ZARA CAPITAL

Hydrological Assessment

LETHABO POWER STATION

HYDROLOGY AND FLOODLINE STUDY FOR THE PROPOSED 132KV POWERLINE FROM THE LETHABO PV PLANT TO THE RWB LETHABO SUBSTATION.

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HYDROLOGY AND FLOODLINE STUDY FOR THE PROPOSED 132KV POWERLINE FROM THE LETHABO PV PLANT TO THE RWB LETHABO SUBSTATION WITHIN METSIMAHOLO LOCAL MUNICIPALITY, FREE STATE.

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GLOSSARY OF TERMS

This section provides a catalogue of terms and definitions, which may be used in this report and, or other documents appended to the report. Where more than one definition for a term exists in the literature, additional definitions have been provided for clarity.

Table 1: Glossary of terms

Term	Definition
Catchment	A catchment defines an area within which water will naturally drain to a defined point.
Catchment Management Agencies	Catchment Management Agencies were created in terms of the National Water Act, 1998 (Act 36 of 1998) to manage water resources within defined major catchments.
Development	Means the building, erection, construction or establishment of a facility, structure or infrastructure, including associated earthworks or borrow pits, that is necessary for the undertaking of a listed or specified activity but excludes any modification, alteration or expansion of such a facility, structure or infrastructure, including associated earthworks or borrow pits, and excluding the redevelopment of the same facility in the same location, with the same capacity and footprint.
E10 to E90	A range of exceedance probability of events – this is the likelihood of a storm event of a certain magnitude being exceeded.
Floodlines	mean lines on a map or drawing depicting water levels likely to be reached by a flood having a specified recurrence interval;
Floodplain	means the land adjoining a watercourse which is susceptible to inundation by floods up to the one-hundred-year recurrence interval;
HEC-RAS	Hydrologic Engineering Center's River Analysis System software that allows the user to perform one-dimensional steady flow calculations, one and two-dimensional unsteady flow calculations, sediment transport/mobile bed computations, and water temperature/water quality modelling.
HEC-GeoRAS	HEC-GeoRAS is a set of procedures, tools, and utilities for processing geospatial data in ArcGIS using a graphical user interface (GUI). The interface allows the preparation of geometric data for import into HEC-RAS and processes simulation results exported from HEC-RAS.
Hydrology	Hydrology describes a field of study that analyses the natural cycles of water as it passes through the environment. Aspects analysed include rainfall, evaporation, transpiration and runoff. Hydrology also refers to the results of analysis of certain aspects of hydrological cycles, such as river flow, or likely peak floods.
MAE	Mean Annual Evaporation refers to the yearly average amount of water that evaporates from open water bodies, land and vegetation surfaces into the atmosphere.
MAP	Mean Annual Precipitation refers to the yearly average precipitation generally calculated from the last 30 years of data for a place or region.

Term	Definition
MAR	Mean Annual Runoff refers to the average amount of water that flows down a particular river, per year, expressed either as a depth (in millimetres) of water spread evenly across the entire drainage basin, or as a volume (in cubic metres) of water flowing past a given point.
Return Period:	Also known as a recurrence interval is an estimate of the likelihood of an event. This is the average interval between rainfall or flood events equalling or exceeding a specified severity.
Runoff	Surface runoff is defined as the water that finds its way into a surface water channel without infiltration into the soil and may include overland flow, interflow and base flow.
SDF	Standard Design Flood method specifically addresses the uncertainty in flood prediction under South African conditions.
WMAs	Water Management Areas. These are catchments defined by the Department of Water and Sanitation for the South African Province, they provide the framework within which water will be managed at regional or catchment level.

LIST OF ABBREVIATIONS / ACRONYMS

ARM	Alternative Rational method
DDF	Depth Duration Frequency
DEM	Digital Elevation Model
DWS	Department of Water and Sanitation
SDF	Standard Design Flood
MAE	mean annual evaporation
MAP	mean annual precipitation
MAR	mean annual runoff
Q_T	Flood peak for return period T
RMDWA	Rational method DWA
RMAL	Rational method Alternative algorithm
SAWS	South African Weather Services
T	Return Period
TIN	Triangulated Irregular Network
SDF	SDF method
WMA	Water Management Area
WUL	Water Use Licences
UPD	Utility Programs for Drainage

1 INTRODUCTION

1.1 BACKGROUND

DIGES Group appointed Zara Capital to undertake a technical Hydrological study and a 1:100-year floodline determination of the proposed 132KV powerline The Hydrological study encompasses the two proposed alternative powerline corridors. The proposed construction of the 132 kV powerline connects from the Lethabo Photovoltaic (PV) plant to the existing Rand Water Board (RWB) Lethabo power substation within the Metsimaholo Local Municipality, Free State.

The main Lethabo Power Station comprises six 618 Mega Watt (MW) coal-fired station production units. Each production unit consists of a boiler, a turbine and generator. The station is also termed a ZLED-station (Zero-Liquid-Effluent-Discharge) due to its nature as a closed system. This means that no water from the process leaves the power station premises, aided by an extensive water recycling and cleaning desalination program. The Lethabo PV Solar Energy Facility will increase the capacity by accommodating PV panels and associated facilities that will generate up to 75 MW hence there is a need to construct a powerline that transmits/ distribute electricity to the grid which is RWB Lethabo substation.

1.2 STUDY AREA

The authorised Lethabo PV Solar Energy Facility is situated on portion 1814 of Farm Bankfontein within the Mestimoholo Local Municipality, which forms part of the Fezile District Municipality. The power station is located east of Vijoensdrif and southeast of Vereeniging and is situated close to the Vaal River at the coordinates S26°44'24.94" and E27°58'29.89". Access to the proposed development site is provided directly from the R716 which runs parallel to the western boundary of the proposed site. **Figure 1**.

The proposed alternative powerline corridors are situated in the broader power station property of approximately 1000 ha on Eskom-owned land. Lethabo forms part of a designated industrial and mining land use zone surrounded by agricultural areas, which is the primary land use in the area. The Vaal River is the main ecological and agricultural support system for the area.

The proposed ± 4.5-kilometer 132 kV powerline will connect from the Lethabo PV Solar Energy Facility to the existing RWB substation. This also includes an additional 88 kV bay, with busbar extension and control plant at the existing Rand Water Board (Lethabo) Substation.

The study aims to determine 1:100-year floodlines for a succession of design storms at specific durations, within the proposed construction area. In addition, the study also assesses possible impacts and mitigation measures that the proposed powerline construction and activities have on the receiving environment, including the catchment and the built environment. The location of the study site is again shown in **Figure 1** below.

