Appendix H.14

SURFACE WATER ASSESSMENT

WSP

STORMWATER MANAGEMENT PLAN FOR THE PROPOSED DALMANUTHA WIND ENERGY FACILITY

WSP

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MAY 2023

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STORMWATER MANAGEMENT PLAN FOR THE PROPOSED DALMANUTHA WIND ENERGY FACILITY

WSP

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WSP

STORMWATER MANAGEMENT PLAN FOR THE PROPOSED DALMANUTHA WIND ENERGY FACILITY

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CONTENTS

TABLES

FIGURES

APPENDICES

APPENDIX A

DESIGN RAINFALL VALUES FOR DALMANUTHI WEF

APPENDIX B

RATIONAL METHOD ALTERNATIVE 2 FOR DALMANUTHI WEF

APPENDIX C

RATIONAL METHOD ALTERNATIVE 3 RESULTS FOR THE DALMANUTHI WEF

APPENDIX D

SDF RESULTS FOR THE DALMANUTHI WEF

APPENDIX E

DOCUMENT LIMITATIONS

Acronyms

DWS	Department of Water and Sanitation
ECO	Environmental Control Officer
EIA	Environmental Impact Assessment
GIS	Geographical Information System
HEC-HMS	Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Center's (CEIWR-HEC) River Analysis System
MAP	Mean Annual Precipitation
MAT	Mean Annual Temperature
OHL	Over Head Lines
PV	Photovoltaic
QC	Quaternary Catchment
SWAT	Soil & Water Assessment Tool
SAWS	South African Weather Service
SWMP	Storm Water Management Plan
UPD	Utility Programme for Drainage
WEF	Wind Energy Facility
WMA	Water Management Area
WULA	Water Use License Application

EXECUTIVE SUMMARY

Dalmanutha Wind (Pty) Ltd and Dalmanutha West Wind (Pty) Ltd are respectively proposing the development of commercial Wind Energy Facilities (WEFS), namely, Dalmanutha WEF and Dalmanutha West WEF, and their associated infrastructure on a site located approximately 12km south-southeast of Belfast, within the Emakhazeni Local Municipality and the Nkangala District Municipality in the Mpumalanga Province. Two alternatives are proposed for the Dalmanutha WEF: Alternative 1 - a full wind energy facility, with a capacity of up to 300MW, comprising up to 70 wind turbines; and Alternative 2 - a hybrid facility, with a capacity of up to 300MW, comprising 44 turbines and two solar fields. This report documents the Surface Water Specialist Study required for the proposed Dalmanutha WEF. The study aims to facilitate the protection of surface water resources and covers the total proposed development area. This report serves to support the Environmental Impact Assessment (EIA) process and has been completed in accordance with Appendix 6 of the EIA regulations for specialist reports. All the stormwater impacts that exist can be managed in a practical and cost-effective manner on site. The moderate rainfall and low gradients of the area suggest that the Detailed Design should not vary significantly from the surface water management concepts presented in this report. The Stormwater Management Plan (SWMP) was created considering the findings from the analysis undertaken as part of this study and presented in this report but should be developed further for Detailed Design by conducting a detailed topographic survey and developing the stormwater layout on the information available and infrastructure layout. It is recommended that the Dalmanutha WEF be authorized as the surface water impacts are minimal and the predicted level of change is acceptable. To avoid, manage and mitigate surface water impacts, the interventions in the SWMP should be included in the Environmental Management Program (EMPr) for the activity for both the construction and operational phases.

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1 INTRODUCTION

1.1 PROJECT BACKGROUND AND DESCRIPTION OF THE ACTIVITY

WSP was appointed by Dalmanutha Wind (Pty) Ltd to develop a Stormwater Water Management Plan (SWMP) for the proposed development of the Dalmanutha WEF. Two alternatives are proposed for the Dalmanutha WEF: Alternative 1 - a full wind energy facility, with a capacity of up to 300MW, comprising up to 70 wind turbines; and Alternative 2 - a hybrid facility, with a capacity of up to 300MW, comprising 44 turbines and two solar fields. The layout of the development area is shown in Figure 1-2.
The SWMP will inform the Environmental Management Programme (EMPr) for the Environmental Impact Assessment (EIA) application to the Department of Forestry, Fisheries, and the Environment (DFFE). This report has been developed in compliance with Appendix 6 of the National Environmental Management Act (NEMA) (Act 107 of 1998) EIA regulations.

1.2 AIMS AND OBJECTIVES

The aim of this report is firstly to protect surface water resources in accordance with the National Water Act (NWA) (Act 36 of 1998) and secondly to minimize impacts to the natural hydrology of the region by the proposed development by applying appropriate environmental management tools (NEMA).

The objective of this report is to design a conceptual SWMP that protects surface water resources, manages erosion risks, and complies with the relevant regulations and guidelines (listed in Section 3.3) for the construction and operation phases of the Dalmanutha WEF.

1.3 SCOPE OF WORK

The scope of work of this project includes but not limited to the following:

- Review available Geographical Information Systems (GIS) data to identify areas of interest.
- Review the latest Dalmanutha WEF layout as supplied by the Client.
- Provide recommendations and management/design criteria for the construction and operational phases of the project in consideration of:
  - Risks to watercourses;
  - Presence of natural and proposed drainage systems;
  - Surface flow across the site during low and high rainfall events;
  - Storage requirements for potentially hazardous substances;
  - General stormwater management of the site and pollution mitigation and management; and
  - Erosion control.

The SWMP is a conceptual study at this stage, and a detailed survey and SWMP study will need to be undertaken during the detailed design of the required infrastructure.

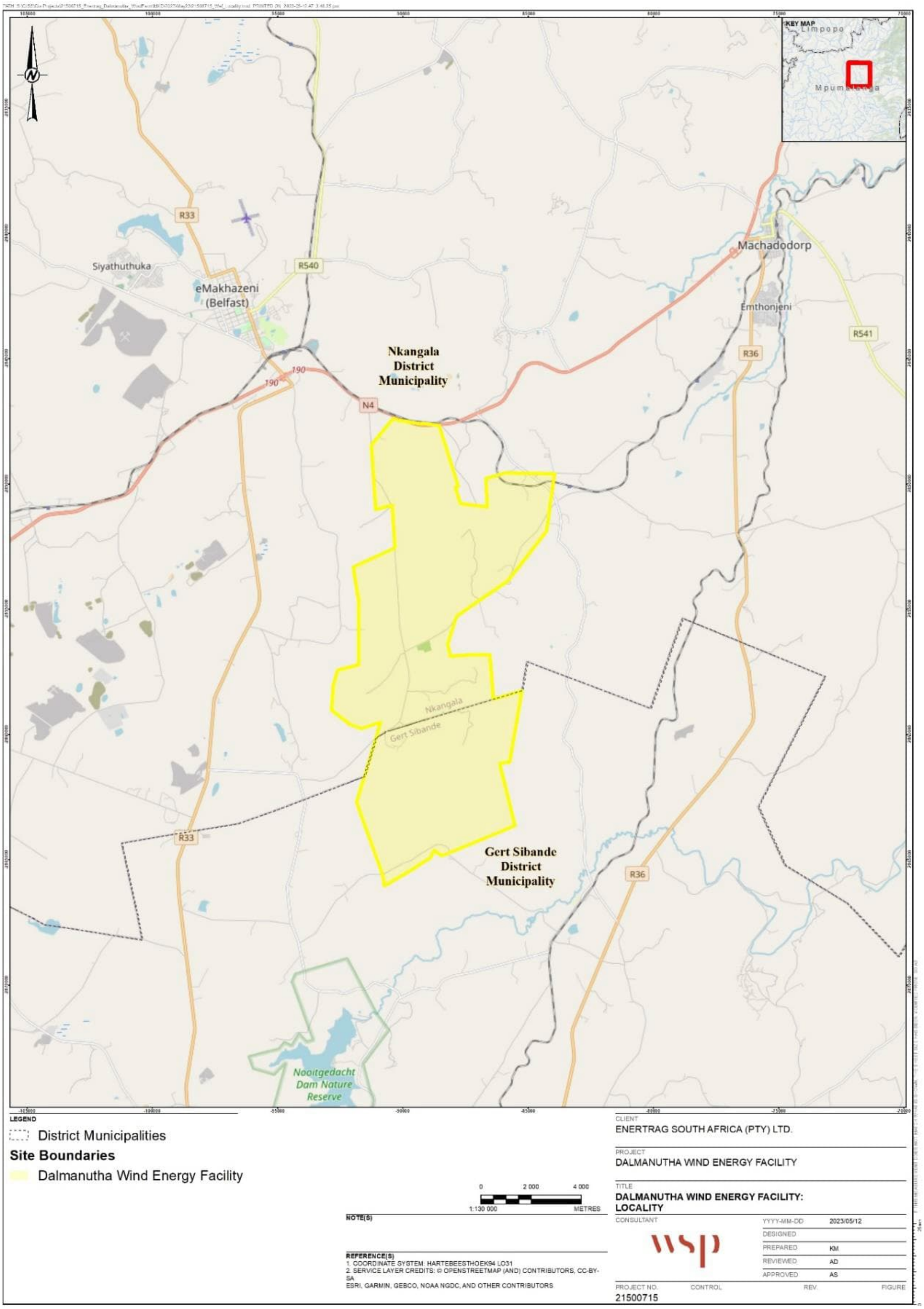

Figure 1-1 – Locality Map for Dalmanutha Wind Energy Facility

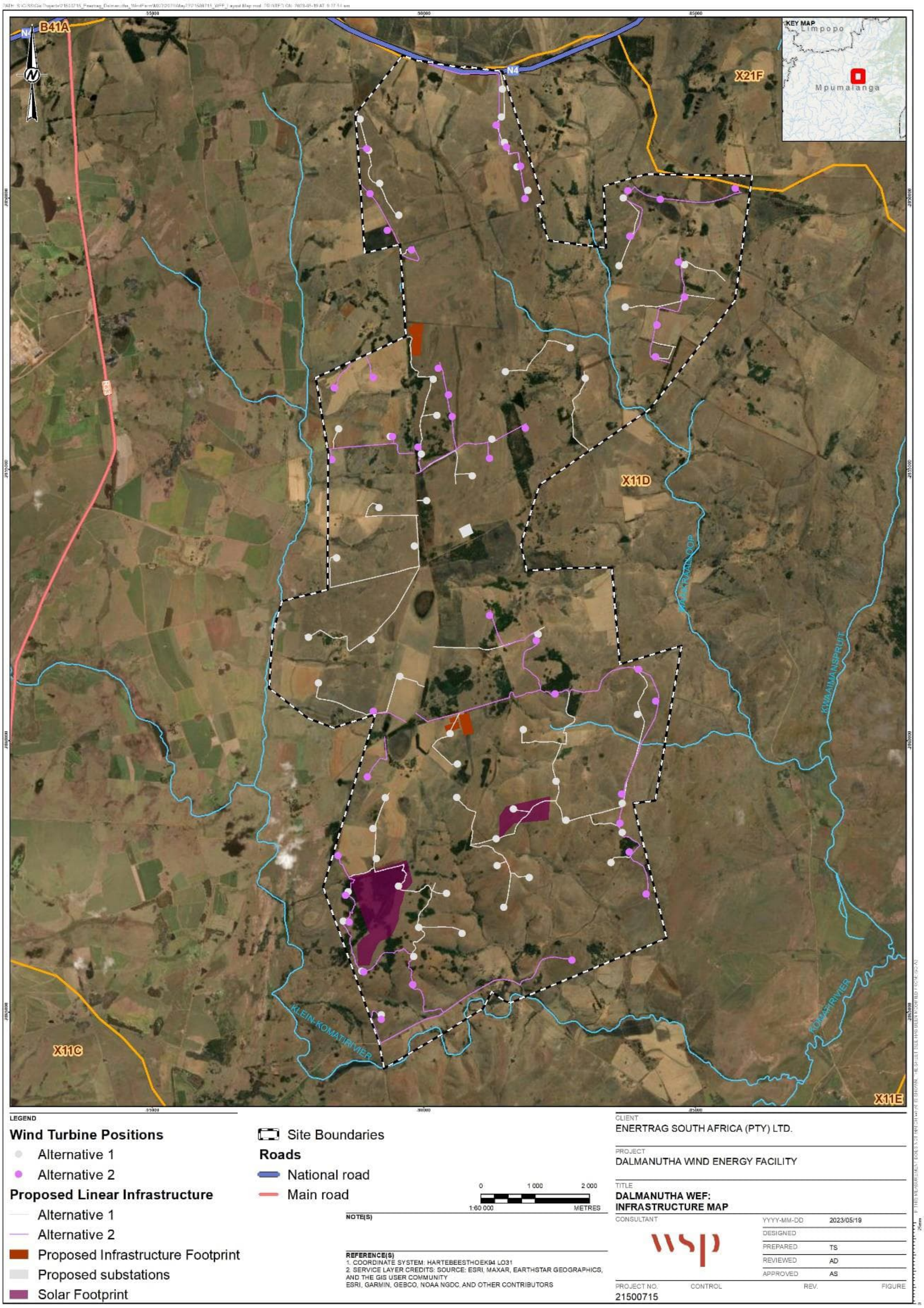

Figure 1-2 - Layout Plan for Dalmanutha WEF (Alternative 1 and 2)

1.4 ASSUMPTIONS, LIMITATIONS AND EXCLUSIONS

Completion of the project will be based on the following limitations and assumptions:

- Rainfall across the catchments is homogenous temporally and spatially;
- Data obtained from site-specific literature, and previous and other professional investigations will be assumed to be valid and true;
- Publicly available topographical data have been used; and
- Any detailed design and engineering drawings are excluded.

