Reporting
2015	Private Client	Soil Chemistry Analysis and Interpretation	Interpretation and Analysis, Reporting
2015	Molo	Molo Graphite Project Soil Analysis	Interpretation and Analysis, Reporting
2014	Estima	Soil and water chemistry analyses	Interpretation and Analysis, Reporting
2014	Kangra	Bokoni Platinum - Soil Monitoring	Interpretation and Analysis, Reporting
2014	Booysendal Mine	Soils, Land-Use and Land Capability Assessment for Booysendal Mine: Soil Chemistry Analysis	Interpretation and Analysis, Reporting
2014	Kangra	Longridge Soil Testing to identify Fertilizer Use: Soil Chemistry Interpretation	Interpretation and Analysis, Reporting
2017-ongoing	Tendele Coal (Pty) Ltd	Kinetic Column Leach Test Assessments for Mining Area 8 and Area 9 at the Somkhele Anthracite Mine	Project Manager, Field Specialist, Analyst, Reporting, Client liaison
Geohydrological, Hydrological and Hydropedological Assessments (EIA, WULA, BA, IWULA, EMP) - Groundwater Investigations, Numerical and Analytical Modelling Application, Floodline Modelling, CSWMP, Water Balances and Hydropedology			
2021	Wallace & Green	Izinga Eco Estate Floodline Update	Project Manager, Field Specialist, Reporting, Client liaison
2021	KSEMS Environmental Consulting	Dingo Animal Kingdom Floodline	Project Manager, Field Specialist, Reporting, Client liaison

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PROFESSIONAL EXPERIENCE

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Year	Client	Project Description	Role / Responsibility
2021	Mkhoba Trust	Mkhoba Trust water use license Application - Geohydrology Assessment	Project Manager, Field Specialist, Reporting, Client liaison
2021	Joseph Baynes Estate (Pty)ltd	Baynesfields Groundwater Supply	Project Manager, Field Specialist, Reporting, Client liaison
2020	Triplo4 Sustainable Solutions (Pty) Ltd	Karpowership SA - Geohydrological, hydropedology and hydrological assessments	Project Manager, Field Specialist, Reporting, Client liaison
2020	Green Door Environmental	Justin Lusso Poultry Farm - Geohydrology and Hydrological Assessments	Project Manager, Field Specialist, Reporting, Client liaison
2020	Metamorphosis Environmental Consulting	Proposed Shongweni Landfill Hydrological Assessment	Project Manager, Field Specialist, Reporting, Client liaison
2020	Green Door Environmental	Middeldrift Bulk Augmentation Hydrological and Hydropedological Assessment	Project Manager, Field Specialist, Reporting, Client liaison
2020	EnviroMatrix	Manyatseng Cemetery Geohydrological and Flood Line Assessment	Project Manager, Field Specialist, Reporting, Client liaison
2021	ECA Consulting	Hydrological study - Okhahlamba	Project Manager, Field Specialist, Reporting, Client liaison
2020	Wallace & Green	Glendale Sugar Mill Hydrology Assessment & Groundwater Numerical Model Development	Project Manager, Field Specialist, Reporting, Client liaison
2020	GIBB	Newcastle Cemetery (Roy Point) Expansion Geohydrological & Hydrological Assessment	Project Manager, Field Specialist, Reporting, Client liaison
2020	GIBB	Newcastle Cemetery (Roy Point) Expansion Hydropeoldogy Assessment	Project Manager, Field Specialist, Reporting, Client liaison
2019	Green Door Environmental	Hydrological Assessment for the Chep Weatherboard Dam	Project Manager, Field Specialist, Reporting, Client liaison
2019	Triplo4 Sustainable	Elaleni Hydropedology Assessment	Project Manager, Field

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PROFESSIONAL EXPERIENCE

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Year	Client	Project Description	Role / Responsibility
	Solutions (Pty) Ltd		Specialist, Reporting, Client liaison
2019	Green Door Environmental	Geohydrological Assessment for the Sani Pass Hotel Expansion	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2019	Green Door Environmental	Evergreen Hilton Retirement Village Geo hydrological Assessment	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2019	Cato Scrap CC	Cato Scrap Metal Facility Geohydrological Assessment	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2019	Green Door Environmental	Hydrogeological Assessment for the Goedgedacht Farm	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2019	ACER (Africa) Environmental Consultants	Hydrogeological Assessment for the Mtuzini Sewage Works	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2019	Tripo4 Sustainable Solutions (Pty) Ltd	Hydrogeological Assessment for the Sezela Mill Molasses Bladder Development Site	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2018	GIBB	Illovo Automotive Supplier Park (ASP) Geohydrological Assessment	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2018	Kangra Coal (Pty) Ltd	Numerical Groundwater Model update for the Maquasa East, Maquasa West and Nooitgezien mining operations	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2018	Tripo4 Sustainable Solutions (Pty) Ltd	Hydrogeological Assessment and Numerical Groundwater Model Development for the Illovo Noodsburg Sugar Mill	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison