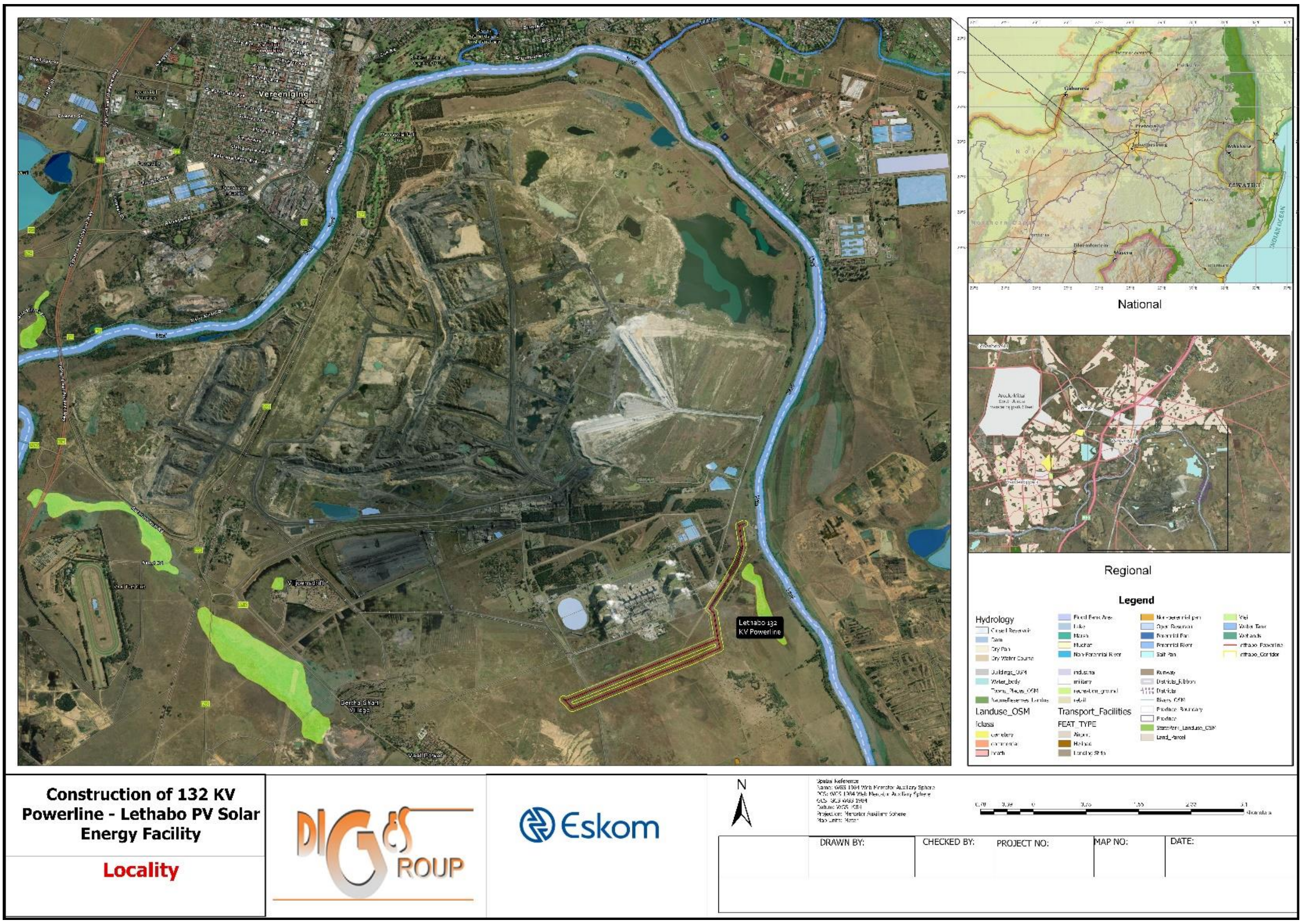

Figure 1: Locality map of the proposed 132 KV powerline

2 SCOPE OF WORK

The study included the following:

- **Baseline hydrology** - Undertake a detailed desktop assessment which includes, a review of all existing information for the project area including, mean annual runoff (MAR), mean annual precipitation (MAP), mean annual evaporation (MAE), catchment characteristics, topography, identification of surface water resources (rivers, drainage paths etc.) and storm rainfall depths for various recurrence intervals.
- **Flood line Determination** - Model a succession of design storms at specific durations and produce peak flows and determine flood lines indicating the areas that will be inundated during a 100-year flood event in the study area. This scope also includes the determination of flood risk and flood hazard throughout the study site.
- **Recommendation** - Recommend mitigation measures associated with the results of the hydraulic analysis.

3 HYDROLOGICAL ASSESSMENT

3.1 INTRODUCTION

To inform the impacts and risk assessments presented by the proposed study, an understanding of baseline hydrology is required. This section presents a comprehensive review of various information sources and defines the baseline climatic and hydrological conditions of the site and surroundings.

3.2 CLIMATIC CONDITIONS

3.2.1 Rainfall and Evaporation

Rainfall data was obtained from the Department of Water and Sanitation (DWS) online database, specifically from the Water Resources of South Africa 2005 Study (WR2005, 2009). The mean annual temperature within the Upper Vaal Water Management Area (WMA) ranges from 1°C to over 28°C in the northern and eastern parts, with maximum temperatures occurring in January (24°C to 30°C) and minimum temperatures in July (-2°C to 2°C), resulting in an average temperature of 25.5°C. Frost is a typical occurrence during winter, with an average of 30 to 50 frost days around the Lethabo Power Station.

The mean annual rainfall in the Upper Vaal WMA decreases uniformly in a westerly direction, with a predominantly seasonal pattern occurring mainly from October to April during the summer months, where there is over a 26% chance of a given day being a wet day. December and January are the peak rainfall months, with an average of 16.3 days receiving at least 96mm of precipitation during this period. Convective thunderstorms and hail accompany the rainfall, with December having the highest probability of 51%. The mean annual precipitation (MAP) varies from 500 mm in the plains zone to 1000 mm at higher elevations, with an average of 700 mm around the site.

Relative humidity is higher in summer than in winter, with February having the highest humidity (daily mean ranging from 65% in the west to 70% in the east) and August having the lowest (daily mean ranging from 55% in the west to 62% in the east). The average potential Mean Annual Gross Evaporation (MAE) is around 1,700mm in the western areas of the site.

Table 2 presents the regional hydrology based on data from the South African Weather Services (SAWS) and Department of Water and Sanitation (DWS) as per the selected weather stations used to characterize rainfall and evaporation at the site.

The rainfall station selected to represent the study site is SAWS station 0438734_W (VILJOENSDRIFT) which is located approximately 5.7 km southwest of the site with a rainfall record length of 94 years. The rainfall records show a mean annual precipitation (MAP) of 629 mm, which will be adopted for the site. **Table 2** presents the average monthly rainfall and evaporation data adopted for the site.

Table 2: Average Monthly Rainfall and Evaporation

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Rainfall (mm)	90	74	57	30	13	5.7	2.6	6.5	17.8	53.9	78.9	89.2	629
Lake Evaporation	198	197	209	198	170	161	129	180	87	97	135	168	1700

3.2.2 Return Period Rainfall Depths

Data taken from the four nearest rain stations measured from the central point of the site was used to estimate the 24-hour design rainfall depth using the Depth Duration Frequency (DDF) Rainfall Estimation (Smithers and Schulze, 2003). A summary of the input stations is presented in **Table 3**.

Table 3: Summary of weather stations used for generating rainfall Depth Duration Frequency (DDF) for the site.

Station Name	SAWS Number	Distance from the site (km)	Record length (years)	MAP (mm)	Altitude(m)
MACCAUVLEI	0438791_W	5.4	45.0	641.0	1442
VILJOENSDRIFT	0438734_W	5.7	94	629.0	1440
KLEIN-LEEUWKUIL	0438703_W	7.4	47.0	628.0	1430
RAND WATER-BOARD	0438731_A	7.6	28.0	673.0	1435
POWERVILLE	0438731_W	7.6	33.0	673.0	1435
VEREENIGING-LESLIE	0438760_W	8.0	36.0	682.0	1440

The Smithers and Schulze method of DDF rainfall estimation is considered more robust than previous single-site methods. WRC Report No. K5/1060 provides further detail on the verification and validation of the method. **Table 4** presents DDF rainfall estimates that were derived from the Smithers and Schulze method.