2.0 METHODOLOGY

The following methodology was proposed to meet the scope of work.

2.1 SITE VISIT

At the time of writing this report, a site visit has not been conducted. For the next phase of the project, it is recommended that a site visit be conducted to supplement the desktop gathered data, for the site, that will be used in this study. The site visits should be conducted to assess the conditions in the catchment, as well as drainage on-site which will inform the site-specific engineering requirements for detailed design.

2.2 INFORMATION GATHERING AND REVIEW

A thorough investigation of all available literature for the site was reviewed. This included the following:

- Meteorological data for the site such as rainfall, runoff and evaporation;
- Academic studies of the hydrology of the site;
- Acquirement of any existing topographical survey data of the site;
- The preliminary layout of the Dalmanutha WEF was studied and assessed; and
- National legislation applicable to the project was obtained and reviewed.

2.3 HYDROLOGICAL BASELINE ASSESSMENT

The hydrological baseline assessment makes provision for the observations made during the site assessment as well as considering the following aspects:

- Climate and hydrometeorological analysis for the area;
- Delineation of sub-catchments up to immediately downstream of the site;
- Determination of the Mean Annual Precipitation (MAP), Mean Annual Runoff (MAR) and Mean Annual Evaporation (MAE) from historical rainfall records from South African Weather Stations (SAWS) and the Water Resources Study of South Africa 2012 (Pitman and Bailey, 2015); and
- Calculation of the design rainfall depths for various return periods and event durations.

2.4 STORMWATER MANAGEMENT PLAN

A conceptual stormwater management plan (SWMP) (this document) was developed to manage surface runoff flows from the wind turbines and linear infrastructure. Guidelines and policy for the design of stormwater drainage and stormwater management were obtained from GN704 (1999) and

Best Practice G1 (DWAF, 2006). Topographical survey data was used to model the stormwater drainage network.

2.5 REPORTING

The findings of the application of the methodologies provided above are detailed in this report highlighting the key aspects as required in the scope of works

3.0 SUPPORTING INFORMATION

This section summarises all available information and assumptions upon which the derivation of the SWMP is based. This is done to highlight how the plan was developed: by matching regulations and guidelines to the specific needs of the project in the local natural conditions. The available information is therefore key to understanding the SWMP.

3.1 PROJECT BACKGROUND

Dalmanutha Wind (Pty) Ltd is proposing the development of a commercial Wind Energy Facility (WEF) and associated infrastructure on a site located approximately 12km south-southeast of Belfast within the Emakhazeni Local Municipality and the Nkangala District Municipality in the Mpumalanga Province. This WEF is referred to as the Dalmanutha WEF.

Two additional projects are concurrently being considered on the surrounding properties and are assessed in separate reports. These projects are known as Dalmanutha West WEF and Dalmanutha Collector SS and 132kV Grid.

The proposed Dalmanutha WEF will be developed with a capacity of up to 300 megawatts (MW), and will comprise the following key components:

Alternative 1

Wind Turbines

- Up to 70 turbines, each with a foundation of approximately 25 m2 in diameter (500 m2 area and requiring ~2 500 m3 concrete each) and approximately 3 m depth;
- Turbine hub height of up to 200 m;
- Rotor diameter up to 200 m; and
- Permanent hard standing area for each wind turbine (approximately 1 ha). The exact layout and specification of the hardstanding will be determined once the detailed design phase has been completed.

IPP Portion Onsite Substation and Battery Energy Storage System (Bess)

- IPP portion onsite substation of up to 4 ha. The substation will consist of a high voltage substation yard to allow for multiple up to 132 kV feeder bays and transformers, control building, telecommunication infrastructure, access road, etc., and
- The Battery Energy Storage System (BESS) storage capacity will be up to 300 MW/1200 megawatt-hour (MWh) with up to four hours of storage. It is proposed that Lithium Battery Technologies, such as Lithium Iron Phosphate, Lithium Nickel Manganese Cobalt oxides or Vanadium Redox flow technologies will be considered as the preferred battery technology; however, the specific technology will only be determined following Engineering, Procurement,

and Construction (EPC) procurement. The main components of the BESS include the batteries, power conversion system and transformer which will all be stored in various rows of containers.

Operation and Maintenance Building Infrastructure

- Operations and maintenance (O&M) building infrastructure will be required to support the functioning of the WEF and for services required by operations and maintenance staff. The O&M building infrastructure will be near the onsite substation and will include:
  - Operations building of approximately 200 m2;
  - Workshop and stores area of approximately 150 m2 each;
  - Stores area of approximately 150 m2; and
  - Refuse area for temporary waste and septic/conservancy tanks with portable toilets to service ablution facilities.
  - The total combined area of the buildings will not exceed 5 000m2.

Construction Camp Laydown

- Temporary laydown or staging area -Typical area 220 m x 100 m = 22 000 m².
- Laydown area could increase to 30 000 m² for concrete towers, should they be required.
- Sewage: septic and/or conservancy tanks and portable toilets.
- Temporary cement batching plant, wind tower factory & yard of approximately 7 ha, comprising amongst others, a concrete storage area, batching plant, electrical infrastructure and substation, generators and fuel stores, gantries and loading facilities, offices, material stores (rebar, concrete, aggregate and associated materials), mess rooms, workshops, laydown and storage areas, sewage and toilet facilities, offices and boardrooms, labour mess and changerooms, mixers, moulds and casting areas, water and settling tanks, pumps, silos and hoppers, a laboratory, parking areas, internal and access roads - Gravel and sand will be stored in separate heaps whilst the cement will be contained in a silo. The maximum height of the silo will be 20 m.

Access Roads

- The Project site can be accessed easily via either the tarred R33 or the N4 national road which run along the northern and western boundaries of the site.
- There is an existing road that goes through the land parcels to allow for direct access to the project development area.
- Internal and access roads with a width of between 8m and 10m, which can be increased to approximately 12 m on bends. The roads will be positioned within a 20 m wide corridor to accommodate cable trenches, stormwater channels and bypass /circles of up to 20 m during construction. Length of the internal roads will be approximately 60 km.

Associated Infrastructure

- The medium voltage collector system will comprise of cables up to and including 33 kV that run underground, except where a technical assessment suggest that overhead lines are required, within the facility connecting the turbines to the onsite substation.
- Over the fence 132kV cable to connect the on-site substation to the Common Collector Switching Station.
- Fencing of up to 4 m high around the construction camp and lighting.
- Lightning protection.
- Telecommunication infrastructure.

- Stormwater channels.
- Water pipelines.
- Offices.
- Operational control centre.
- Operation and Maintenance Area / Warehouse/workshop.
- Ablution facilities.
- A gatehouse.
- Control centre, offices, warehouses.
- Security building.
- A visitor's centre.
- Substation building.

Alternative 2

The key difference to alternative 1 is the reduction of the number of turbines from 70 to 44, and the inclusion of solar PV as follows;

- PV panels will be up to a height of 6 m (when the panel is horizontal) and will be mounted on fixed tilt, single axis tracking or dual axis tracking mounting structures. Monofacial or bifacial Solar PV Modules are both considered;
- Footprint: ~160 ha; and
- Inverters, transformers and other required associated electrical infrastructure and components
- The internal roads width is also different for the WEF (4m wide).

The proposed development footprint (buildable area) is approximately 400 ha (subject to finalisation based on technical and environmental requirements), and the extent of the project area is approximately 9 197 ha (total extent of the farm portions). The development footprint includes the turbine positions and all associated infrastructure as outlined above. The farm portions are namely:

- Berg-en-Dal 378 JT (Portions 1 and 9)
- Vogelstruispoort 384 JT (Portion 5 and 7)
- Waaikraal 385 JT (Portions 6, 7, 8, 10, 12,13 and 24)
- Leeuwkloof 403 JT (Portions 3 and 4)
- Leeuwkloof 404 JT (Portions 1 and 2)
- Geluk 405 JT (Portion 3)
- Camelia 467 JT (Portion 0)
- Welgevonden 412 JT (Portion 1)

3.2 DESKTOP STUDY OBSERVATIONS

Based on a Desktop study, the Dalmanutha WEF site terrain appears to be relatively flat with areas of rocky outcrops along the ridges and wide flat areas between.

The site's soil is predominantly fine sand with silt. Permeability of the soil on the site area is semi-permeable to permeable. The site has minor drainage lines draining in a south-easterly direction. There is a watershed that splits the footprint of the WEF into two basins. As such, there are two main rivers observed in the study area. These two main rivers are Waarkraalloop situated on the East, and Klein-Komati situated on the West portions of the study arear. There are also several small streams within the footprint of the WEF. A flood model will be generated to determine the inundation of these streams during low and high rainfall events. The profile of the channels is relatively shallow. The vegetation appears to be dense, consisting of shrubs and grasses along the site areas, which are also sufficient for animal grazing. Denser vegetation can be observed along sections of the drainage lines.

3.3 LEGISLATION AND GUIDELINES

SWMPs are generally required to support the EMPr and Water Use License Applications (WULA). The following was considered when compiling the SWMP:

- Best Practice Guidelines G1 for Stormwater Management (Department Water Affairs and Forestry (DWAF), 2006);
- Regulation 704 of the National Water Act (Department of Water Affairs and Forestry, 4 June 1999).

Municipal regulations, which may introduce specific standards for each municipality, but still adhere to the overall principles of the regulations and guidelines above, should be considered during Detailed Design (if relevant).

The International Finance Corporation (IFC) Performance Standards on Environmental and Social Sustainability (2012) were taken into consideration in the development of this report. A review of the standards revealed that they are prevalently for impacts affecting communities. As the hydrological risks do not affect any communities in this study, the standards were found not to be directly applicable.

3.4 NATURAL CONDITIONS

3.4.1 STUDY SITE AND CLIMATE

Pertinent to this section of the report, is the Scoping Assessment prepared by WSP in 2022 for the same WEF proposed activities. As such, herein, various references are made to this scoping assessment. If the Assessment is unknown to the reader, recommendation is hereby given to read the assessment before continuing with this report.

The site is situated within Quaternary Catchment X11D, which is located in the Inkomati Water Management Area (WMA) as depicted in Figure 1-2.

The WEF and its associated grid infrastructure are located within the Emakhazeni Local Municipality, Mpumalanga Province. The current land use designation for the properties is natural land, with some areas being used for agriculture, albeit with low agricultural potential. Seasonal grazing is also still practiced across the site, which is mostly characterised by short grass and sparse trees.

According to the July 2022 Scoping Assessment report by WSP, the region experiences rainfall throughout the year, with majority of the rainfall occurring between September to March. The mean annual rainfall is 733 mm, as observed from the Brakspruit rainfall station 0517235 W. The average S-Class pan potential evaporation, as measured at X2E002 station, is approximately 1 268.3 mm/year. Table 3-1 displays the monthly average evaporation and rainfall readings for the Dalmanutha area. From the table, is it evident that the mean evaporation exceeds the annual rainfall, except for the month of November. This suggests that the area has a high evaporative demand and is a water-limited system The mean maximum annual temperature for the project area is approximately 25 ºC in summer and between 0 ºC and 2 ºC during the winter months.

Table 3-1 - Mean Monthly Rainfall observed from Brakspruit Station

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Mean Rainfall (mm)	126	94	79	41	15	6	6	7	26	75	125	133	733
S-Pan evaporation (mm)	144.8	141.2	118.6	87.7	84.8	59.9	68.6	89.5	112.7	110.6	104.3	161	1283.7

3.4.2 TOPOGRAPHY

The topography of the entire WEF cluster areas has relatively gentle slopes starting from the northwest corner of the cluster to the southeast. The site elevation varies from a minimum of approximately 1519 to a maximum of 1879 meters above mean sea level (mamsl). The area also appears to include rocky outcrops spread sparsely around the wide flat areas. The total area of the WEF cluster is approximately 20 000 ha.

4.0 HYDROLOGICAL BASELINE ASSESSMENT

4.1 REGIONAL DRAINAGE

The site lies within the Inkomati Water Management Area (WMA) and all rivers in this WMA drain in a generally eastern direction, and flow together at the border with Mozambique, to form the Inkomati River which discharges into the Indian Ocean immediately north of Maputo. As part of the analysis, the quaternary catchment data for the site was extracted from Water Research Commission 2012. The site is situated within Quaternary Catchment X11D having a MAP of 733 mm.

Two main streams flow through the WEF footprint with tributaries originating within the footprint. Tributaries to the western side of the area feed the Klein-Komati stream and tributaries to the eastern side of the area feed the Waarkraalloop stream. Several of the tributaries cross the planned roads for the cluster area.

4.2 RAINFALL

An analysis of the rainfall data available for the site was undertaken to determine which dataset would best represent the site rainfall and whether the site should have individual rainfall parameters assigned or if rainfall should be assigned to represent the entire WEF cluster area.

The three nearest stations to the site were selected and the design rainfall for each rainfall was extracted from Design Rainfall Estimation software by Schulze and Smithers (Smithers & Schulze, 2002). The metadata for each rainfall station is provided in Table 4-1.

The average Mean Annual Precipitation (MAP) for all three weather stations located near the site is 745 mm. Weather Station Brakspruit has a higher percentage reliability in terms of measured data. For the purposes of the SWMP, the weather station with the highest reliability of the three was chosen. The final chosen value for the rainfall station is Brakspruit, with a MAP of 733 mm and rainfall record of 80 years, which was deemed sufficient. The design rainfall to be used for the site is presented in Table 4-2.