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PROFESSIONAL EXPERIENCE

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Year	Client	Project Description	Role / Responsibility
2018	Zululand Anthracite Colliery (ZAC)	Hydrogeological Assessment and Numerical Model Development for the Deep E Opencast and New Mngeni Shaft operational areas.	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2018	Green Door Environmental	Hydrogeological Assessment for the Isandlwana Settlement Development	Project Manager, Field Specialist, Assessments, Reporting, Client liaison
2018	Green Door Environmental	Hydrogeological Assessment for the Rem 8532 Northington Farm Bottling Plant	Project Manager, Field Specialist, Assessments, Reporting, Client liaison
2018	EnvironMatrix	Hydrogeological Assessment for the Spilsbury Piggery	Project Manager, Field Specialist, Assessments, Reporting, Client liaison
2018	Tripo4 Sustainable Solutions (Pty) Ltd	Hydrogeological Assessment for the UCL Sugar Mill	Project Manager, Field Specialist, Assessments, Reporting, Client liaison
2018	Triplo4 (Pty) Ltd	Hydrogeological Investigation for the Noodsburg Sugar Mill	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2018	Green Door Environmental	Hydrogeological Assessment for the Burnlea farm, situated near Underberg.	Project Manager, Field Specialist, Assessments, Reporting, Client liaison
2018	EcoLeges	Hydrogeological Assessment for the Proposed Development of Chicken Farms near Klippan	Project Manager, Field Specialist, Assessments, Reporting, Client liaison
2018	EcoLeges	Hydrogeological Assessment for the E&T Abattoir	Project Manager, Assessments, Reporting, Client liaison
2017	Zinoju Coal (Buffalo Coal)	Numerical Groundwater Model Update for the Magdalena Colliery	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2017	Tendele Coal (Pty) Ltd (Somkhele Anthracite Mine)	Hydrogeological Investigation for KwqQubuka and Luhlanga Opencast Operations	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison

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PROFESSIONAL EXPERIENCE

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Year	Client	Project Description	Role / Responsibility
2017	Glencore	Numerical Groundwater Flow and Transport Model Development for the Lydenburg Smelter	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2017	Tripo4 Sustainable Solutions (Pty) Ltd	Hydrogeological investigation for the Illovo Eston Sugar Mill	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2017	Frame Knitting Factory	Hydrogeological investigation for the Frame Knitting Factory - As part of the WULA	Project Manager, Analyst, Reporting, Client liaison
2017	Royal HaskoningDHV - South Africa	Hydrogeological Assessment for the proposed Ballito Hills Development project	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2016	Tripo4 Sustainable Solutions (Pty) Ltd	Geohydrological Assessment for the Priority 1 Sewer Pipeline Development Project	Project Manager, Field Specialist, Assessments, Reporting, Client liaison
2016	Tongaat Hulett Developments (Pty) Ltd	Geohydrological Assessment for the Tinley Manor Development Project	Project Manager, Field Specialist, Assessments, Reporting, Client liaison
2016	Tongaat Hulett Developments (Pty) Ltd	Geohydrological Assessment for the Inyaninga Development Project	Project Manager, Field Specialist, Assessments, Reporting, Client liaison
2016	GIBB	Umzimkhulu WWTW Geohydrological Assessment	Project Manager, Field Specialist, Assessments, Reporting, Client liaison
2015	Magalela and Associates	Geohydrological Assessment Elandspruit	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2015	Tripo4 Sustainable Solutions (Pty) Ltd	Gledhow Sewer Pipeline Geohydrological Assessment	Project Manager, Field Specialist, Analyst, Reporting, Client liaison
2015	Ground Truth	Matuba Mall Geohydrological Assessment for WULA	Project Manager, Field Specialist, Analyst, Reporting, Client liaison
2015	Royal HaskoningDHV	Desktop Geohydrological Assessment for Sibaya Sewer Pump Stations	Project Manager, Field Specialist, Analyst,