Table 4: Depth Duration Frequency Estimates for the site

Duration (m/h/d)	Rainfall Depth (mm)						
	1:2yr	1:5yr	1:10yr	1:20yr	1:50yr	1:100yr	1:200yr
5 m	8.6	11.4	13.4	15.2	17.7	19.5	21.4
10 m	12.5	16.7	19.4	22.2	25.7	28.4	31.1
15 m	15.6	20.7	24.2	27.6	32	35.4	38.7
30 m	19.8	26.4	30.8	35.1	40.7	45	49.3
45 m	22.8	30.4	35.5	40.4	46.9	51.8	56.7
1 h	25.2	33.6	39.2	44.7	51.8	57.2	62.7
1.5 h	29	38.6	45.1	51.4	59.6	65.9	72.1
2 h	32	42.7	49.8	56.8	65.9	72.8	79.7
4 h	37.6	50.2	58.6	66.8	77.5	85.6	93.7
6 h	41.4	55.2	64.4	73.4	85.2	94.1	103.1
8 h	44.3	59	68.9	78.5	91.1	100.7	110.2
10 h	46.6	62.2	72.6	82.8	96	106.1	116.1
12 h	48.7	64.9	75.8	86.4	100.2	110.7	121.2
16 h	52.1	69.4	81.1	92.4	107.2	118.4	129.6
20 h	54.9	73.1	85.4	97.3	112.9	124.7	136.6
24 h	57.2	76.3	89.1	101.6	117.8	130.1	142.5
1 d	49.6	66.1	77.2	88	102.1	112.8	123.5
2 d	60.9	81.3	94.9	108.1	125.5	138.6	151.7
3 d	68.8	91.7	107	122	141.5	156.3	171.2
4 d	74.4	99.2	115.8	132	153.1	169.2	185.2
5 d	79.1	105.5	123.1	140.3	162.8	179.8	196.9
6 d	83.1	110.9	129.5	147.5	171.2	189	207
7 d	86.7	115.6	135	153.9	178.5	197.2	216

3.3 HYDROLOGICAL SETTING

3.3.1 Introduction

South Africa is divided into 9 Water Management Areas (WMA), managed by separate water boards. Water Management Areas (WMA) are made up of quaternary catchments which relate to the drainage regions of South Africa, ranging from A – X (excluding O). These drainage regions are subdivided into four known divisions based on size.

For example, the letter A denotes the primary drainage catchment, A2 will represent the secondary catchment, A21 represents the tertiary catchment and A21D would represent the quaternary catchment, which is the lowest subdivision in the WR2005 manual. Each of the quaternary catchments has associated hydrological parameters including area, mean annual precipitation (MAP) and mean annual runoff (MAR) to name a few.

The proposed construction site falls in the Upper Vaal Water Management Area (WMA) which covers parts of the Free State, Gauteng, North West, and Mpumalanga provinces.

3.3.2 Regional Hydrology

The proposed construction area is situated within the quaternary catchment C22F, which has a gross total catchment area of 440 km^2 and a net mean annual runoff (MAR) of 11 mm^3. C22F receives runoff contributions from the upstream catchments of C22E, C22G, and C22L, which are all part of the Upper Vaal Water Management Area (WMA 5).

The primary river within the C22F catchment is the Vaal River, which is fed by the Klip River located upstream. The water quality within the Vaal River is variable, with areas of poor water quality in developed regions and better water quality in less developed areas. The land use within the C22F catchment encompasses a range of activities, including agriculture, extensive gold and coal mining, power generation, and industrial operations.

The average elevations at the eastern and western boundaries of C22F range from approximately 1843 m.a.s.l in the east to about 1275 m.a.s.l in the vicinity of the Vaal Barrage to the west. Along the proposed construction site, the elevation drops gradually to about 1489 m.a.s.l. Figure 2 indicates the hydrological setting of the proposed construction site.

Table 5 summarizes the surface water characteristics of the C22F quaternary catchment, including the Mean Annual Precipitation (MAP), Mean Annual Runoff (MAR), and Mean Annual Evaporation (MAE). These values were obtained from the Water Resources of South Africa 2018 Study (WR2018).

Table 2: C22F quaternary catchment

Quaternary Catchment	Catchment Area km^2	MAE (mm)	Evaporation Zone	Rainfall Zone	MAP (mm)	MAR (mm^3)
C22B	440	1700	5A	C	655	11.95

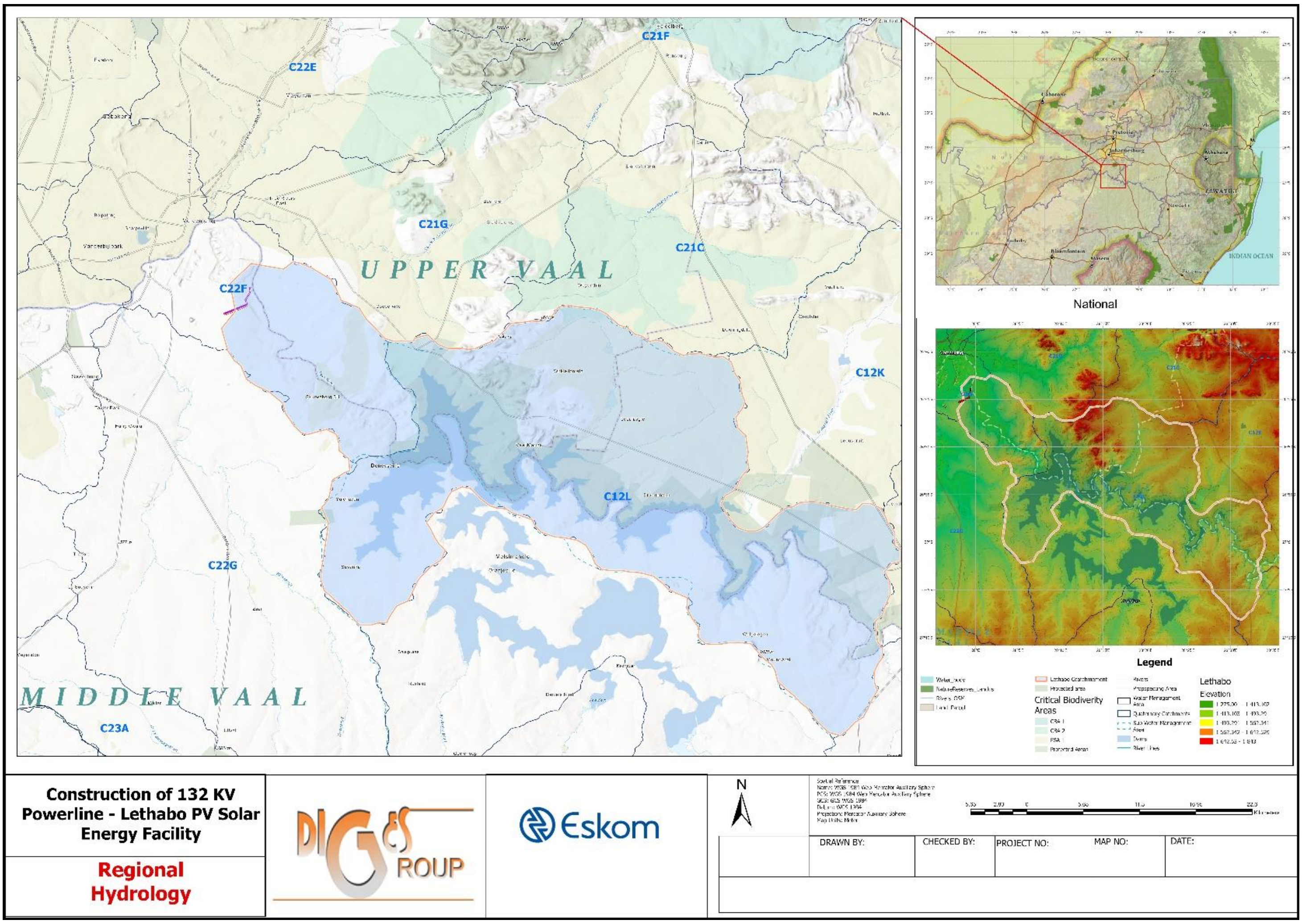

Figure 2: Regional Hydrology

3.3.3 Topography and Vegetation

The hydrogeomorphic setting is a channelled valley bottom formed by the Vaal River. The relief along the channelled valley bottom is gentle with a range of low hills and plains near the lower catchment as shown in **Figure 2.** It appears to display numerous floodplain characteristics with alluvial deposits and alternate flow paths within the system.