Table 4-1 - Three nearest SAWS to cluster area centroid

Station number	Station Name	Distance (km)	Record period (years)	Period of records	Reliability (%)	MAP (mm)
0517257 W	Waaikraal	6.2	81	1919 - 2000	15.8	762
0517235 W	Brakspruit	12.2	80	1920 - 2000	50	733
0517072 W	Belfast (Pol)	13.9	80	1920 - 2000	39.5	739

Table 4-2 - Design rainfall data for the site extracted from the Design Rainfall Estimation Software

Design Rainfall Data (mm)							
MAP	**749**	**mm**	**Latitude**	**25**	**Degrees**	**48**	**Minutes**
Altitude	**1472**	**mamsl**	**Longitude**	**30**	**Degrees**	**6**	**Minutes**
Storm Duration	**Return Period (Years)**						
	2	**5**	**10**	**20**	**50**	**100**	**200**
5 minutes	9.0	12.0	14.1	16.2	19.1	26.2	23.7
15 minutes	16.1	21.3	25.1	28.8	34.0	38.1	42.3
1 hour	21.4	35.0	41.2	47.3	55.8	62.5	69.5
1.5 hours	30.6	40.5	47.6	54.7	66.4	72.3	80.4
2 hours	33.9	44.9	52.7	60.6	71.5	80.1	89.1
8 hours	48.6	64.4	75.7	87.0	102.6	114.9	127.8
24 hours	64.7	85.7	100.7	115.8	136.5	152.9	170.1
5 days	90.7	120.2	141.2	162.4	191.4	214.4	238.5
7 days	100.0	132.6	155.7	179.0	211.1	236.5	263.0

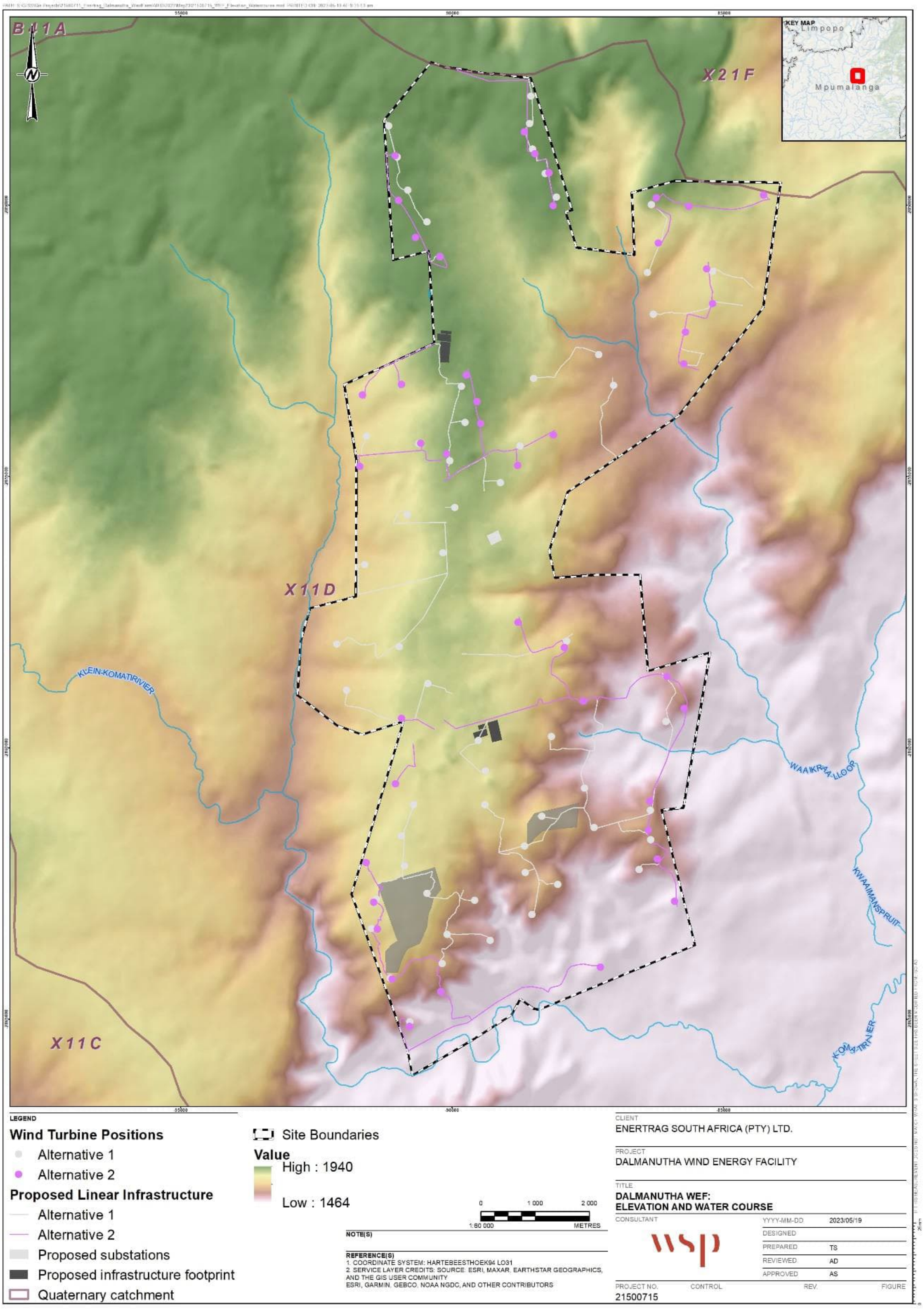

Figure 4-1 - Regional Drainage

4.3 EVAPORATION

The average S-Class pan evaporation for the site is 1268.3 mm/year measured at X2E002 station. The station is approximately 14 km away from the site area. The highest average monthly evaporation occurs in December, as shown in Table 4-3.

Table 4-3 - Average S-Class pan evaporation

Month	S-Pan evaporation (mm/month)
January	144.8
February	141.2
March	118.6
April	87.7
May	84.8
June	59.9
July	68.6
August	89.5
September	112.7
October	110.6
November	104.3
December	161
Total	1283.7

In comparison to the rainfall (see Figure 4-2) the evaporation is generally higher than the rainfall over the course of the year, except for the month of November. This indicates that most of the precipitation is evaporated.

The evaporation varies throughout the year, with the highest evaporation in the area observed in the months of October to March and the lowest evaporation occurring during the months of April to September.

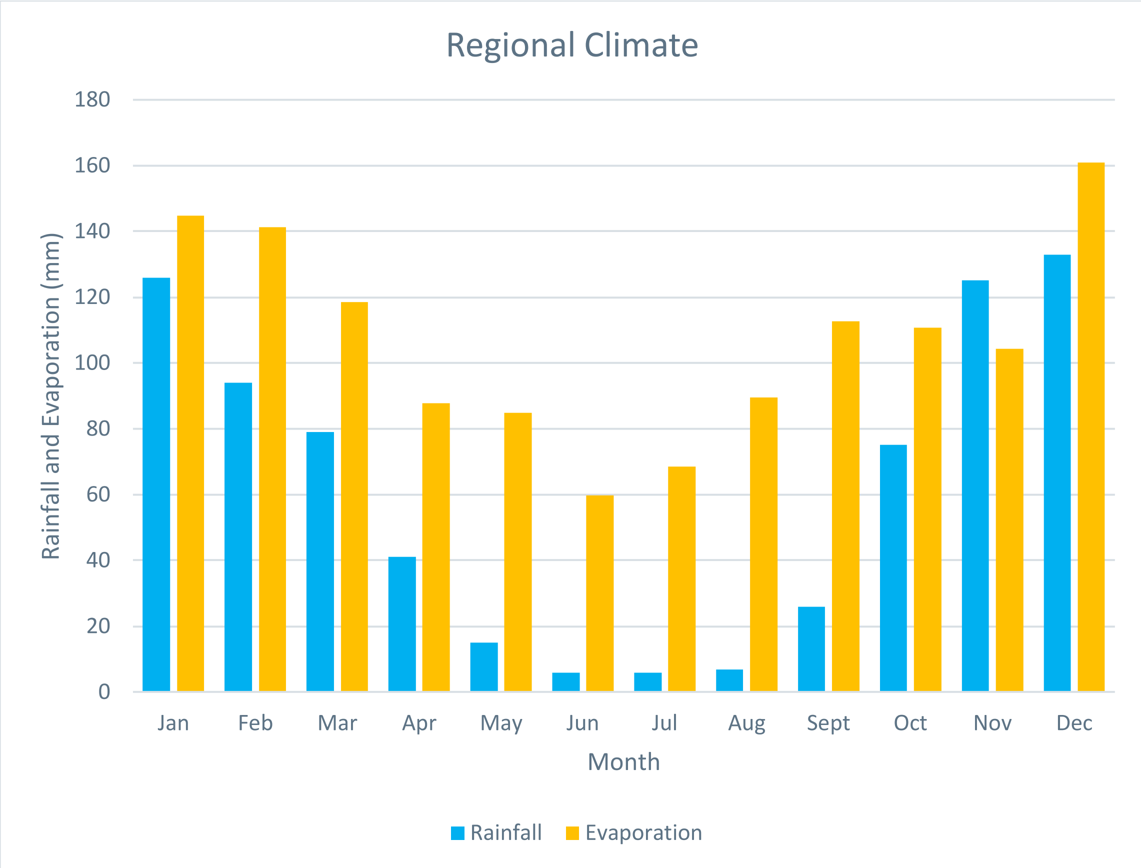

Figure 4-2 - Monthly rainfall and evaporation

5.0 DALMANUTHA WEF SUB-CATCHMENTS

5.1 DELINEATION OF SUB-CATCHMENTS

To delineate the catchments, a Digital Terrain Model (DTM) was created for use in GIS to determine these delineations and charaterisation of the various catchments. ArcGIS and HEC-HMS software were used to delineate the WEF sub-catchments. No detailed survey information was available at the time of the study; therefore, 5-meter contours (where available) were sourced from ngi.gov.za and compared to elevation data on Google Earth.

The delineated catchments are as shown in Figure 5-1 below.

5.2 CATCHMENT PARAMETERS

The slope of a catchment is a very important characteristic in the determination of flood peaks. Steep slopes cause faster runoff to shorten the critical duration of flood inducing storms, thus leading to higher rainfall intensities in the runoff formulae. On steep slopes, the vegetation is generally less dense, soil layers are shallower, and there are fewer depressions, all of which cause water to run off more rapidly. The result is that infiltration is reduced, and flood peaks are consequently elevated. For flat catchments such as those encountered on this site, the opposite holds true.

Land use is another critical characteristic as it alters the vegetation present and the degree of soil compaction. Compacted soil is less permeable, and vegetation can slow down stormflows over the land surface. Lastly, the soil type can also be important with some soils allowing quicker infiltration resulting in runoff for each catchment.

Table 5-1 presents the conceptual catchment characteristics used in this study.

Table 5-1 - Conceptual Catchment Characteristics

Catchment	Catchment Area (km2)	Permeability (desktop assessment, not lab tested)	Flow type	Vegetation
Catchment A	229 km2	Permeable to Semi-Permeable	Overland Flow	Grasslands, Light Bush, and farmlands
Catchment B	236 km2	Permeable to Semi-Permeable	Overland Flow	Grasslands, Light Bush, and farmlands

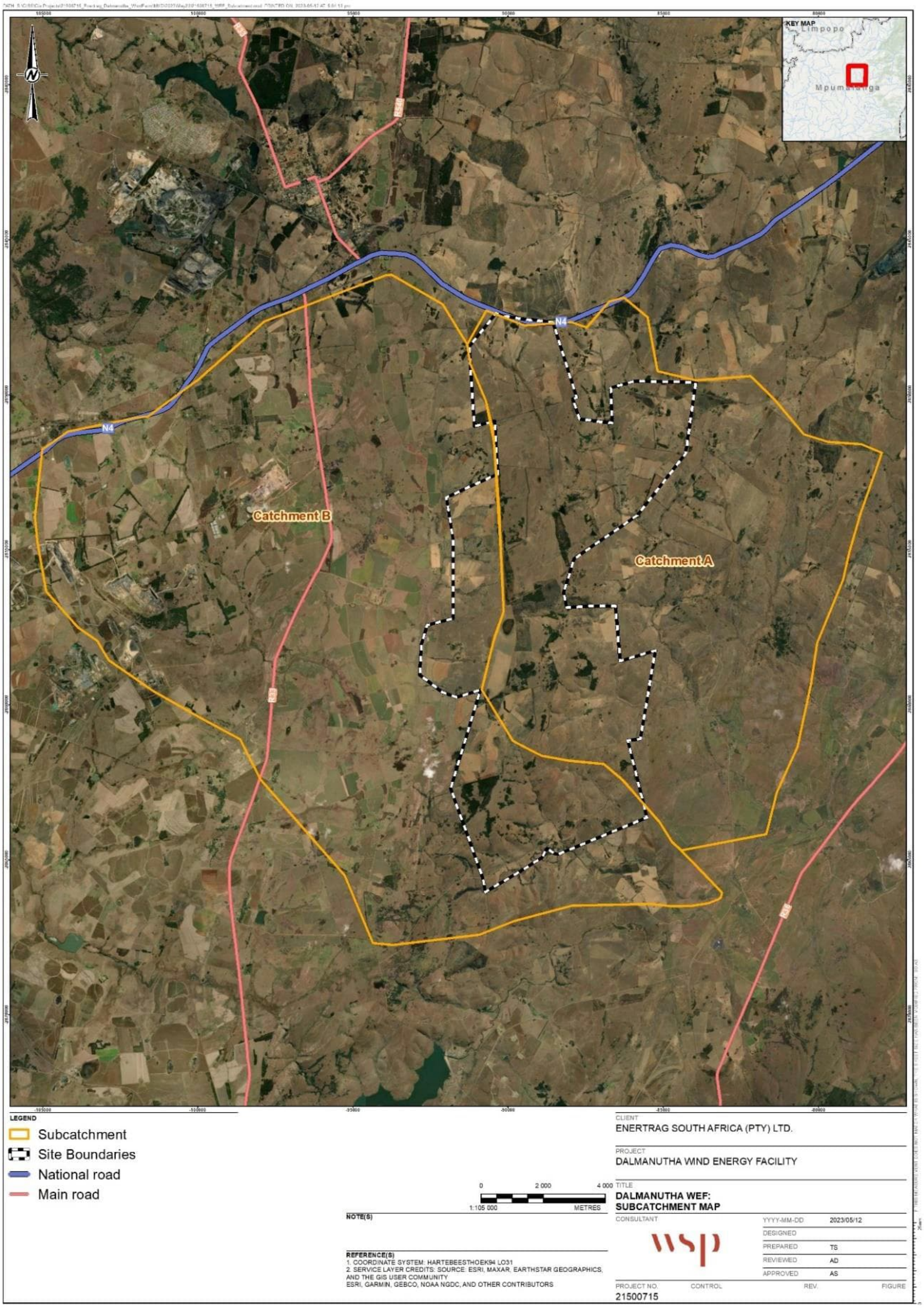

Figure 5-1 - Dalmanutha WEF Sub-catchments

5.3 STORM PEAK FLOWS

The hydrological and hydraulic parameters of all the catchments contributing towards the study area were calculated and the overland peak flow rates were determined in the study area.