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PROFESSIONAL EXPERIENCE

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Year	Client	Project Description	Role / Responsibility
			Reporting, Client liaison
2015	Anglo Gold Ashanti	AngloGold Ashanti VR, MWS and WW Salt Load Allocations per Source Facility Update	Project Manager, Field Specialist, Analyst, Reporting, Client liaison
2014	Anglo Gold Ashanti	Surface and Groundwater Monitoring Assessment	Reporting, Analyst, Reporting, Client liaison
2014	EIMS	De Wittekrans Groundwater Update and Hydrocensus	Field Specialist
2014	Kangra Coal (Pty) Ltd	Ballengeich Pollution Control Project	Project Manager, Field Specialist, Analyst, Reporting, Client liaison
2014	Kemafahla and Trading	Cornfields Geohydrological Assessment	Project Manager, Field Specialist, Analyst, Reporting, Client liaison
2014	Total Coal South Africa (TCSA)	Dorsfontein and Forzando Geohydrological Assessment	Project Manager, Field Specialist, Analyst, Reporting, Client liaison
2014	Sivest	Preliminary and Desktop Hydrogeological Assessment for the Msinga Local Municipality Landfill Site in the Pomeroy Area	Reporting
2014	Tripo4 Sustainable Solutions (Pty) Ltd	King Shaka Mall Geohydrological Assessment	Project Manager, Field Specialist, Analyst, Reporting, Client liaison
2014	Tripo4 Sustainable Solutions (Pty) Ltd	Steve Biko Housing Development Geohydrological Assessment	Project Manager, Field Specialist, Analyst, Reporting, Client liaison
2014-2016	Tendele Coal (Pty) Ltd	Somkhele Waste and Geochemical Management Plan	Project Manager, Field Specialist, Analyst, Reporting, Client liaison
2016-2018	Tendele Coal (Pty) Ltd	Area 1 Pit Lake Feasibility Assessment	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
Water Supply			

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GCS Water & Environmental Consultants

PROFESSIONAL EXPERIENCE

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Year	Client	Project Description	Role / Responsibility
2021	Joseph Baynes Estate (Pty)ltd	Baynesfields Groundwater Supply	Project Manager, Field Specialist, Reporting, Client liaison
2020	Wallace & Green	Izinga Eco Estate & Balito Hills Water Supply	Project Manager, Field Specialist, Reporting, Client liaison
2020	Triplo4	Siza Water Groundwater Supply & Geohydrological Evaluation	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
2018	MBB Projects	Groundwater Supply Investigation for the iSimangaliso Wetland Park	Project Manager, Analyst, Reporting, Client liaison
2018	MBB Projects	Groundwater Supply Investigation for the iSimangaliso Wetland Park	Project Manager, Analyst, Reporting, Client liaison
2016	Condor Construction (Pty) Ltd	Geohydrological Investigation and Drilling Feasibility for Mount Ayliff Police Station	Project Manager, Field Specialist, Analyst, Reporting, Client liaison
2015	Tendele Coal (Pty) Ltd	Somkhele Water Supply	Project Manager, Field Specialist, Reporting, Client liaison
2015	DWS	Rural Water Supply & Resource Management	Field Specialist
2016-2017	Focus Project Management	KZN Drought Relief Borehole Feasibility Study	Project Manager, Field Specialist, Modler, Analyst, Reporting, Client liaison
Water Monitoring			
2014 2016	Buffalo Coal	Buffalo Coal Water Monitoring	Field Specialist, Reporting
2018	Tripo4 Sustainable Solutions (Pty) Ltd	Groutville D Sanitation Programme - Water Monitoring	Project Manager, Field Specialist, Assessments, Reporting, Client liaison
2016	Tripo4 Sustainable Solutions (Pty) Ltd	Monitoring Plan for the Proposed Bhamshela Filling Station	Project Manager, Field Specialist, Reporting, Client liaison