The Lethabo 132kV powerline forms part of the Dry Highveld Grassland Bioregion. The vegetation of the bioregion is predominantly grassland with scattered trees, shrubs, and rocky outcrops. The grasses are typically short and tufted, with species such as *Themada triandra* and *Eragrostis curvalva* being common. Trees found in the area include species such as *Acacia karoo, Searsia Lancea*, *and Dombeya rotundifolia.*

During the site visit, it was observed that a greater part of the floodplain's vegetation included short and long grasses with patches of clustered trees that include Acacia and Eucalyptus. The reed vegetation along sections of the Vaal River, however, absorbs particularly high rates of water to reduce sludge (sludge stabilization and dewatering) and mitigate environmental concerns. Agricultural activities on either side of the floodplain have resulted in changes in the topsoil, consequently resulting in the introduction of some invasive plant species.

Catchment	Vegetation around catchment streams		
1	 *Clusters of Eucalyptus trees along an access road along the proposed powerline corridor.*	 *Floodplain vegetation include grasses and scattered trees inundated by flood water along the southwestern end of the proposed construction site. Direction: Southwest.*	 *Cultivated land along the left bank of the Vaal River, with small clusters of trees. Direction: Southeast*

Figure 3: Typical Riparian Vegetation

4 FLOOD ASSESSMENT

4.1 INTRODUCTION

Watercourses and their associated floodplains can convey significant volumes of water under flood conditions. A floodplain is defined as an area susceptible to inundation by a 100-year flood, as indicated in **Figure 4** below.

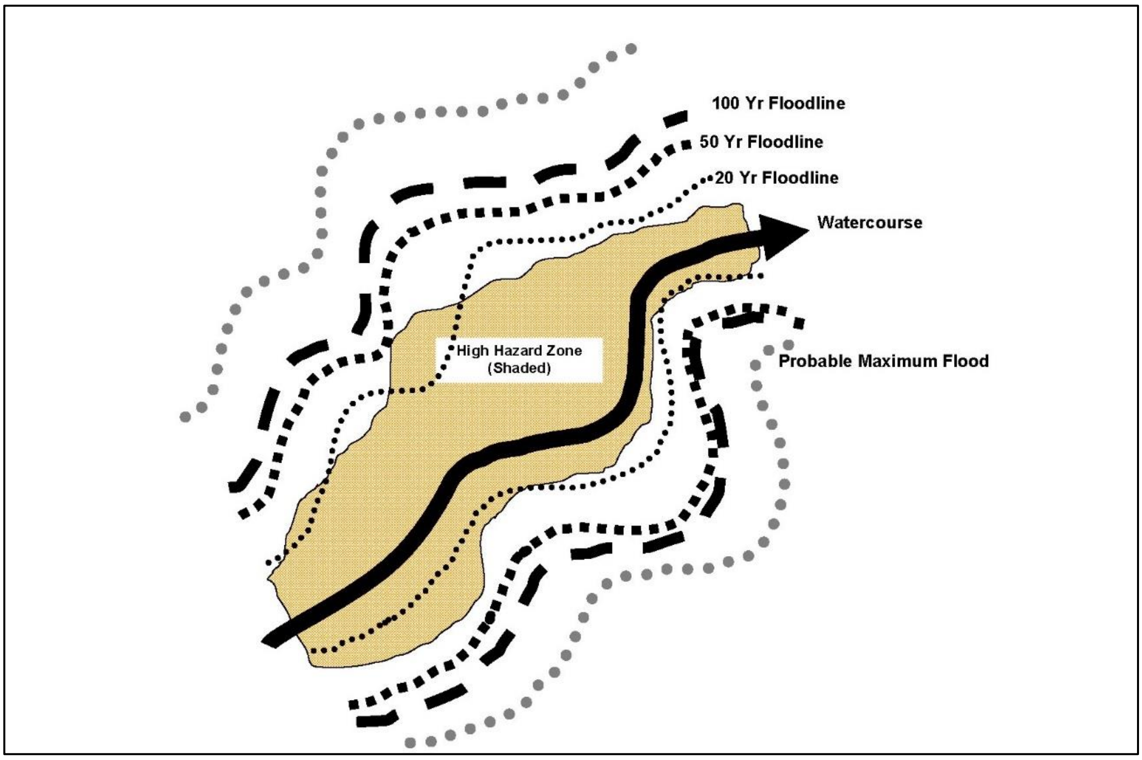

Figure 4: Schematic representation of floodplain depicting watercourse and significant floodlines.

The high-hazard zone within a floodplain, based on an analysis of the expected flow characteristics of the 100-year flood, is what will be determined and factored in the powerline design. The ability to ensure the stability of infrastructure is deemed seriously compromised under these conditions. The permissible extent and nature of land use, development or activities within floodplains must be subject to stringent evaluation and control in the interests of public safety. In particular, obstruction to the free flow of water within the 20-year floodline area shall not be permitted. However, between the 50 and 100-year floodlines, some developments or activities may be permitted, subject to such conditions as the authorities may in their discretion impose, while developments with particular evacuation or emergency response issues such as a powerline and other high-risk developments will only be permitted above the 100-year flood line.

4.2 METHODOLOGY

This section provides the methodology and inputs used to determine the 1:100-year floodlines and the model results. To inform flood-line modelling and the design of channel realignment and flood protection measures at the site, an understanding of the flood hydrology of the tributary that transverses the powerline is required.

The Vaal River is classified as perennial, and it is widely observed that surface water flow events occur seasonally and continuously throughout the site catchment. The flow characteristics of the river vary throughout its course, influenced by factors such as rainfall patterns, land use, and dam operations. Consequently, the recommended best practice methods for estimating flood magnitude are considered appropriate for accurately representing the flood hydrology in such a catchment. Various methods, including the Alternative Rational method (ARM), Standard Design Flood (SDF), and Regional Method Flood, have been utilized to estimate peak flows, with returns of over 100 m^3/s for a 1:2-year event. However, it is worth noting that significant flow occurrences have only transpired a few times in the last four decades. Thus, this flood hydrology study encompasses a review of both regional and local hydrological information, anecdotal evidence from historical flood events, and flow estimations utilizing regional methodologies for flood hydrology in ungauged catchments.

4.3 INPUT DATA SOURCES

A sub-catchment was delineated to cover the watercourses within the vicinity of the site and were utilised to determine the flood peaks for the 1: 100-year extreme event to define the flood risks.

4.3.1 Topography

The topography of the study area and surrounds is undulating with some relatively side floodplains and wetlands. The contour interval of this dataset is 1m, from this data a Digital Elevation Mode (DEM) was modelled and used further in the floodlines modelling.