The peak flows were calculated for the catchments using the Rational method (Alternative 2), Rational Method (Alternative 3) and the Standard Design Flood Method (SDF), as outlined in the SANRAL Drainage Manual (2013) in areas where flow data was not available. The SDF method was used to estimate peak flow rates based on the catchment parameters and rainfall intensity. The SDF method is based on the use of regional design storms, which are rainfall events that have been statistically derived from long-term rainfall data for a specific region. This is a conservative approach to make sure the system is not under designed. The peak flows are summarised in Table 5-2 below. The high contrast in values is due to the catchment size limitations of the design approaches.

The peaks flows are relevant to both pre-development and post-development scenarios, because the vegetation, topography and soil conditions will largely remain the same, except where the main buildings (O&M building, substation, stores, etc.) are placed, and this accounts for a negligible proportion of the development area from a surface area viewpoint.

Note that wash water was not considered in the peak flows, because turbine washing is unlikely to be done in the rainy season, and volumes will be negligible in comparison to storm volumes. The implications of the storm peak flows calculated, and their impact on the SWMP, are discussed in Section 6.0.

Table 5-2 - Peak Flows for Conceptual Catchments in cubic meters per second

Catchment ID	Method	Return Period (Years)					
		2	5	10	20	50	100
A	Rational (Alt. 2)	107.46	196.36	276.59	375.89	568.42	774.66
	Rational (Alt. 3)	132.13	191.01	243.02	309.64	446.76	597.44
	SDF	81.43	418.08	739.08	1107.52	1663.75	**2135.16**
B	Rational (Alt. 2)	60.85	112.04	158.81	217.45	332.95	458.00
	Rational (Alt. 3)	81.34	117.63	149.78	190.79	275.22	367.85
	SDF	47.90	245.87	434.72	651.43	987.60	**1255.88**

5.4 FLOOD LINE DETERMINATION

Modelling of the flood lines was performed by using the commonly used HEC-RAS v6.3.1 program of the U.S Army Corps of Engineers in South Africa. To create a detailed model, numerous cross sections were generated throughout the contributing area, including ineffective areas. Manning's n-values were determined using the land use coverage of each cross sections. The Hydraulic Reference Manual of HEC-RAS (2010) was used to obtain the Manning's n-values for channel areas with a range of 0.03 to 0.04.

Design flood values were used as inputs for the relevant reaches. Due to the slope of the catchment and the distance to downstream hydrological infrastructure, some inundation within the study site was expected but not from external features on the watercourse. As such, Normal Depth was selected for the reach boundary conditions, and the slope of the channel was used as the value for the backwater calculation of the initial condition.

5.5 FLOOD LINE DETERMINATION FOR MINOR AND MAJOR CHANNELS

As HEC-RAS is highly sensitive to the resolution of the terrain data used in the model, small non-perennial channels such as drainage lines are often not captured within the model. It is expected that the flood output for such minor channels would be insignificant.

It is important to note that although small non-perennial channels may not contribute significantly to the overall flood output, they can still pose a significant risk in localised areas and should not be overlooked in flood risk assessments. Therefore, a more well-defined survey such as 0.5 m to 1 m topographical contours would be required for the next phase of the project.

Through the flood analysis, it is clear that the proposed infrastructure (Construction camp, laydowns, internal access roads and onsite Substations) will not be at risk of damage through flooding from the channels. This is largely due to the general low rainfall in the area and the small catchments on the site, resulting in less accumulated surface runoff. Additionally, the structures are mostly placed on plateau areas, well outside of the flood extent. The post-development state will result in a very slight increased peak flow due to an increase in impervious structures and a resultant increase in storm flow. This has been accommodated through the storm water management plan. Although the laydown areas and crane pads are on the plateau of the mountain, they do still pose a risk of triggering erosion channels. In similar vein, the roads that traverse up steep slopes need to be secured against erosion.

The 1:100-year flood event, which is used in Water License Application was used to generate the flood lines. The inundation caused by this flood event is shown in Figure 5-2.

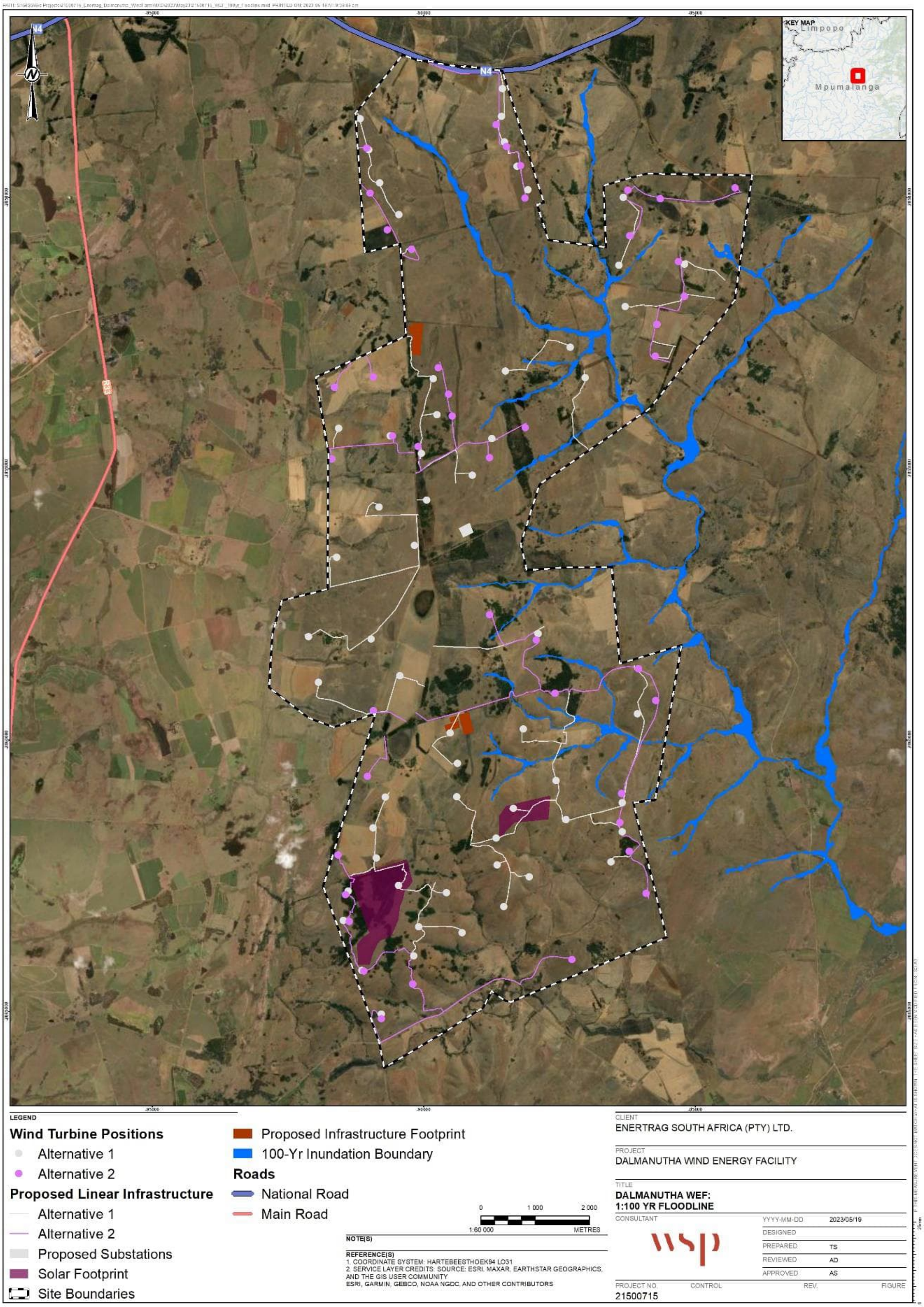

Figure 5-2 - Flooding during a 1:100-year rainfall event

6.0 CONCEPTUAL SWMP

6.1 DESIGN CRITERIA AND PROJECT OBJECTIVES

As per Best Practice Guideline – G1: Stormwater Management (DWAF, 2006) and GN 704 the SWMP for the site will seek to achieve certain objectives based on a philosophy of protecting the receiving environment from hydrological impacts.

- Clean and dirty water should be separated, and it should be ensured that all stormwater structures are designed to keep dirty and clean water separate and can accommodate a defined precipitation event;
- The clean water catchment area should be maximized, and clean water should be routed to a natural watercourse with minimal damage to that watercourse in terms of quantity and frequency of discharge;
- Dirty areas should be minimized, and runoff from these areas contained and neither treated to an acceptable quality to discharge to the environment or removed from the site for disposal; and
- Natural watercourses and the environment should be protected from contamination by dirty areas by ensuring that the dirty water cannot enter the clean water system by spillage or seepage.

In addition to these aims, the following project specific objectives for this SWMP were developed based on the site-specific characteristics:

- Stormwater should be directed such that no water flows in an uncontrolled manner that may jeopardise the safety of personnel or infrastructure, or such that is a nuisance;
- Protection of the soils by preventing erosion is also a key requirement of the SWMP;
- Minimise modification of the natural topography of the area and avoid any modification of the natural watercourses as far as possible;
- Do not impede surface or subsurface water flows unless unavoidable;
- Include a monitoring and inspection system for spills, leaks and erosion and commit to remediation where needed;
- Review and improve the SWMP regularly;
- Ensure no infrastructure, except road crossings, are built within the watercourses; and
- Do not build infrastructure, in particular infrastructure containing potential pollutants, within 100 m of natural drainage lines.

6.2 DELINEATION OF CLEAN AND DIRTY AREAS

The development area is divided into clean and dirty areas as follows:

Dirty areas:

- The workshop where oils and lubricants may be stored and used;
- A chemical storage area will be constructed for the operational phase of the project, which will include proper containment and bunding for all chemicals stored on site;
- Transformers at the substation, as these will contain oil;
- The conservancy tanks, as this will contain sewage; and,
- Vehicle wash bay that has a hard standing surface on which vehicles are washed, generating dirt water which drains to a sump.

Clean areas are deemed to be all areas on the site outside of those stated above as dirty areas.

Requirements for bunding of areas housing potential contaminants are specified in detail in the National Norms and Standards for the Storage of Waste (Notice 926 of 29 November 2012, Department of Environmental Affairs, national Environmental Management: Waste Act 2008, Act No. 29 of 2008). The specification, which will apply to the development area, reads as follows: *"bunds having a capacity which can contain at least 110% of the maximum content of the waste storage facility. Where more than one container or tank is stored, the bund must be capable of storing at least 110% of the largest tank or 25% of the total storage capacity, whichever is greater (in the case of drums the tray or bund size must be at least 25% of total storage capacity)."*

Bunded areas should be sized and sealed to ensure spilled contaminants cannot leak out of the bunded areas.

6.3 SWMP DESIGN PHILOSOPHY FOR A WEF

A typical WEF is a large expanse of land, over the surface of which are located wind turbines, preferably at high points to optimise exposure to wind. The turbines are placed several hundred meters away from one another. A road network provided access to each turbine and the substation. Cables run from the turbines to the substation. The land within the site footprint on which components are placed is not altered in any way by the WEF development. Typical stormwater management interventions for each of these components during both construction and operational phases are defined in this section.

The SWMP will be guided by Low Impact Design (LID) principles. LID in land development aims to manage stormwater as close to its source as possible by simulating or enhancing natural processes. This is achieved by interception of rainfall on the catchment surface as it lands by enabling natural infiltration into the soil, increasing roughness using vegetation, and aiding soil stability by the establishment of vegetation. LID was selected as a suitable method for several reasons.

Firstly, LID addresses the risk of erosion and downstream sedimentation caused by concentrated flows. Concentrated flow emanating from a catchment has higher velocities and associated streamflow than overland flow. It is desirable to keep peak flow velocity below 1.5 m/s.