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Year	Client	Project Description	Role / Responsibility
2014-2015	Total Coal South Africa (TCSA)	Steincoalspruit Colliery Water Monitoring for Closure	Project Manager, Field Specialist, Reporting, Client liaison
2016-2019	Tripo4 Sustainable Solutions (Pty) Ltd	Avon Peaking Power Plant Groundwater and Surface Water Monitoring	Project Manager, Field Specialist, Assessments, Reporting, Client liaison
2015-2019	Tripo4 Sustainable Solutions (Pty) Ltd	King Shaka Mall Monitoring Plan and Water Monitoring	Project Manager, Field Specialist, Reporting, Client liaison
2014-Ongoing	Tendele Coal (Pty) Ltd	Somkhele Anthracite Mine Water Monitoring	Project Manager, Field Specialist, Reporting, Client liaison
2019	Wallace & Green	Glendale Sugar Mill Groundwater Model	Project Manager, Field Specialist, Reporting, Client liaison
Hydropedological Assessments			
2019	Rokwil Civils	InyaningaSoil Pollution Study	Project Manager, Field Specialist, Assessments, Reporting, Client liaison
2020	GIBB AFRICA	Newcastle Cemetery Geohydrology & Hydropedology	Project Manager, Field Specialist, Assessments, Reporting, Client liaison
2020	EnviroPro	N12 Filling stations Geohydrological & Hydropedology	Project Manager, Field Specialist, Reporting, Client liaison
2020	Nemai Consulting	Duvha Power Station Seepage Drains Hydropedological Assessment	Project Manager, Field Specialist, Reporting, Client liaison
2020	KSEMS Environmental Consulting	Renishaw Hills Estate Hydropedology	Project Manager, Field Specialist, Assessments, Reporting, Client liaison
2020	Zimbali Coastal Resort	Hydropedology study	Project Manager, Field Specialist, Reporting, Client liaison
2020	KJS Developments	Msinsi Mews Hydropedology	Project Manager, Field Specialist, Reporting, Client liaison

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Year	Client	Project Description	Role / Responsibility
2020	Eco-Pulse Environmental Consulting Services	Langefontein Hydropedology	Project Manager, Field Specialist, Reporting, Client liaison
2020	Eco-Pulse Environmental Consulting Services	South Coast Stone Crushers Hydropedology	Project Manager, Field Specialist, Reporting, Client liaison
2020	Eco-Pulse Environmental Consulting Services	Widenham Development Hydropedology	Project Manager, Field Specialist, Reporting, Client liaison
2020	Triplo4 Sustainable Solutions	Glendow Sugar Mill Hydropedology	Project Manager, Field Specialist, Reporting, Client liaison
2020	Acer Africa	Mtunzini Development Hydropedology	Project Manager, Field Specialist, Reporting, Client liaison
2021	Modikwa Platinum	Modikwa Platinum Soil Study	Project Manager, Field Specialist, Reporting, Client liaison
2021	Thirsti Bottling Plant	Thirsti Hydropedology	Project Manager, Field Specialist, Reporting, Client liaison

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PAPERS / DISSERTATIONS: -

Year	*Title*	*Presented*
2013	*Hydrological Modelling of the Boskop Dam Catchment with SWMM (Thesis)*	*North-West University*
2015	Understanding Site Hydrology of the Northern Kwazulu-Natal Anthracite Coal Fields With Special Reference to Discard and Tailings Disposal Practices (Paper)	14th Biennial Groundwater Division Conference: From Theory to Action
2016	Geohydrological impact of co-disposed coal material into an opencast pit (Thesis)	North-West University
2018	Viability Of Converting A South African Coal Mining Pit Lake System Into A Water Storage Facility	ICARD 2018
2019	Evaluating Groundwater Availability Based on Land Cover and Local Hydrogeology - A Groundwater Balance Approach	*16th Groundwater Conference and Exhibition, Port Elizabeth, 20-23 October 2019.*
2021	Impact of Engineered Tree Plantations on Water Transfer through the Upper Vadose Zone and Implications on Vertical Groundwater recharge.	*17th Biennual GWD Groundwater Conference and Exhibition*

CONFERENCES/ TRAINING: -

Year	*Course/ Conference*
2015	14th Biennial Groundwater Division Conference: From Theory to Action
2015	Fire Prevention and Protection Training Course
2018	*International Mine Water Association (IMWA) - International Convention for Acid Rock Drainage (ICARD) Conference*
2019	*16th Groundwater Conference and Exhibition, Port Elizabeth, 20-23 October 2019.*

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2021	*Digital Soils Africa (DSA) Webinar - Hydropedology Requirements in South Africa*
2021	*17th Biennual GWD Groundwater Conference and Exhibition*

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DECELERATION

DECLARATION

I, **Henrik Botha** hereby declare that the details furnished above are true and correct to the best of my knowledge and belief and I undertake to inform you of any changes therein, immediately. In case any of the above information is found to be false or untrue or misleading or misrepresenting, I am aware that I may be held liable for it.

Signature: ______ Date: 28 February 2022