The common land use in the proposed construction area is mostly agricultural and industrialized. The soil is of low to moderate infiltration and drainage characteristics. The proposed construction area is also characterized by a diverse amount of fringing riparian vegetation in combination with extensive areas of emergent and submerged vegetation – including reeds and grasses within the flood plains.

4.3.2 Sub-catchment Delineation

The following catchment was delineated based on the supplied 1m elevation contour lines and a Digital Elevation Model (DEM) database.

- **Catchment 1** is a part of Quaternary catchment C22F and includes the transfer zone (Zone 1) of the Vaal River. The catchment's upstream section of the Vaal River, which is approximately 23.88 kilometres, is considered for peak flow calculations. The Vaal Dam feeds the upstream section of the river. is important to consider the upstream section of the Vaal River when calculating peak flow, as it is directly affected by the inflows from the Vaal dam.
- The transfer zone (Zone 1) of the Vaal River is a critical area that plays a vital role in the overall hydrology of the catchment. Therefore, accurate peak flow calculations for this catchment are crucial for effective water resource management and flood control.

The sub-catchment is characterised by the peak flow calculations as detailed in the Drainage Manual (SANRAL, 2007). The values of each of these model parameter classes were then determined by professional subjective judgement/ discretion, and visual inspection of the terrain and fraction of the catchment. Catchment characteristics were evaluated and used to estimate the flood peaks for the identified catchment as detailed in **Table 6** below:

Table 3: Catchment Characteristics

Parameter	Catchment 1
Catchment area - km^2	1204.95
Mean annual precipitation – mm	655
Length of longest stream – km	23.88
Height difference along 10-85 slope -m	54
Average slope along the 10-85 - m/m	0.00302
SDF Basin	7

4.4 METHODOLOGY

The objective of this study is to determine the 1:100-year floodlines for the section of the Vaal River that transverses with the proposed powerline. The river is characterised by closed contours, which increase in depth from the perimeter to a central area of greatest depth and within which water will accumulate. Flood peaks for the catchment selected for flood modelling were estimated by the following methods: Using the Utility Programs for Drainage (UPD) software, 2007 with the methods detailed in SANRAL, 2013:

- Standard Design Flood Method (Deterministic)
- Rational Method (Deterministic)
- Alternative Rational Method (Deterministic)

4.4.1 Rational Method

This method is based on the conservation of mass and is applicable for catchment areas below 15 km^2. Aerial and time distributions of rainfall in this method are assumed to be uniform throughout the catchment. Flood peaks and empirical hydrographs can be determined by this method.

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

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

Where: Q = peak flow (m^3/s)

C = runoff coefficient (dimensionless)
I = average rainfall intensity over the catchment (mm/hour)
A = effective runoff area of the

4.4.2 Alternative Rational Method

This method is based on the rational method with the point precipitation being adjusted using the Design Rainfall Estimation Methodology developed by Smithers and Schulze (2003) to consider local South African conditions. This method can work for large catchments without any limitation.

The Smithers and Schulze method of DDF rainfall estimation is considered more robust than previous single-site methods. WRC Report No. K5/1060 provides further detail on the verification and validation of the method. Table 7 presents DDF rainfall estimates that were derived from the Smithers and Schulze method.

Table 7: Design Rainfall inputs to Alternative Rational Method (ARM) (TR102 Rainfall Data)

Weather Service station	OLIVINE						
Weather Service station no.	328726						
Mean annual precipitation	510 mm						
Coordinates	26° 55'S 28° 06'E						
Duration (m/h/d)	Return Period (Years)						
	2	5	10	20	50	100	200
1 d	49	68	82	96	118	137	157
2 d	62	87	107	128	158	184	213
4 d	68	94	115	136	167	193	221
7 d	84	118	144	172	211	243	279

4.4.3 Standard Design Flood

The Standard Design Flood (SDF) method is a flood prediction tool that was specifically developed to address the uncertainties associated with flood prediction in South African conditions. The method relies on historical data to adequately describe flood frequency relationships and replaces the runoff or discharge coefficient (C) with a calibrated value that is based on the subdivision of the country into 29 regions of Water Management Areas (WMAs).

One of the key advantages of the SDF method is its ability to work effectively for large catchments without any significant limitations. This is because the method considers the unique characteristics of each WMA, such as topography, geology, and land use, which can significantly impact the runoff coefficient.

The calibration of the SDF method is based on a thorough analysis of the historical flood records in each WMA, which enables the method to accurately predict flood levels and intensities for a range of return periods. This ensures that engineers and planners can make informed decisions about the design and construction of infrastructure projects, such as bridges, culverts, and stormwater management systems, which are critical for protecting communities and minimizing flood damage.

Overall, the SDF method is a highly effective flood prediction tool that has been extensively tested and calibrated to meet the unique challenges of flood prediction in South African conditions. Its ability to accurately predict flood levels and intensities for a range of return periods, combined with its applicability to large catchments, make it an invaluable resource.

The SDF method requires catchment area and slope in addition to the specification of the site as lying within SDF Basin number 7. The station information is summarized below:

Table 8: Rainfall Station in the study (Olivine)

Station No.	Latitude	Longitude	Record	MAP	MAE	M	R	C2	C100
	(°)	(°)	(Years)	(mm)	(mm)	(mm)	(d)	(%)	(%)
328726	28° 06′	26° 55′	45	510	1700	49	39	15	60

4.5 Peak Flow Estimates

The resulting peak flows from the catchment are presented in **Table 9**. It was decided to use the average of all methods for the flood modelling.

Table 9: Flood peaks

Catchment	Calculation Method	Return Periods	
		50	100
1	Rational Method (m^3/s)	811.32	1133.24
	SDF Method (m^3/s)	2505.22	3172.59
	Alternative Rational Method (ARM) (m^3/s)	691.65	1906.3

4.5.1 Recommended Flood Peak for the catchments.

The flood final flood peaks were calculated by applying the following arithmetic:

Q_T = [RMDWA + RMAL + SDF] / N

With:

Q_T = Flood peak for return period T
T = Return Period
RMDWA = Rational method DWA
RMAL = Rational method Alternative algorithm
SDF = SDF method
N = 3

The recommended flood peaks in cumec (cubic meter per second) at the site are listed. in **Table 10** below:

Table 10: Recommended Flood Peaks

Catchment	Return Period	
	1:50	1:100
1	1336.06 m^3/s	2070.71m^3/s

5 FLOOD MODELLING

5.1 Model Development

The hydrologic tools used allowed for the identification of sinks, determination of flow direction, calculation of flow accumulation, delineation of watersheds, and simulation of stream networks and flood models.

Development of the hydraulic model included the following steps:

- Creation of a TIN from the contour data.
- Digitizing the pan storage area polylines and flow paths using ArcGIS pro.
- Generating cross-sections approximately 10m apart through the storage area using ArcGIS Pro.
- Importing geometric data into HEC-RAS.

- Entering the Manning's values, peak flows, and storage and downstream slope boundary conditions in HEC-RAS.
- Performing steady, mixed-flow regime hydraulic modelling within HEC-RAS to generate flood levels at modelled cross-sections; and
- Importing flood levels and studying levels onto the TIN using HEC-GeoRAS to determine the flood inundation areas.

5.1.1 Choice of Software

HEC-RAS is a hydraulic program 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.

ArcGIS Pro is a GIS desktop mapping software that also provides methods for describing the physical components of a surface. The hydrologic tools allow you to identify sinks, determine flow direction, calculate flow accumulation, delineate watersheds, and create stream networks. And create flood models.