Secondly, by reducing concentrated flow, LID minimizes alteration of the pre-development hydrograph of the catchments in terms of peak discharge and duration of runoff. This is feasible because the total surface area modified by the WEF components is very small relative to the total surface area of the catchment (in order of 5%).

Finally, in terms of water quality, there are no water demands, uses, or discharges from a WEF meaning that only stormwater quality needs to be managed. Aside from dirty areas defined above, the only water contaminant will be suspended solids from disturbed soil during the construction phase and road runoff during construction and operational phases. The LID interventions specified below will effectively reduce the particle load in the water by settling in temporary sumps during construction, and filtering with vegetation lined channels and dissipaters during operation.

6.4 SITE SPECIFIC CONSIDERATIONS

6.4.1 POSITIONING OF TURBINES

For the most part, the majority of the 70 wind turbines for alternative 1 and 44 wind turbines for alternative 2 in Dalmanutha WEF are positioned along the crests of diagonal rocky ridges, with the rest located near or on high points. Due to the turbines being at the higher surface elevations within the catchments, it is anticipated that their resultant hydrological impacts, such as impedance of flow, will be minimal. None of the turbines are located within the vicinity of a river or a drainage line and therefore are not a risk to them.

6.4.2 ACCESS ROADS

The network of access roads connecting the wind turbines and substations; laydown areas and auxiliary buildings is appropriately 60 km in length in total, and therefore cumulatively will affect a small percentage of surface permeability and infiltration of the catchment.

The majority of the Dalmanutha WEF access road network does not intersect any major drainage lines or rivers. A few roads intersect several non-perennial streams, a SWMP for these access roads is discussed in Section 6.6.

6.5 SWMP FOR WIND TURBINE FOOTPRINT

The SWMP presented in this section is applicable to all turbines in the WEF for both construction and operational phases. A typical WEF site drainage is shown in Figure 6-1.

6.5.1 CONSTRUCTION PHASE

General principles are given to guide the planning of stormwater during the construction period. The construction period has the greatest hydrological impact and therefore careful planning is essential.

An example of the construction of a wind turbine foundation is shown in Figure 6-1. The foundation of a wind turbine is buried below ground surface, typically at a depth of 3.5 – 4.0 m below natural ground elevation. Thus, earth excavation is required. In addition to the foundation works, a compacted hardstand adjacent to the foundation is required for laydown purposes.

The following interventions are required for stormwater management during construction of the wind turbine:

- Use excavated soil to form a diversion berm on the upslope of the foundation sitting. This will serve to divert clean surface runoff from upstream around the works. The upstream contributing catchment area is expected to be minor because all turbines are sited on high points in the topography. It is still necessary to minimize the water entering the area of disturbed soil.
- Construct a temporary sump at a low point on the boundary of the works. This will serve to collect runoff and allow for settlement of particles out of the water. Pump out to the environment once settled.
- If erosion is observed, place straw bales or grass mats in the area to protect the soil or construct silt fences to capture the eroded material and place back in the erosion gullies.

Figure 6-1 - Typical Wind Turbine Foundation Construction. Image source: Kevin, 0:23

6.5.2 OPERATIONAL PHASE

It is assumed that once constructed, the foundation excavation will be backfilled, topsoiled, and grassed. Gravel should be placed around the base of the wind turbine as a LID intervention to encourage infiltration of runoff from the turbine support back into the soil. This will result in clean runoff from the site. It is recommended that runoff be allowed to free-drain back into the environment as overland flow, as opposed to concentrating the flow and introducing a risk of localized erosion at the outlet point.

6.6 SWMP FOR ACCESS ROADS

It is assumed that the access roads will be gravel roads. The following interventions are recommended for stormwater management on the road:

- The roads should be cambered to drain to one side.
- V-drains should be constructed along the length of the road on both sides. The upslope side should be sized to have sufficient capacity to convey runoff from the upstream contributing catchment. The v-drain on the downslope side of the road should have sufficient capacity to contain runoff from the road surface.
- Where the slope is gentle, the v-drains shall be soil, planted with vegetation forming a permeable swale. This is a LID intervention and will facilitate infiltration of flow into the soil, protect against erosion, and allow for settling and filtration of suspended solids and motor oil that may come from the road.
- Where the slope is steep, the v-drain shall be lined with riprap. This too is permeable but provides greater resistance against scour that may result from velocities of flow from steep slope.

- All v-drains should follow the natural topography of the land and ultimately drain to the watercourse.
- If the outlet of the road drains into the watercourses, an energy dissipater shall be installed. This would consist of gabion mattresses with a step down at the inlet, widening and daylighting to meet natural ground level at which point rip rap shall be placed. This will effectively dimmish the flow and reintegrate it into the natural environment and enter into the watercourse without causing erosion.
- At a shallow road crossing with watercourses, a drift shall be constructed for traffic. The drift shall be constructed of concrete on compacted soil. The downslope of the drift shall be lined with gabion mattresses and riprap to dissipate the flow over the drift prior to release into the watercourse.
  - The roads throughout the site have been assumed to be class 3 roads. As such, the 1:20 year event should be used in sizing the culverts. This peak event varies throughout the catchment position and whether a major or minor crossing occurs.
  - At deeper road crossings with watercourses, culverts shall be constructed. Culverts are recommended to be concrete, with wing walls and gabion mattresses and riprap on the downstream side to dissipate the energy of water flowing through the culvert. Number of culvert opening should be maximized to distribute as much as possible.
    - It is recommended that for major crossings, the proponent utilises a low-level crossing or portal culverts and for minor crossings, the proponent uses pipe culverts. Once the final details of the road and exact crossing points have been determined, the size of each culvert can be calculated.

Detailed design drawings, based on the above discussions, will be compiled in the next phase of the project.

6.7 SWMP FOR PHOTOVOLTAIC (PV) PLANT

The PV Plant includes inter alia that the natural vegetation of the site should remain and that only the large trees/shrubs should be removed. Furthermore, that the PV panels will be mounted above the natural vegetation and therefore no bulk earthworks will be required.

As no bulk earthworks will be required, we believe that minimal stormwater measures will be required. Furthermore, the Mean Annual Precipitation (MAP) for this site is almost always lesser than the Mean Annual Evaporation (MAE) which further substantiates the minimal need for stormwater management with natural vegetation intact.

The proposed stormwater measures for the PV Plant includes the draining of each drainage area by means of suitably sized grass lined earth channels positioned in low-lying area where water naturally flows.

6.8 SWMP FOR SUBSTATION AND AUXILIARY BUILDINGS

The stormwater runoff from the substations and auxiliary building will be clean. It is recommended that at outlet point from downpipes, energy dissipation features be installed after which the stormwater can be discharged into the environment.

7.0 WASTE AND WASTEWATER MANAGEMENT

Waste will be disposed of at a registered landfill site and domestic wastewater at a licensed wastewater treatment plant (i.e., waste will be treated off site), hence, the SWMP only focuses on temporary storage on site.

Domestic waste should be stored out of the rain and wind, collected regularly, and disposed of as is currently proposed for the development.

The conceptual design of the wastewater (sewage) conservancy tank was not within the scope of this report; however, the current conceptual plan was evaluated in terms of the risks that this may pose to surface water. Poor management of the tank is the main risk because the system could fail if the tank is not emptied regularly resulting in overflows. Consequently, a float switch controlled alert system is recommended.

Oil and lubricants in the workshop, and oil from the transformers must be bunded as per legal requirements and hence, this was recommended without alternatives.

8.0 EROSION AND SEDIMENT TRANSPORT

In general, the main erosion risks on a wind turbine facility are channel outlets, roads, road crossings, foundation excavations and stockpiles. Erosion on roads is excluded as a risk as this is unlikely as long as the roads have no significant camber.

In the case of stockpiles and foundation excavations, diversion berms or silt fences are recommended to be placed on the upslope and downslope respectively. Topsoil that is cleared for the development of the turbine footprints and hardstand areas should be stockpiles for the decommissioning and rehabilitation of the facility. The stockpiles, if possible, should have gentle slopes of 1 in 5 or less to encourage revegetation and limit erosion. The stockpile should be bunded until it revegetates. The gently slopes will necessitate a stockpile with a larger surface area. This is considered the lower impact option as it limits erosion though it disturbs more surface area.

Sometimes, material excavated during construction of the turbine foundations might be significant (cumulative volume). If that is the case, the material should be removed from and disposed of off-site responsibly (e.g., use cover material on landfill site).

9.0 SWMP MONITORING AND MANAGEMENT

Monitoring and management are key to the success of a SWMP. The following are therefore included as a key aspect of SWMP.

- Frequent inspections until the success of the design and any unexpected problems are resolved/confirmed and maintenance frequency is determined;
- Review of the plan after a few years to improve, where possible, its practicality, cost-effectiveness or efficacy;
- Alerts that do not rely on a full-time environmental management on site (which may not be feasible) including:

- Automatic alert system for the wastewater conservancy tank (e.g., a float driven switch alert system);
- Brief, annual refresher training on stormwater protection that should not take more than fifteen minutes for each staff member; and
- Well placed signs that remind staff members or reporting of incident/issues, as soon as possible and reduce the likelihood that forgetfulness or confusion will prevent reporting.

10.0 SURFACE WATER FINDINGS, IMPACTS AND MITIGATIONS

Then site is undeveloped aside from farming activities. According to the desktop study, it appears the only existing impacts are the development of gravel roads and homesteads. The extent of this development, or modified environment, is a small fraction of the total surface area and thus can be assumed to have negligible surface water impacts. It was also assumed that the grazing activities do not significantly alter the vegetation or soil characteristics of the area. Therefore, the site is not considered to be modified from its natural condition and thus, it is presumed that no existing hydrological impacts exist.

In relation to an activity, cumulative impact "means the past, current and reasonably foreseeable future impact of an activity, considered together with the impact of activities associated with that activity, that in itself may not be significant, but may be significant when added to the existing and reasonably foreseeable impacts eventuating from similar or diverse activities" (NEMA EIA Reg GN R982 of 2014). It is important to consider the bigger picture where numerous small impacts can lead to greater cumulative impacts. The recommended mitigation measures are aligned with the identified construction and operation impacts. Key mitigation measures would be to minimise stormwater runoff, share construction access roads, utilize the same spoil areas and utilize water efficiently.

In South Africa, the Renewable Energy Development Zones (REDZ) were established as areas that have been identified as having the highest potential for renewable energy development, based on factors such as wind and solar resources, existing infrastructure, and environmental considerations. This project is planned to be situated outside of the eight REDZ.

Given the site's location outside the REDZ, it is considered to be located within an area that is developing in this focus area. From a hydrological perspective, due to the low rainfall and suggested mitigation measures, the proposed development would have a **low negative impact**. Also, as the site is undeveloped and has no existing hydrological impacts, there are no existing impacts that will exacerbate those resulting from the construction and operation of the wind turbines.

Existing surrounding projects with an approved status are listed further below.

- The construction of the 14MW Machadodorp PV 1 solar energy facility on portion 8 0f the farm De Kroon 363 in Mpumalanga Province – 11km NE of the Site
- Proposed establishment of the Haverfontein wind energy facility near Carolina, Mpumalanga Province – 9km S of the Site
- Eskom Arnot PV Facility at the Arnot Power Station on Remainder of Portion 24 of Reitkuil 491 JS near Middleburg in Mpumalanga – 31km SW of the site

In terms of the level of acceptable change, this could be defined as the extent of modification which does not alter hydrological flow regimes or introduce erosion or soil sedimentation to the environment and watercourses. As the WEF is comprised of isolated turbines, interconnected by access roads, the catchment characteristics will effectively only experience minor change (as opposed to a site with a large surface area of development) and thus are not anticipated to alter the hydrology of the catchment significantly or to push it beyond an acceptable level of change.

Included in the Scoping Assessment, prepared by WSP, was a matrix listing each surface water finding similar to this study that is required to protect surface water resources from impacts from the proposed activity. An aim, as presented in GN 704 and the Best Practice Guidelines for Stormwater Management (DWAF, 2006) were identified followed by the specific objectives that will achieve this aim. Risk of impacts were addressed by either avoidance, prevention or mitigation by site practices and planning.

These methods of managing the surface water risk introduced by the proposed activity are recommended to be included in the EMPr.

11.0 CONCLUSION AND RECOMMENDATIONS

A specialist surface water study was carried out by WSP to support the EIA application for the Dalmanutha WEF development in Mpumalanga proposed by the Dalmanutha Wind (Pty) Ltd. It was found that the layout of the Dalmanutha WEF consists of discrete points where turbines are erected, interconnected by linear infrastructure (access roads), as well as minor auxiliary buildings and substations. The development is spread over a large area of approximately 9 179 ha meaning that the gross surface area occupied by the components mentioned is small in comparison to the entire footprint of the Dalmanutha WEF (estimated to be less than 5%). As hydrology is controlled by sub-catchment surface area characteristics, and the alteration of the surface characteristics is minimal, it can be concluded that the net impact of the development on hydrology is minor. However, local management of surface runoff is required at the turbine positions (turbine foundation and adjacent hardstand) and along the roads. Interventions to avoid, manage and mitigate potential impacts during both construction and operational phase are specified in both Section 10.0 of this report and in the Scoping Assessment prepared by WSP.25 It was found that the most impacts and risks to surface water resources occurs during the construction phase at the excavation for the turbine foundation.

It is recommended that the proposed activity and all associated infrastructure be authorised as it has been found that surface water impacts resulting from the activity are minimal and within an acceptable level of change. These impacts are summarised below:

- Level of change to runoff regime is minimal, i.e., frequency and magnitude of peak discharges from sub-catchments is not expected to be changed and baseflow is not expected to be impacted.
- Erosion and sedimentation are a risk at the locations of the wind turbines and along the access roads and thus would only occur at localized points which can be prevented.
- As all turbines are positioned at high elevations, it is unlikely that their zone of influence will extend to the watercourses within the site footprint.
- It was found that no turbines are positioned within watercourses and therefore no risk of impact to the riverbeds or banks exists.

- The only constituent of concern that may pollute waterways is suspended solids from disturbed soils. These solids can be managed and allowed to settle out of surface runoff prior to release to the environment. Therefore, the resultant impact on surface water quality will be negligible.

As well as the impacts being minimal, all impacts can be avoided, managed, and mitigated by implementing the SWMP presented in this report. In order to achieve this, all SWMP interventions should be included in the EMPr.

Is it recommended that the SWMP be developed further during the Detailed Design by:

- Conducting a detailed topographical survey;
- Developing a stormwater layout and designs based on the above information and infrastructure layout plan;
- Sizing the culverts or drifts associated with the proposed road crossings such that they can handle at least the 1:20-year flood event, or a minimum of 600 mm diameter or height (for maintenance purposes);
- Developing conceptual designs into detailed designs with sufficient details to support construction; and
- The plan should be incorporated into an environmental specification for use during construction and incorporated into the operation environmental management of the site.

In conclusion:

- The proposed infrastructure is not at risk of flood damage.
- The proposed facility will have an intrinsically low impact on surface water resources;
- The potential stormwater impacts that do not exist can be managed in a practical and cost-effective way; and
- The plan is conceptual, because no detailed contour data is available and only conceptual infrastructure layout were made available at the time of the study – that said, moderate to low rainfall and low flow gradients characteristic of the area suggest that details design should not vary considerably from the concepts presented in this report.

12.0 REFERENCES

BAILEY, AK & PITMAN, WV. (2015) WATER RESOURCES OF SOUTH AFRICA 2012 STUDY (WR2012). WRC Report K5/2143/1

Department of Water Affairs and Forestry, 2006. Best Practice Guideline G2: Water and Salt Balances.

Drainage Manual, The South African Roads Agency Limited (SANRAL), 6th edition, 2013

DWA (2010) Department of Water Affairs, Hydrological Information System. http://www.gov.za/Hydrology/ (Accessed 28 April 2023)

Kevin Lass (2016, October 26). Wind Turbine Foundation Pour [Video]. Retrieved from https://www.youtube.com/watch?v=9DMSODCtHcw&ab_channel=kevinlass

Lynch, SD. 2003: Development of a Raster Database of Annual, Monthly and Daily Rainfall for Southern Africa, WRC Report No. 1156/1/03, Water Research Commission, Pretoria, RSA.

ODOT Hydraulics Manual, 2014.

Schulze, R.E. (2003). Development of a Database of Gridded Daily Temperatures for Southern Africa. University of Natal, Pietermaritzburg, School of Bioresources Engineering and Environmental Hydrology. ACRUcons Report, 41. pp 82.

Smithers, J. C., & Schulze, R. E. (2002). Design Rainfall Estimation Program; Rainfall Statistics for Design Flood Estimation in South Africa. WRC Project K5/1060.

South Africa. (1998). General Notice 704 of the National Water Act (36 of 1998). Pretoria: Department of Water and Forestry.

US Army Corps of Engineers, Hydrologic Modelling System HEC-HMS version 4.11

US Army Corps of Engineers, HEC-RAS version 6.3.1

Visual SCS-SA, R.E. Schulze, E.J. Schmidt and J.C. Smithers, University of Natal

Water Research Commission: [Water Resources of South Africa, 2012 Study - Resource Centre (waterresourceswr2012.co.za)]

WSP, 2022, Scoping Assessment for the Proposed Dalmanutha Wind Energy Facility.

Appendix A

DESIGN RAINFALL VALUES FOR DALMANUTHI WEF

Design Rainfall in South Africa: Ver 3 (July 2012)

User selection has the following criteria:
Coordinates: Latitude: 25 degrees 48 minutes; Longitude: 30 degreess 9 minutes
Durations requested: 5 m, 10 m, 15 m, 30 m, 45 m, 1 h, 1.5 h, 2 h, 4 h, 6 h, 8 h, 10 h, 12 h, 16 h, 20 h, 24 h, 1 d, 2 d, 3 d, 4 d, 5 d, 6 d, 7 d
Return Periods requested: 2 yr, 5 yr, 10 yr, 20 yr, 50 yr, 100 yr, 200 yr
Block Size requested: 1 minutes

Data extracted from Daily Rainfall Estimate Database File
The six closest stations are listed

Station Name	SAWS Number	Distance (km)	Record (Years)	Latitude (°)	Latitude (')	Longitude (°)	Longitude (')	MAP (mm)	Altitude (m)	Duration (m/h/d)	2	2L	2U	5	5L	5U	10	10L	10U	20	20L	20U	50	50L	50U	100	100L	100U	200	200L	200U
BRAKSPRUIT	0517235_W	12.6	63	25	55	30	9	749	1472	1 d	57.2	56.8	57.4	75.8	75.4	76.1	89.0	88.3	89.8	102.3	101.2	103.7	120.6	118.1	123.1	135.1	131.6	139.3	150.3	145.1	156.6
										2 d	71.2	70.9	71.5	92.6	92.2	93.1	107.2	106.4	107.7	121.4	120.3	122.6	140.2	138.2	142.4	154.6	151.6	157.8	169.3	165.6	174.5
										3 d	82.4	82.0	82.8	106.7	106.2	107.2	122.7	122.2	123.4	138.3	137.7	138.9	158.5	157.5	159.4	173.6	172.2	175.3	188.8	186.9	190.7
										4 d	90.2	89.7	90.5	116.3	115.9	116.9	133.6	133.0	134.3	150.1	149.0	151.2	171.4	169.5	173.1	187.1	184.4	190.0	202.9	199.2	207.0
										5 d	94.8	94.3	95.2	122.2	121.7	122.8	140.1	139.1	140.8	157.3	155.8	158.7	179.2	176.5	181.9	195.4	191.7	199.4	211.6	206.5	217.1
										6 d	100.0	99.5	100.4	128.3	127.7	128.9	146.5	145.4	147.6	163.7	161.8	165.4	185.4	182.2	188.2	201.2	197.2	205.3	216.7	211.3	223.4
										7 d	106.4	105.8	106.8	136.3	135.8	137.0	155.6	154.9	156.4	173.6	172.3	175.2	196.3	193.9	198.9	212.9	209.2	216.1	229.0	224.6	233.7
BELFAST (POL)	0517072_W	17.8	94	25	41	30	2	782	1899	1 d	47.9	47.6	48.1	63.5	63.2	63.8	74.5	73.9	75.2	85.7	84.7	86.8	101.0	98.9	103.1	113.2	110.2	116.7	125.9	121.5	131.1
										2 d	60.7	60.5	61.0	79.0	78.7	79.4	91.5	90.8	91.9	103.6	102.7	104.6	119.6	117.9	121.5	131.9	129.4	134.6	144.4	141.3	148.9
										3 d	69.9	69.6	70.3	90.5	90.2	91.0	104.2	103.7	104.7	117.4	116.9	117.9	134.5	133.7	135.3	147.4	146.2	148.8	160.2	158.7	161.9
										4 d	76.1	75.7	76.4	98.2	97.8	98.7	112.8	112.3	113.3	126.7	125.7	127.6	144.6	143.0	146.1	157.9	155.6	160.3	171.2	168.1	174.7
										5 d	82.5	82.0	82.8	106.2	105.8	106.7	121.8	121.0	122.4	136.7	135.4	138.0	155.8	153.5	158.1	169.9	166.6	173.4	184.0	179.6	188.8
										6 d	88.8	88.3	89.1	113.9	113.3	114.4	130.0	129.0	131.0	145.3	143.6	146.8	164.5	161.7	167.0	178.6	175.0	182.2	192.3	187.6	198.3
										7 d	94.4	93.9	94.8	121.0	120.5	121.6	138.1	137.5	138.8	154.1	152.9	155.4	174.2	172.0	176.5	188.9	185.7	191.8	203.2	199.3	207.4
MACHADODORP	0517430_W	18.0	96	25	40	30	15	790	1554	1 d	53.6	53.3	53.8	71.1	70.7	71.4	83.4	82.8	84.2	96.0	94.9	97.2	113.1	110.8	115.4	126.7	123.4	130.6	141.0	136.1	146.8
										2 d	66.8	66.6	67.2	87.0	86.6	87.4	100.7	100.0	101.2	114.0	113.0	115.2	131.7	129.8	133.8	145.3	142.4	148.2	159.0	155.5	163.9
										3 d	75.9	75.6	76.3	98.2	97.8	98.7	113.0	112.6	113.6	127.4	126.8	127.9	146.0	145.1	146.8	159.9	158.6	161.4	173.9	172.2	175.6
										4 d	83.5	83.0	83.8	107.7	107.3	108.2	123.7	123.2	124.3	139.0	137.9	140.0	158.7	156.9	160.3	173.3	170.7	175.9	187.8	184.4	191.6
										5 d	89.8	89.4	90.2	115.7	115.3	116.3	132.7	131.8	133.4	149.0	147.6	150.4	169.8	167.2	172.3	185.2	181.6	189.0	200.5	195.7	205.7
										6 d	96.0	95.5	96.4	123.2	122.6	123.8	140.6	139.5	141.7	157.1	155.3	158.7	177.9	174.9	180.7	193.1	189.3	197.0	208.0	202.9	214.4
										7 d	101.0	100.5	101.4	129.4	128.9	130.1	147.7	147.1	148.4	164.8	163.6	166.3	186.4	184.0	188.8	202.1	198.6	205.2	217.4	213.2	221.9
NOOITGEDACHT DAM (IRR)	0517147_W	18.5	39	25	57	30	4	728	1524	1 d	50.1	49.9	50.4	66.5	66.2	66.8	78.1	77.4	78.8	89.8	88.7	91.0	105.8	103.6	108.0	118.6	115.5	122.2	131.9	127.3	137.4
										2 d	67.7	67.4	68.0	88.1	87.7	88.5	101.9	101.2	102.4	115.4	114.4	116.6	133.3	131.4	135.4	147.0	144.2	150.1	161.0	157.5	165.9
										3 d	74.4	74.1	74.8	96.3	95.9	96.8	110.9	110.4	111.4	124.9	124.4	125.5	143.1	142.3	143.9	156.8	155.6	158.3	170.5	168.8	172.2
										4 d	84.2	83.8	84.6	108.7	108.3	109.2	124.8	124.3	125.5	140.3	139.2	141.2	160.1	158.4	161.7	174.9	172.3	177.5	189.6	186.1	193.4
										5 d	89.0	88.5	89.3	114.6	114.1	115.2	131.4	130.5	132.1	147.5	146.1	148.9	168.1	165.6	170.6	183.4	179.8	187.1	198.5	193.7	203.7
										6 d	93.8	93.3	94.2	120.3	119.7	120.9	137.4	136.3	138.4	153.5	151.8	155.1	173.9	170.9	176.5	188.7	184.9	192.5	203.2	198.2	209.5
										7 d	99.0	98.5	99.4	126.8	126.3	127.5	144.8	144.1	145.5	161.5	160.3	163.0	182.6	180.4	185.0	198.1	194.7	201.1	213.1	208.9	217.4
SUIKERBOSCHFONTEIN	0517566_W	21.7	33	25	56	30	18	788	1768	1 d	70.4	70.0	70.7	93.3	92.9	93.8	109.6	108.7	110.6	126.1	124.6	127.7	148.6	145.5	151.6	166.5	162.2	171.6	185.2	178.7	192.9
										2 d	78.9	78.6	79.3	102.7	102.3	103.2	118.9	118.0	119.5	134.6	133.5	136.0	155.5	153.2	157.9	171.5	168.2	175.0	187.8	183.6	193.5
										3 d	86.9	86.6	87.4	112.5	112.1	113.1	129.5	129.0	130.2	146.0	145.3	146.6	167.3	166.2	168.2	183.2	181.8	185.0	199.2	197.3	201.2
										4 d	94.6	94.1	94.9	122.0	121.5	122.6	140.1	139.5	140.8	157.5	156.3	158.5	179.7	177.8	181.5	196.3	193.4	199.3	212.8	208.9	217.1
										5 d	99.8	99.2	100.2	128.5	128.0	129.1	147.4	146.3	148.1	165.4	163.9	167.0	188.5	185.7	191.4	205.6	201.6	209.8	222.6	217.3	228.4
										6 d	106.0	105.5	106.5	136.0	135.3	136.7	155.3	154.1	156.4	173.5	171.5	175.3	196.5	193.2	199.5	213.3	209.1	217.6	229.7	224.0	236.8
										7 d	112.3	111.7	112.8	143.9	143.3	144.6	164.2	163.5	165.1	183.3	181.9	184.9	207.2	204.7	209.9	224.7	220.9	228.2	241.8	237.1	246.7
ELANDSFONTEIN	0517275_W	23.4	41	25	35	30	9	771	1911	1 d	54.0	53.7	54.2	71.6	71.2	71.9	84.1	83.4	84.8	96.7	95.5	97.9	113.9	111.6	116.3	127.6	124.3	131.6	142.0	137.1	147.9
										2 d	69.1	68.8	69.4	89.9	89.5	90.3	104.0	103.3	104.5	117.8	116.8	119.0	136.1	134.1	138.2	150.1	147.1	153.2	164.3	160.7	169.4
										3 d	79.2	78.9	79.6	102.6	102.2	103.1	118.0	117.5	118.6	133.0	132.4	133.6	152.4	151.5	153.3	167.0	165.6	168.6	181.5	179.8	183.4
										4 d	88.1	87.6	88.5	113.7	113.2	114.3	130.6	130.0	131.2	146.7	145.6	147.7	167.5	165.6	169.2	182.9	180.2	185.7	198.3	194.7	202.3
										5 d	93.0	92.5	93.4	119.8	119.3	120.4	137.4	136.4	138.1	154.2	152.8	155.7	175.8	173.1	178.4	191.7	188.0	195.6	207.5	202.6	212.9
										6 d	100.6	100.0	101.0	129.0	128.4	129.6	147.3	146.2	148.4	164.6	162.7	166.3	186.4	183.2	189.2	202.3	198.3	206.4	217.9	212.5	224.6
										7 d	106.6	106.0	107.0	136.5	136.0	137.2	155.8	155.2	156.6	173.9	172.5	175.4	196.6	194.2	199.2	213.2	209.5	216.5	229.4	224.9	234.1