5.1.2 Topographic Profile Data

A Triangulated Irregular Network (TIN) from the 1-meter contour datasets forms the foundation for the ArcGIS Pro model and was used to extract elevation data for the stream profile together with the elevation points. However, the survey points only encompassed the northern bank The 1-meter contour lines were then derived from survey elevation points provided by the client. The TIN was also used to determine placement positions for the cross-sections along the stream and can be accurately modelled to the resolution of the provided topographical data.

5.2 FLOODLINES

As noted, the floodlines extent coarsely determine from the 1-meter contours will overtop the floodplains and some of the cultivated land around the proposed construction sites. This results in a wider floodline towards the northern banks of the site tributary (Catchment 1).

It is important to note that the floodlines determination methodology used is conservative and considered a worst-case scenario given up to a 1:100-year flood peak. The 1:100-year floodlines are indicated on **Figure 5-1**:

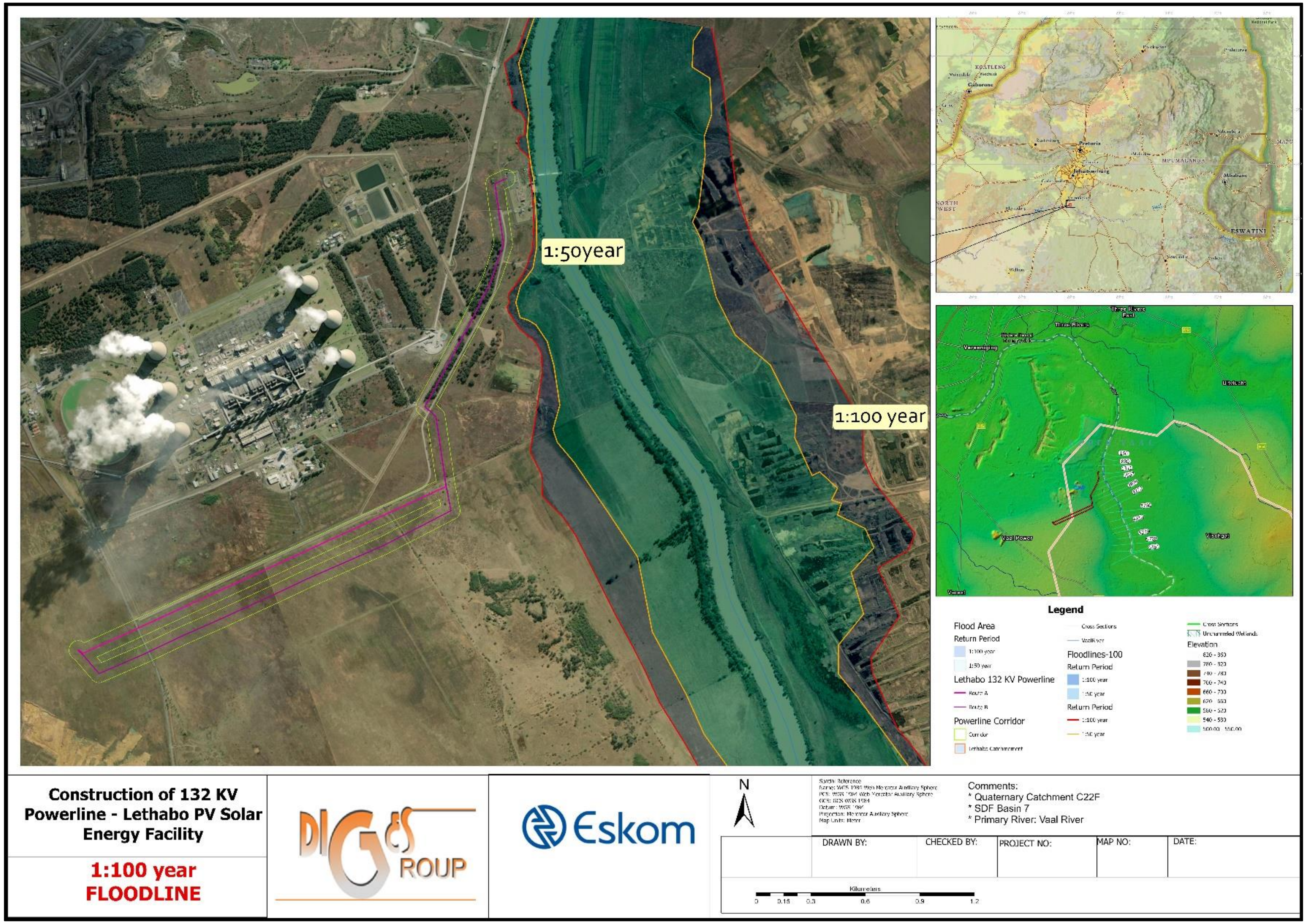

Figure 5-1: 1:100-year floodline for Catchment 1 of the Lethabo 132 KV Powerline

6 IMPACT ASSESSMENT

6.1 INTRODUCTION

Informed by the baseline hydrology and study description, the potential impacts of the proposed activities which may impact the surrounding land use and environmental resources are discussed in this section.

The Impact Assessment process is not to provide an incontrovertible rating of the significance of various aspects but to provide a; structured, traceable, and defendable methodology of rating the relative significance of impacts in a specific context. This gives the study proponent a greater understanding of the impacts of the proposed construction and the issues which need to be addressed by mitigation and gives the regulators information on which to base their decisions.

6.1.1 Impact Rating

The impact rating process is designed to provide a numerical rating of various environmental impacts identified by the use of the Input-Output model.

The equations and calculations were derived using Aucamp (2009).

The significance rating process follows the established impact/risk assessment formula:

$$Significance = Consequence\ x\ Probability$$

$$Where\ Consequence = Severity + Spatial\ Scale + Duration$$

$$And\ Probability = Likelihood\ of\ an\ impact\ occurring$$

The matrix calculates the rating out of 147, whereby severity, spatial scale, duration, and probability are each rated out of seven. The weighting is then assigned to the various parameters for positive and negative impacts in the formula. Impacts are rated before mitigation and again after consideration of the mitigation measure proposed in the EMP.

6.2 IMPACT ASSESSMENT AND MITIGATION MEASURES

The impacts of the construction of the proposed power line and infrastructure are assessed based on the impact's magnitude, as well as the receptor's sensitivity, culminating in impact significance for the most important impacts that require management.

The following activities are likely to have significant impact on surface water during the construction phases:

- Wetland and floodplain soil erosion enhanced by the construction process: Clearing or removal of vegetation leaves the soils prone to erosion during rainfall events, and as a result runoff from these areas will be high in suspended solids increasing turbidity in the natural water resources.
- Temporary impedance of surface water flow during construction.
- Hydrocarbon contamination on surface water during construction of the proposed Power line
- Debris run off into the catchment streams.

- Emergence of alien invasive fauna, post construction

The proposed study design includes various mitigation and design measures. Theoretically without these measures the drainage impacts on the environment would be much higher.

There are moderate pressures on the water resources of the site catchment from the utilization of groundwater and surface water systems. The catchment wetland system suffers from erosion and sedimentation, undesirable plant species and aquatic fauna infestations. Artificial drainages have become prominent due to exacerbated power leakages into the channels. Judicious planning and management are required to ensure equitable allocation of the available water resources and that the water resource is not depleted nor polluted. In addition, it is necessary to plug artificial drainage channels created by development or historical mining practices to drain wetland areas from other land uses such as heavy industries and residential areas.

Water quality however remains at risk of impacts in the catchment of the proposed construction. In terms of potential surface water quality, water overflow could prove catastrophic as the area is part of a greater wetland system.