Gridded values of all points within the specified block

Latitude (°)	Latitude (')	Longitude (°)	Longitude (')	MAP (mm)	Altitude (m)	Duration (m/h/d)	2	2L	2U	5	5L	5U	10	10L	10U	20	20L	20U	50	50L	50U	100	100L	100U	200	200L	200U
25	47	30	8	766	1689	5 m	9.0	7.3	10.8	12.0	9.6	14.3	14.1	11.3	16.9	16.2	12.9	19.5	19.1	15.1	23.1	21.3	16.8	26.2	23.7	18.6	29.4
						10 m	13.0	10.3	15.7	17.2	13.7	20.8	20.2	16.0	24.6	23.3	18.3	28.4	27.4	21.4	33.7	30.7	23.9	38.1	34.2	26.3	42.9
						15 m	16.1	12.6	19.6	21.3	16.8	26.0	25.1	19.6	30.6	28.8	22.5	35.4	34.0	26.2	42.0	38.1	29.2	47.5	42.3	32.2	53.4
						30 m	20.6	16.5	24.8	27.3	21.8	32.9	32.1	25.6	38.8	36.9	29.3	44.8	43.5	34.2	53.2	48.8	38.1	60.2	54.2	42.0	67.7
						45 m	23.8	19.2	28.5	31.6	25.5	37.8	37.1	29.8	44.5	42.7	34.2	51.4	50.3	39.9	61.1	56.4	44.5	69.1	62.7	49.1	77.7
						1 h	26.4	21.5	31.4	35.0	28.5	41.7	41.2	33.3	49.1	47.3	38.2	56.7	55.8	44.6	67.4	62.5	49.7	76.3	69.5	54.8	85.7
						1.5 h	30.6	25.1	36.1	40.5	33.2	47.9	47.6	38.9	56.4	54.7	44.6	65.2	64.5	52.1	77.4	72.3	58.0	87.6	80.4	63.9	98.4
						2 h	33.9	28.0	39.8	44.9	37.1	52.8	52.7	43.4	62.3	60.6	49.8	71.9	71.5	58.1	85.4	80.1	64.8	96.6	89.1	71.4	108.6
						4 h	40.6	33.2	48.0	53.8	44.0	63.7	63.2	51.5	75.1	72.6	59.0	86.7	85.6	68.9	102.9	95.9	76.8	116.5	106.7	84.6	130.9
						6 h	45.1	36.6	53.6	59.8	48.6	71.0	70.2	56.9	83.8	80.7	65.2	96.7	95.2	76.1	114.8	106.6	84.8	130.0	118.6	93.5	146.1
						8 h	48.6	39.3	57.9	64.4	52.2	76.8	75.7	61.0	90.5	87.0	70.0	104.5	102.6	81.7	124.1	114.9	91.1	140.5	127.8	100.4	157.9
						10 h	51.5	41.5	61.5	68.3	55.1	81.6	80.2	64.5	96.2	92.2	73.9	111.0	108.7	86.3	131.8	121.8	96.2	149.2	135.4	106.0	167.7
						12 h	54.0	43.4	64.6	71.6	57.6	85.7	84.1	67.4	101.0	96.7	77.3	116.6	114.0	90.3	138.5	127.7	100.6	156.7	142.0	110.9	176.2
						16 h	58.2	46.6	69.8	77.2	61.9	92.6	90.6	72.4	109.2	104.2	83.0	126.1	122.8	96.9	149.7	137.6	108.0	169.4	153.1	119.0	190.4
						20 h	61.7	49.3	74.1	81.8	65.3	98.3	96.0	76.5	116.0	110.4	87.7	133.9	130.2	102.4	159.0	145.8	114.1	179.9	162.2	125.7	202.2
						24 h	64.7	51.5	77.9	85.7	68.3	103.3	100.7	80.0	121.8	115.8	91.7	140.7	136.5	107.1	167.0	152.9	119.3	189.0	170.1	131.5	212.4
						1 d	56.0	44.6	67.5	74.3	59.2	89.5	87.2	69.3	105.5	100.3	79.4	121.9	118.3	92.8	144.7	132.5	103.4	163.8	147.4	113.9	184.1
						2 d	69.1	59.6	78.5	91.7	79.1	104.1	107.6	92.5	122.8	123.8	106.1	141.7	145.9	123.9	168.3	163.5	138.0	190.5	181.8	152.2	214.1
						3 d	78.2	70.6	85.7	103.6	93.7	113.7	121.7	109.6	134.1	140.0	125.6	154.9	165.0	146.7	183.9	184.8	163.5	208.1	205.6	180.2	233.9
						4 d	85.0	75.4	94.6	112.7	100.0	125.5	132.3	117.0	147.9	152.2	134.1	170.8	179.4	156.6	202.8	201.0	174.5	229.6	223.5	192.3	258.0
						5 d	90.7	79.3	102.1	120.2	105.1	135.4	141.2	123.0	159.7	162.4	141.0	184.4	191.4	164.7	218.9	214.4	183.5	247.7	238.5	202.3	278.4
						6 d	95.6	82.6	108.6	126.8	109.6	144.1	148.9	128.2	169.9	171.2	147.0	196.2	201.8	171.6	232.9	226.1	191.3	263.6	251.5	210.8	296.3
						7 d	100.0	85.5	114.5	132.6	113.5	151.9	155.7	132.8	179.1	179.0	152.2	206.8	211.1	177.7	245.5	236.5	198.1	277.9	263.0	218.3	312.3

Appendix B

RATIONAL METHOD ALTERNATIVE 2 FOR DALMANUTHI WEF

RATIONAL METHOD (ALTERNATIVE 2)

Description of catchment	Dalmanutha West WEF		
River detail	Klein-Komati River		
Calculated by	WSP	**Date**	11-May-23

Physical characteristics

Size of catchment (A)	236	km^2	Rainfall region
Longest watercourse (L)	36	km	
Average slope (S_{av})	0.0102	m/m	
Dolomite area ($D_{\%}$)	0	%	
Mean annual precipitation (MAP)⓪[#]	750	mm	

Area distribution factors

Rural (α)	Urban (β)	Lakes (γ)
0.95	0.05	0

Rural ①

Surface slope	**%**	**Factor**	**C_s**
Wetlands and pans	20	0.03	0.006
Flat areas	70	0.08	0.056
Hilly	10	0.16	0.016
Steep areas	0	0.26	0
Total	100	-	0.078
Permeability	**%**	**Factor**	**C_p**
Very permeable	0	0.04	0
Permeable	50	0.08	0.04
Semi-permeable	50	0.16	0.08
Impermeable	0	0.26	0
Total	100	-	0.12
Vegetation	**%**	**Factor**	**C_v**
Thick bush and plantation	0	0.04	0
Light bush and farm-lands	45	0.11	0.0495
Grasslands	50	0.21	0.105
No vegetation	5	0.28	0.014
Total	100	-	0.1685

Urban ②

Description	**%**	**Factor**	**C_2**
Lawns			
Sandy, flat (<2%)	20	0.1	0.02
Sandy, steep (>7%)	10	0.2	0.02
Heavy soil, flat (<2%)	0	0.17	0
Heavy soil, steep (>7%)	0	0.35	0
Residential areas			
Houses	40	0.3	0.12
Flats	5	0.5	0.025
Industry			
Light industry	5	0.5	0.025
Heavy industry	0	0.6	0
Business			
City centre	0	0.7	0
Suburban	10	0.5	0.05
Streets	10	0.7	0.07
Maximum flood	0	1	0
Total (C_2)	100	-	0.33

Time of concentration (T_C)

Overland flow③	Defined watercourse
$T_C = 0{,}604\left(\frac{rL}{\sqrt{S_{av}}}\right)^{0{,}467}$	$T_C = \left(\frac{0{,}87L^2}{1000S_{av}}\right)^{0{,}385}$
hours	6.12 hours

Notes :

Assume no Dolomite.
Assume initial Saturation. (Catchment is flat and Permeable).

Run-off coefficient

Return period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Run-off coefficient, C_1 ($C_1 = C_S + C_P + C_V$)	0.3665	0.3665	0.3665	0.3665	0.3665	0.3665	
Adjusted for dolomitic areas, C_{1D} ($= C_1(1 - D_{\%}) + C_1 D_{\%}(\sum(D_{factor} \times C_{S\%}))$④	0.3665	0.3665	0.3665	0.3665	0.3665	0.3665	
Adjustment factor for initial saturation, F_t⑤	0.50	0.55	0.60	0.67	0.83	1.00	
Adjusted run-off coefficient, C_{1T} ($= C_{1D} \times F_t$)	0.1833	0.2016	0.2199	0.2456	0.3042	0.3665	
Combined run-off coefficient C_T ($= \alpha C_{1T} + \beta C_2 + \gamma C_3$)	0.1906	0.2080	0.2254	0.2498	0.3055	0.3647	

Rainfall

Return period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Point rainfall (mm), P_T⑥	32.91	55.52	72.62	89.73	112.34	129.45	
Point intensity (mm/hour), P_{iT} ($= P_T/T_C$)	5.38	9.07	11.86	14.66	18.35	21.15	
Area reduction factor (%), ARF_T⑦	90.60	90.60	90.60	90.60	90.60	90.60	
Average intensity (mm/hour), I_T ($= P_{iT} \times ARF_T$)	4.87	8.22	10.75	13.28	16.63	19.16	
Return period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Peak flow (m^3/s), $Q_T = \frac{C_T I_T A}{3{,}6}$	60.85	112.04	158.81	217.45	332.95	458.00	

RATIONAL METHOD (ALTERNATIVE 2)

Description of catchment	Dalmanutha WEF		
River detail	Waarkraalloop River		
Calculated by	WSP	**Date**	11-May-23

Physical characteristics

Size of catchment (A)	229	km²	Rainfall region		
Longest watercourse (L)	16.3	km	**Area distribution factors**		
Average slope (S_{av})	0.0144	m/m	Rural (α)	Urban (β)	Lakes (γ)
Dolomite area ($D_{\%}$)	0	%	0.9	0.1	0
Mean annual precipitation (MAP)⓪#	750	mm			

Rural ①				**Urban ②**			
Surface slope	**%**	**Factor**	**C_s**	**Description**	**%**	**Factor**	**C_2**
Wetlands and pans	20	0.03	0.006	**Lawns**			
Flat areas	70	0.08	0.056	Sandy, flat (<2%)	20	0.1	0.02
Hilly	10	0.16	0.016	Sandy, steep (>7%)	10	0.2	0.02
Steep areas	0	0.26	0	Heavy soil, flat (<2%)	0	0.17	0
Total	100	-	0.078	Heavy soil, steep (>7%)	0	0.35	0
Permeability	**%**	**Factor**	**C_p**	**Residential areas**			
Very permeable	0	0.04	0	Houses	40	0.3	0.12
Permeable	50	0.08	0.04	Flats	5	0.5	0.025
Semi-permeable	50	0.16	0.08	**Industry**			
Impermeable	0	0.26	0	Light industry	5	0.5	0.025
Total	100	-	0.12	Heavy industry	0	0.6	0
Vegetation	**%**	**Factor**	**C_v**	**Business**			
Thick bush and plantation	0	0.04	0	City centre	0	0.7	0
Light bush and farm-lands	45	0.11	0.0495	Suburban	10	0.5	0.05
Grasslands	50	0.21	0.105	Streets	10	0.7	0.07
No vegetation	5	0.28	0.014	Maximum flood	0	1	0
Total	100	-	0.1685	Total (C_2)	100	-	0.33

Time of concentration (T_C)

Overland flow③		Defined watercourse		Notes :
$T_C = 0,604\left(\frac{rL}{\sqrt{S_{av}}}\right)^{0,467}$		$T_C = \left(\frac{0,87L^2}{1000S_{av}}\right)^{0,385}$		Assume no Dolomite. Assume initial Saturation. (Catchment is flat and Permeable).
	hours	2.91	hours	

Run-off coefficient

Return period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Run-off coefficient, C_1 ($C_1 = C_S + C_P + C_V$)	0.3665	0.3665	0.3665	0.3665	0.3665	0.3665	
Adjusted for dolomitic areas, C_{1D} ($= C_1(1 - D_{\%}) + C_1 D_{\%}(\sum(D_{factor} \times C_{S\%}))$)④	0.3665	0.3665	0.3665	0.3665	0.3665	0.3665	
Adjustment factor for initial saturation, F_t⑤	0.50	0.55	0.60	0.67	0.83	1.00	
Adjusted run-off coefficient, C_{1T} ($= C_{1D} \times F_t$)	0.1833	0.2016	0.2199	0.2456	0.3042	0.3665	
Combined run-off coefficient C_T ($= \alpha C_{1T} + \beta C_2 + \gamma C_3$)	0.1979	0.2144	0.2309	0.2540	0.3068	0.3629	

Rainfall

Return period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Point rainfall (mm), P_T⑥	28.47	48.02	62.81	77.6	97.16	111.95	
Point intensity (mm/hour), P_{iT} ($= P_T/T_C$)	9.78	16.49	21.57	26.65	33.37	38.45	
Area reduction factor (%), ARF_T⑦	87.30	87.30	87.30	87.30	87.30	87.30	
Average intensity (mm/hour), I_T ($= P_{iT} \times ARF_T$)	8.54	14.40	18.83	23.26	29.13	33.56	
Return period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Peak flow (m³/s), $Q_T = \frac{C_T I_T A}{3,6}$	107.46	196.36	276.59	375.89	568.42	774.66	

Appendix C

RATIONAL METHOD ALTERNATIVE 3 RESULTS FOR THE DALMANUTHI WEF

RATIONAL METHOD (ALTERNATIVE 3)

Description of catchment	Dalmanutha WEF		
River detail	Waarkraalloop River		
Calculated by	WSP	**Date**	11-May-23

Physical characteristics

Size of catchment (A)	229	km²	Rainfall region		
Longest watercourse (L)	16.3	km	**Area distribution factors**		
Average slope (S_{av})	0.0144	m/m	Rural (α)	Urban (β)	Lakes (γ)
Dolomite area ($D_{\%}$)	0	%	0.95	0.05	0
Mean annual precipitation (MAP)⓪#	750	mm			

Rural ①

Surface slope	**%**	**Factor**	C_s
Wetlands and pans	20	0.03	0.006
Flat areas	70	0.08	0.056
Hilly	10	0.16	0.016
Steep areas	0	0.26	0
Total	100	-	0.078
Permeability	**%**	**Factor**	C_p
Very permeable	0	0.04	0
Permeable	50	0.08	0.04
Semi-permeable	50	0.16	0.08
Impermeable	0	0.26	0
Total	100	-	0.12
Vegetation	**%**	**Factor**	C_v
Thick bush and plantation	0	0.04	0
Light bush and farm-lands	45	0.11	0.0495
Grasslands	50	0.21	0.105
No vegetation	5	0.28	0.014
Total	100	-	0.1685

Urban ②

Description	**%**	**Factor**	C_2
Lawns			
Sandy, flat (<2%)	20	0.1	0.02
Sandy, steep (>7%)	10	0.2	0.02
Heavy soil, flat (<2%)	0	0.17	0
Heavy soil, steep (>7%)	0	0.35	0
Residential areas			
Houses	40	0.3	0.12
Flats	5	0.5	0.025
Industry			
Light industry	5	0.5	0.025
Heavy industry	0	0.6	0
Business			
City centre	0	0.7	0
Suburban	10	0.5	0.05
Streets	10	0.7	0.07
Maximum flood	0	1	0
Total (C_2)	100	-	0.33

Time of concentration (T_C)

Overland flow③	Defined watercourse
$T_C = 0{,}604\left(\frac{rL}{\sqrt{S_{av}}}\right)^{0{,}467}$	$T_C = \left(\frac{0{,}87L^2}{1000S_{av}}\right)^{0{,}385}$
hours	2.91 hours

Notes :

Assume no Dolomite.
Assume initial Saturation. (Catchment is flat and Permeable).

Run-off coefficient

Return period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Run-off coefficient, C_1 ($C_1 = C_S + C_P + C_V$)	0.3665	0.3665	0.3665	0.3665	0.3665	0.3665	
Adjusted for dolomitic areas, C_{1D} ($= C_1(1 - D_{\%}) + C_1 D_{\%}(\sum(D_{factor} \times C_{S\%}))$)④	0.3665	0.3665	0.3665	0.3665	0.3665	0.3665	
Adjustment factor for initial saturation, F_t⑤	0.50	0.55	0.60	0.67	0.83	1.00	
Adjusted run-off coefficient, C_{1T} ($= C_{1D} \times F_t$)	0.1833	0.2016	0.2199	0.2456	0.3042	0.3665	
Combined run-off coefficient C_T ($= \alpha C_{1T} + \beta C_2 + \gamma C_3$)	0.1906	0.2080	0.2254	0.2498	0.3055	0.3647	

Rainfall

Return period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Point rainfall (mm), P_T⑥	36.35	48.15	56.53	65	76.68	85.9	
Point intensity (mm/hour), P_{iT} ($= P_T/T_C$)	12.48	16.54	19.42	22.32	26.34	29.50	
Area reduction factor (%), ARF_T⑦	87.30	87.30	87.30	87.30	87.30	87.30	
Average intensity (mm/hour), I_T ($= P_{iT} \times ARF_T$)	10.90	14.44	16.95	19.49	22.99	25.75	
Return period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Peak flow (m³/s), $Q_T = \frac{C_T I_T A}{3{,}6}$	132.13	191.01	243.02	309.64	446.76	597.44	

RATIONAL METHOD (ALTERNATIVE 3)

Description of catchment	Dalmanutha West WEF		
River detail	Klein-Komati River		
Calculated by	WSP	**Date**	11-May-23

Physical characteristics

Size of catchment (A)	236	km^2	Rainfall region		
Longest watercourse (L)	36	km	**Area distribution factors**		
Average slope (S_{av})	0.0102	m/m	Rural (α)	Urban (β)	Lakes (γ)
Dolomite area ($D_{\%}$)	0	%	0.95	0.05	0
Mean annual precipitation (MAP)⓪[#]	750	mm			

Rural①				**Urban②**			
Surface slope	**%**	**Factor**	**C_s**	**Description**	**%**	**Factor**	**C_2**
Wetlands and pans	20	0.03	0.006	**Lawns**			
Flat areas	70	0.08	0.056	Sandy, flat (<2%)	20	0.1	0.02
Hilly	10	0.16	0.016	Sandy, steep (>7%)	10	0.2	0.02
Steep areas	0	0.26	0	Heavy soil, flat (<2%)	0	0.17	0
Total	100	-	0.078	Heavy soil, steep (>7%)	0	0.35	0
Permeability	**%**	**Factor**	**C_p**	**Residential areas**			
Very permeable	0	0.04	0	Houses	40	0.3	0.12
Permeable	50	0.08	0.04	Flats	5	0.5	0.025
Semi-permeable	50	0.16	0.08	**Industry**			
Impermeable	0	0.26	0	Light industry	5	0.5	0.025
Total	100	-	0.12	Heavy industry	0	0.6	0
Vegetation	**%**	**Factor**	**C_v**	**Business**			
Thick bush and plantation	0	0.04	0	City centre	0	0.7	0
Light bush and farm-lands	45	0.11	0.0495	Suburban	10	0.5	0.05
Grasslands	50	0.21	0.105	Streets	10	0.7	0.07
No vegetation	5	0.28	0.014	Maximum flood	0	1	0
Total	100	-	0.1685	Total (C_2)	100	-	0.33

Time of concentration (T_C)				Notes :
Overland flow③		Defined watercourse		Assume no Dolomite. Assume initial Saturation. (Catchment is flat and Permeable).
$T_C = 0{,}604\left(\frac{rL}{\sqrt{S_{av}}}\right)^{0{,}467}$		$T_C = \left(\frac{0{,}87L^2}{1000S_{av}}\right)^{0{,}385}$		
	hours	6.12	hours	

Run-off coefficient

Return period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Run-off coefficient, C_1 ($C_1 = C_S + C_P + C_V$)	0.3665	0.3665	0.3665	0.3665	0.3665	0.3665	
Adjusted for dolomitic areas, C_{1D} ($= C_1(1 - D_{\%}) + C_1 D_{\%}(\sum(D_{factor} \times C_{S\%}))$)④	0.3665	0.3665	0.3665	0.3665	0.3665	0.3665	
Adjustment factor for initial saturation, F_t⑤	0.50	0.55	0.60	0.67	0.83	1.00	
Adjusted run-off coefficient, C_{1T} ($= C_{1D} \times F_t$)	0.1833	0.2016	0.2199	0.2456	0.3042	0.3665	
Combined run-off coefficient C_T ($= \alpha C_{1T} + \beta C_2 + \gamma C_3$)	0.1906	0.2080	0.2254	0.2498	0.3055	0.3647	

Rainfall

Return period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Point rainfall (mm), P_T⑥	43.99	58.29	68.49	78.73	92.86	103.97	
Point intensity (mm/hour), P_{iT} ($= P_T/T_C$)	7.19	9.52	11.19	12.86	15.17	16.98	
Area reduction factor (%), ARF_T⑦	90.60	90.60	90.60	90.60	90.60	90.60	
Average intensity (mm/hour), I_T ($= P_{iT} \times ARF_T$)	6.51	8.63	10.14	11.65	13.74	15.39	
Return period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Peak flow (m^3/s), $Q_T = \frac{C_T I_T A}{3{,}6}$	81.34	117.63	149.78	190.79	275.22	367.85	

Appendix D

SDF RESULTS FOR THE DALMANUTHI WEF

STANDARD DESIGN FLOOD METHOD

Description of catchment	Dalmanutha WEF		
River detail	Waarkraalloop River		
Calculated by	WSP	**Date**	11-May-23

Physical characteristics

Size of catchment (A)	229	km^2	Time of concentration (T_C) $T_C = \left(\frac{0,87L^2}{1000S_{av}}\right)^{0,385}$	2.9116	hours
Longest watercourse (L)	16.3	km			
Average slope (S_{av})	0.014400	m/m			
SDF basin⓪*	29		Time of concentration, t (= $60T_C$)	174.6952	minutes
2-year return period rainfall (M)①	66	mm	Days of thunder per year (R)①	11	days/year

TR102 n-day rainfall data

Weather Service station		Mean annual precipitation (MAP)	749	mm
Weather Service station no.		Coordinates	&	

Duration (days)	Return period (years) 2	5	10	20	50	100	200
1 day	66	93	113	135	168	196	
2 days	78	108	130	154	189	218	
3 days	89	125	153	183	227	265	
7 days	113	159	194	232	286	331	

Rainfall

Return period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**200**
Point precipitation depth (mm), $P_{t,T}$②	28.4645	48.0194	62.8120	77.6047	97.1596	111.9523	
Area reduction factor (%), ARF $\left(= (90000 - 12800\ln A + 9830\ln t)^{0.4}\right)$	87.2961	87.2961	87.2961	87.2961	87.2961	87.2961	
Average intensity (mm/hour), I_T (= $P_{t,T}$ x ARF / T_C)	8.5343	14.3973	18.8325	23.2677	29.1307	33.5659	

Run-off coefficients

Calibration factors①	C_2 (2-year return period) (%)	15	C_{100} (100-year return period) (%)	100

Return period (years)	**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), $C_T = \frac{C_2}{100} + \left(\frac{Y_T}{2,33}\right)\left(\frac{C_{100}}{100} - \frac{C_2}{100}\right)$	0.1500	0.4564	0.6170	0.7483	0.8979	1	
Peak flow (m^3/s), $Q_T = \frac{C_T I_T A}{3,6}$	81.431491	418.0187	739.082072	1107.5212	1663.75473	2135.16185	

STANDARD DESIGN FLOOD METHOD

Description of catchment	Dalmanutha WEF		
River detail	Klein-Komati		
Calculated by	WSP	**Date**	11-May-23

Physical characteristics

Size of catchment (A)	236	km²	Time of concentration (T_C) $T_C = \left(\frac{0,87L^2}{1000S_{av}}\right)^{0,385}$	6.1215	hours
Longest watercourse (L)	36	km			
Average slope (S_{av})	0.01019	m/m			
SDF basin⓪#	29		Time of concentration, t (= $60T_C$)	367.288	minutes
2-year return period rainfall (M)①	66	mm	Days of thunder per year (R)①	11	days/year

TR102 n-day rainfall data

Weather Service station		Mean annual precipitation (MAP)	749	mm
Weather Service station no.		Coordinates	&	

Duration (days)	Return period (years) 2	5	10	20	50	100	200
1 day	66	93	113	135	168	196	
2 days	78	108	130	154	189	218	
3 days	89	125	153	183	227	265	
7 days	113	159	194	232	286	331	

Rainfall

Return period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**200**
Point precipitation depth (mm), $P_{t,T}$②	32.9123	55.5227	72.6269	89.7310	112.3415	129.4457	
Area reduction factor (%), ARF $\left(=(90000-12800\ln A+9830\ln t)^{0.4}\right)$	90.5953	90.5953	90.5953	90.5953	90.5953	90.5953	
Average intensity (mm/hour), I_T (= $P_{t,T}$ x ARF / T_C)	4.8709	8.2172	10.7485	13.2799	16.6261	19.1575	

Run-off coefficients

Calibration factors①	C_2 (2-year return period) (%)	15	C_{100} (100-year return period) (%)	100

Return period (years)	**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), $C_T = \frac{C_2}{100} + \left(\frac{Y_T}{2,33}\right)\left(\frac{C_{100}}{100} - \frac{C_2}{100}\right)$	0.1500	0.4564	0.6170	0.7483	0.8979	1	
Peak flow (m³/s), $Q_T = \frac{C_T I_T A}{3,6}$	47.89709	245.8739	434.71978	651.4315469	978.60187	1255.8783	

Appendix E

DOCUMENT LIMITATIONS

DOCUMENT LIMITATIONS

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