The potential unmitigated impacts (unrealistic worst-case scenario), and residual water impacts of the study after considering the design mitigation measures proposed are qualitatively assessed in this section and presented together with the proposed mitigation in **Table 11.**

All measures implemented for the mitigation of impacts should be regularly reviewed as best practice and as compliance with various licences issued on site by authorities including Water Use Licences (WULs).

Table 11: Rating of potential impacts

Impact	**Pre-mitigation:**						**Recommended mitigation**	**Post-mitigation:**				
	Duration	**Extent**	**Intensity**	**Consequence**	**Probability**	**Significance**		**Duration**	**Extent**	**Intensity**	**Probability**	**Significance**
Water pollution from powerline running adjacent to the line and Tributary.	Long term	Local	Highly negative	Slightly detrimental	likely	negative	- Use dust suppressants like water where appropriate to reduce dust during construction - Ensure erosion control measures are in place and collect eroded water for settling from the construction sites - Prevent water from flowing through the areas under construction by temporary diversion as well as undertaking the work in the dry season if possible - Maintenance is required for the existing power line to reduce the impact of unchanneled flow into the channel.	long term	Limited	Low - negative	probable	Negligible - negative

Impact	Pre-mitigation:						Recommended mitigation	Post-mitigation:				
	Duration	Extent	Intensity	Consequence	Probability	Significance		Duration	Extent	Intensity	Probability	Significance
Wetland and flood plain pollution and erosion	Medium to long term	Local to regional	Moderate to high	Moderate	Likely	Moderate	According to Wetland NFEPAs or portions thereof should not be drained or filled in. - Cut-off drains should be in such a way that the zone of influence (the area affected by the drain – these drains divert surface and sub-surface flow in a certain direction, and lead to drawdown over a wide area) is well away from any wetland NFEPA. The area of influence should be determined by a Hydrogeologist. - No roads should be constructed through or around more than 20% of the edge of wetland NFEPA or their buffers. - No land-user should drain or cultivate any wetland or area within the flood zone of any watercourse (including its buffer), except in terms of a written permit in terms of the National Water Act. - The diversion of natural stormwater runoff away from wetland NFEPA and into a stormwater management system should be avoided wherever possible.	Short to long term	Limited	Low negative	Improbable	Negligible

Impact	Pre-mitigation:						Recommended mitigation	Post-mitigation:				
	Duration	Extent	Intensity	Consequence	Probability	Significance		Duration	Extent	Intensity	Probability	Significance
Sedimentation and siltation of the Vaal River Water course	Beyond study life	Potential to extend across site and nearby water resources	Moderate - high	Moderate - high	Likely	Negative	- Erosion control: One of the main causes of sedimentation and siltation is soil erosion, which can be caused by factors such as land development, deforestation, and agriculture. Implementing measures such as the use of vegetation, soil stabilization techniques, and stormwater management systems can help reduce erosion and sedimentation. -Silt curtains: Prevent sediment from spreading. They can be used during construction, dredging operations, or other activities that may disturb sediment. Drip trays must be used to capture any oil leakages. Servicing of vehicles and machinery should be undertaken at designated hard park areas. Any used oil should be disposed of by accredited contractors.	Short term	Localized to downstream	Low	Probable	Negligible

Impact	Pre-mitigation:						Recommended mitigation	Post-mitigation:				
	Duration	Extent	Intensity	Consequence	Probability	Significance		Duration	Extent	Intensity	Probability	Significance
Hydrocarbon contamination on surface water during construction of the proposed Power line	Beyond study life	Across the site and wetlands	Low - negative	Moderate to low	Likely	Moderate - negative	- The hydrocarbon and chemical storage areas and facilities must be located on hard-standing area (paved or concrete surface that is impermeable), roofed and bunded in accordance with SANS1200 specifications. This will prevent mobilisation of leaked hazardous substances. The vehicles should regularly undergo maintenance. - Ensure that the construction and service vehicles are fitted with drip trays - Where the storage of materials is on site, the storage areas should be on bunded, hard surfaces with collection points. -Use non-toxic materials: Use non-toxic materials for construction, such as non-toxic lubricants and hydraulic fluids, to reduce the impact on the environment	construction Life cycle	Limited	low	Unlikely	Negligible

Impact	Pre-mitigation:						Recommended mitigation	Post-mitigation:				
	Duration	Extent	Intensity	Consequence	Probability	Significance		Duration	Extent	Intensity	Probability	Significance
Temporary impedance of surface water flow during construction.	Short term	Local	Moderate - negative	Moderately detrimental	Highly probable	Minor - negative	- Ensure that the identified river crossings by the road or river have the bridges/culverts of sufficient capacity to drain in extreme design flood events -ensure that the construction of the proposed powerline is carried out during dry periods where there is no storm flow, alternatively done in phases to allow temporary diversion of flow during construction -Ensure that even small drainage channels are identified and incorporated to design sufficient capacity.	Short term	Local	Moderate - negative	Highly probable	Minor - Positive

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7 LIMITATIONS AND FURTHER WORK

It is recommended that the hydraulic gradients and channel sizes are checked during the detailed design of channels. The requirement for, and design of, in-channel velocity control measures should be confirmed during the detailed design of the channels and culverts.

8 MONITORING PROGRAMME

8.1 MONITORING PROGRAM

A monitoring programme is essential as a tool to identify any risks of potential impacts as they arise and to assist in impact management plans by assessing if mitigation measures are operating effectively. Monitoring should be implemented throughout the design in the site area.

8.2 MONITORING

Recommendations on surface water monitoring are presented in Table 12-1 below.

Table 12-1 : Surface Water Monitoring Programme

Monitoring Element	Description	Frequency
Water quality	Ensure that monitoring is implemented to cover all activity areas. Analytical suites for water quality analysis recommended include full chemical analysis including Volatile organic carbons and heavy metals.	Monitoring needs to carry on at least 3 years after the project has ceased, as is standard or best practice to detect residual impacts.
Pollutants	Site walkovers to determine the condition of facilities and identify any leaks or overflows, blockages, overflows, and system malfunctions for immediate remedial action	Weekly

8.2.1 Reporting

Reporting on the above monitoring should be as follows:

- Internal Reporting – Monthly
  - Drainage Inspections
  - Pollutant Inspections
- External Reporting – Annual:
  - Water Quality

  - Spillages / Emissions
- Accidental spillages should be reported as when they occur to the relevant authorities.

9 RECOMMENDATIONS

9.1 RECOMMENDATION

The following are recommended:

1. As can be seen from the Floodline map, the line will be constructed outside the Flood line therefore an approval either in form of Generation Water Authorisation or Water Use Licence is subject to compliance in terms of the National Water Act (Act 36 of 1998).
2. Use best management practices for erosion and sediment control: Implement best management practices for erosion and sediment control, such as silt fences, sediment basins, and sediment traps. This will help to prevent soil erosion and sedimentation into the river during construction.
3. Runoff from dirty areas should not be allowed to flow into the stream, unless DWS discharge authorisation and compliance with relevant discharge standards as stipulated in the NWA is obtained.
4. Prevent water from flowing through the areas under construction by temporary diversion as well as undertaking the work in the dry season if possible.
5. Use non-toxic materials: Use non-toxic materials for construction, such as non-toxic lubricants and hydraulic fluids, to reduce the impact on the environment.
6. Remove alien invasive plants, along the floodplains (catchment 1), to encourage channelled drainage.
7. Minimize the clearing of vegetation: Clear only the minimum amount of vegetation required for the construction of the powerline. This will help to minimize the impact on the ecosystem and reduce soil erosion and sedimentation into the river.
8. Construction of the proposed powerline is carried out during dry periods where there is no storm flow, alternatively done in phases to allow temporary diversion of flow during construction.
9. Ensure that even small drainage channels are identified and incorporated to design sufficient capacity.
10. Ongoing surface water monitoring is imperative during all phases of the project life and post closure to allow for early detection of potential contaminants that may cause unforeseen negative impacts on the receiving environment.

9.2 CONCLUSION

A study was conducted to determine the 1:100-year floodlines for a proposed powerline in the Mestimoholo Local Municipality, part of the Fezile District Municipality in South Africa. The study used rainfall data obtained from the Department of Water and Sanitation's online database and estimated flood peaks using various methods.

The Lethabo PV solar energy facility is situated within the C22F quaternary catchment, which receives runoff from contributions from the upstream catchments C22E, C22G, and C22L. The primary river within the site catchment is the Vaal River, which is fed by the Vaal Dam located upstream. These peak flows were utilized for hydraulic modelling as input flows within the HEC-RAS model. Modelled floodlines indicate that the existing and proposed infrastructure, including the additional expansion area, lie outside the floodwater way for both the 1:50-year and 1:100-year flood events.

The recommended flood peaks for the 1:50-year and 1:100-year flood events were 1336.06 and 2070.71 cubic meters per second, respectively. It has been noted that the flood levels within the catchment do not encroach into the existing built environment or the proposed power line. However, the Vaal River segment that transverses the proposed power line floodlines is wider across the pediment with a North-eastern pediment (upstream). The Floodlines encroach the flood plain upstream of the proposed power line. Therefore, it is recommended that the placement of any future additional infrastructure should be outside the modelled 1:100-year floodlines.

The proposed project poses potential environmental risks associated with sedimentation and siltation of nearby surface waterbodies due to eroded disturbed soils. Additionally, potential contamination from hydrocarbon and hazardous chemical spillages and leaks may impact water resources. However, despite these impacts, the project is unlikely to result in significant impacts on the receiving watercourse.

In conclusion, the study has determined the 1:100-year floodlines for the proposed solar energy facility and powerline in the Mestimoholo Local Municipality. The recommended flood peaks for the 1:50-year and 1:100-year flood events were 1336.06 and 2070.71 cubic meters per second, respectively. Although the project poses potential environmental risks, it is unlikely to result in significant impacts on the receiving watercourse. It is recommended that any future additional infrastructure should be located outside the modelled 1:100-year floodlines from the edge of the Vaal River.

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ANNEXURE A SPECIALIST CV

Tenisia Rugora Chidzurira

A resourceful and highly skilled Civil Engineering Technologist with 16 years of experience.

+27 82 291 2091 teewashe@gmail.com LinkedIn Profile

SKILLS COMPETENCY:

SOFT SKILLS:	HARD SKILLS:
• Project Management Analytical thinking • Problem-solving skills • Customer Service • Planning and Organizing	• Infrastructure Assessments and Recommendations • Civil 3D, AutoCAD • Microsoft Project • Civil Design • Hydrological Modelling with HEC-RAS, HEC-SSP

QUALIFICATIONS, EDUCATION, AND TRAINING:

1999 Advanced level (Equivalent to Matric), Nyashanu High School

2006 B. Engineering (Honours) (Civil and Water Engineering), National University of Science and Technology

PROFESSIONAL COURSES/ TRAINING:

• Health & Safety Representative Course, Educlaw, Safety Solutions- 2007	• TechnoCAD training (Roadmate, Pipemate, Watermate and Surfmate), Technocad Training Center- 2015

• Civil 3D, Modena Training Center, Midrand- 2008 • AutoCAD In-House Training / Senapelo Consulting Engineers- 2008 • EMESA Conference- 2014 • Civil Designer Roads and Stormwater Certificate, Civil Designer South Africa - 2014	• ECSA Assessor/ Moderator Training, Engineering Council South Africa -2018 • GCC/ FIDIC/ NEC Contracts Training, Alusani Skills and Training Center -2019 • Program In Project Management, University of Pretoria (Enterprise) – 2018

PROFESSIONAL REGISTRATION:

- Engineering Council South Africa (201470237).

PROFESSIONAL EXPERIENCE AND CAREER PROGRESSION:

Corporate Governance and Traditional Affairs

Corporate Governance and Traditional Affairs is a functional and developmental local government system that delivers on its Constitutional and legislative mandates within a system of cooperative governance.

Position	Duration
Technical Expert	**1 January 2020- 10 Jan 2023**
Municipal Infrastructure Support Agent (Misa)	**March 2019 – December 2019**

Main Responsibilities as Technical Expert:	**Main Responsibilities as Municipal Infrastructure Support Agent (MISA):**
• Advising on infrastructure delivery • Implementation Plans for the infrastructure projects • Site inspections for roads, sports facilities, water, sewer, and stormwater projects	• Reviewing the designs for MISA Projects – Bokwe Water Project, Bokwe Sewer Project, eMondlo Sewer Treatment Works Upgrade

• Design reviews on service providers' submissions • Mentoring technical officials within municipalities • Compiling Operations and Maintenance Plans for infrastructure (roads, water, and sanitation infrastructure) • Advising on operations and maintenance of infrastructure • Advising on designs and programs submitted by service providers	• Supporting Zululand District Municipality and Abaqulusi Local Municipality on Municipal Infrastructure Grant Projects and all Infrastructure Projects • Design Reviews • Contracts Management

Civil Engineer (June 2015 – February 2019)

Shumba Engineering Services

Shumba Engineering Services is a consulting engineering company with offices in Limpopo and Gauteng.

Main Responsibilities: • Lehlokwaneng/ Tswaing Access Bridge – Pavement Design. • Mokwakwaila Youth Centre – Water and Sewer Services Design. • Polokwane High Court – Water and Sewer Services Design review	• Phalaborwa 5 Special Services Refurbishment of Services and State Houses- Design review • Lulekani Magistrate Offices - project management and • Project management on Department of Education School Infrastructure

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Senapelo Consulting Engineers

Senapelo Consulting Engineers is a wholly Black-owned, civil and construction engineering consulting firm based in South Africa.

Position	Duration
Office and Projects Manager/Engineer	**January 2011 – May 2015**
Projects Engineer	**January 2009 – December 2010**
Projects And Design Engineer	**July 2008- December 2008**

Main Responsibilities as Office and Projects Manager: • Responsibilities	• Compiling progress reports, Engineer's claims, and Contractor's certificates.

● Directly managing a staff complement of 19. ● Representing the company to 6 clients. ● Overseeing total management of geotechnical studies for water tank foundations, hydrological studies, topographic surveys, and site investigations. ● Conducting concept-designing alternative schemes. ● Compiling technical and designing reports. ● Compiling detailed designs, preparing documents, tendering processes, and evaluating and overall project management.	**Main Responsibilities as Projects Engineer:** ● Designing and managing projects. ● Road D3507, Upgrading from gravel to tar. **Main Responsibilities as Design Engineer:** ● Designing projects. ● Compiling documentation. ● Compiling payment certificates. ● Liaising with clients.

EMPLOYMENT HISTORY CONTINUED

ORGANISATION	POSITION	DURATION
Aganang Bohle- Lonerock Construction	Assistant Site Engineer	February 2008- June 2008
Kuchi (Pty) Ltd	Site Engineer	September 2006 – December 2007
Ministry Of Transport And Communication	Assistant Resident Engineer	January 2005 –August 2006
Murray & Roberts (Pty) Ltd	Student Engineer	September 2003 –June 2004

****References and further information supplied upon request.**