UPGRADE ENERGY (PTY) LTD

Wildebeestkuil PV2 SWMP

Stormwater Management Plan

Issue Date: 22 March 2021
Revision No: 0
Project No: 15962
Document No: 15962-WILDEBEESTKUIL_PV2-SWMP-VM-REV0.DOCX

Date:	22 March 2021
Document Title:	15962 – Wildebeestkuil PV2 SWMP
Revision Number	0
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Client:	Upgrade Energy (Pty) Ltd

Confidentiality Statement

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1. INTRODUCTION & BACKGROUND

Upgrade Energy (Pty) Ltd propose to construct four 5MW Photovoltaic (PV) facilities and associated infrastructure on Farm Wildebeestkuil 59 and Farm Leeuwbosch 44, approximately 6-8km east of Leeudoringstad in the North West Province. The proposed sites are located within the Maquassi Hills Local Municipality which falls within the Dr Kenneth Kaunda District Municipality.

SiVEST SA (Pty) Ltd (SiVEST) were appointed to undertake the Basic Assessment Process which requires various specialist studies. SiVEST's Civil Engineering Division was appointed as the specialist consultant to develop a conceptual stormwater management plan (SWMP) for each of the proposed sites.

This SWMP focuses on the Wildebeestkuil PV2 site which is located on Farm Wildebeestkuil No 59 (Portions 13, 14, 22). This report serves to provide a broad guideline for the developers, owners and professional teams to manage the stormwater and comply with the necessary rules and regulations of the relevant authorities and should not be viewed as a detailed design report.

The locality of the project and the PV site is shown in Figure 3-1 and Figure 3-2.

2. OBJECTIVES & SCOPE OF WORK

The main objective of the study is to develop a conceptual stormwater management plan for Site PV2. The scope of works comprises the following:

- Data collection;
- Liaison with the client;
- Site inspection to confirm topographical conditions;
- Hydrological assessment of the site;
- Development of conceptual drawings and design guidelines; and Compilation of the SWMP in the form of report.

3. DATA COLLECTION

The following data was collected and used to undertake this study:

- 5m contour data from Planet GIS;
- Proposed development footprint from SiVEST Environmental;
- Climate information from South African Weather Services;
- Design Rainfall data (JC Smithers & RE Schulze);
- Aerial Imagery from Google Earth and ESRI online base maps.

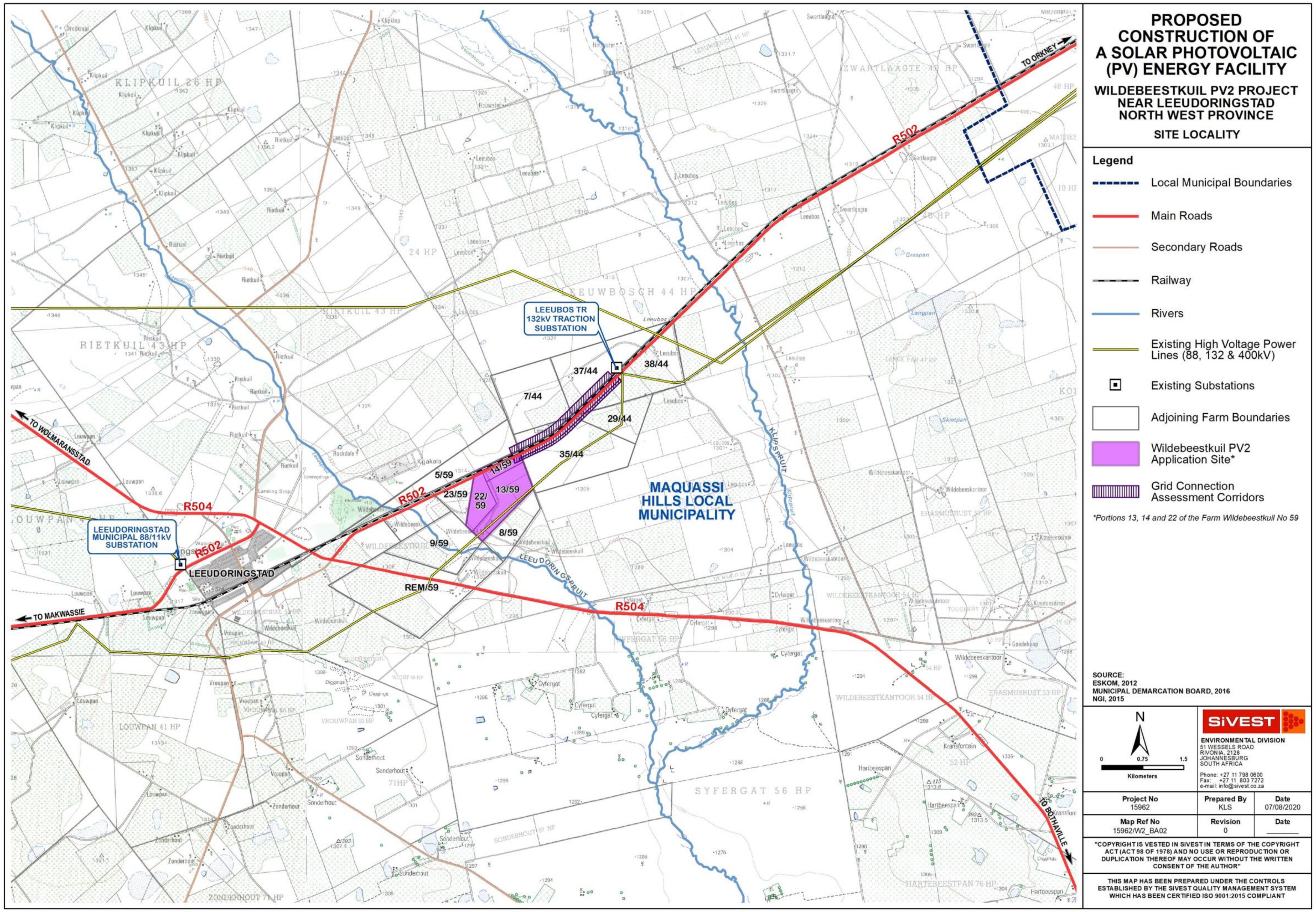


Figure 3-1: Site Locality

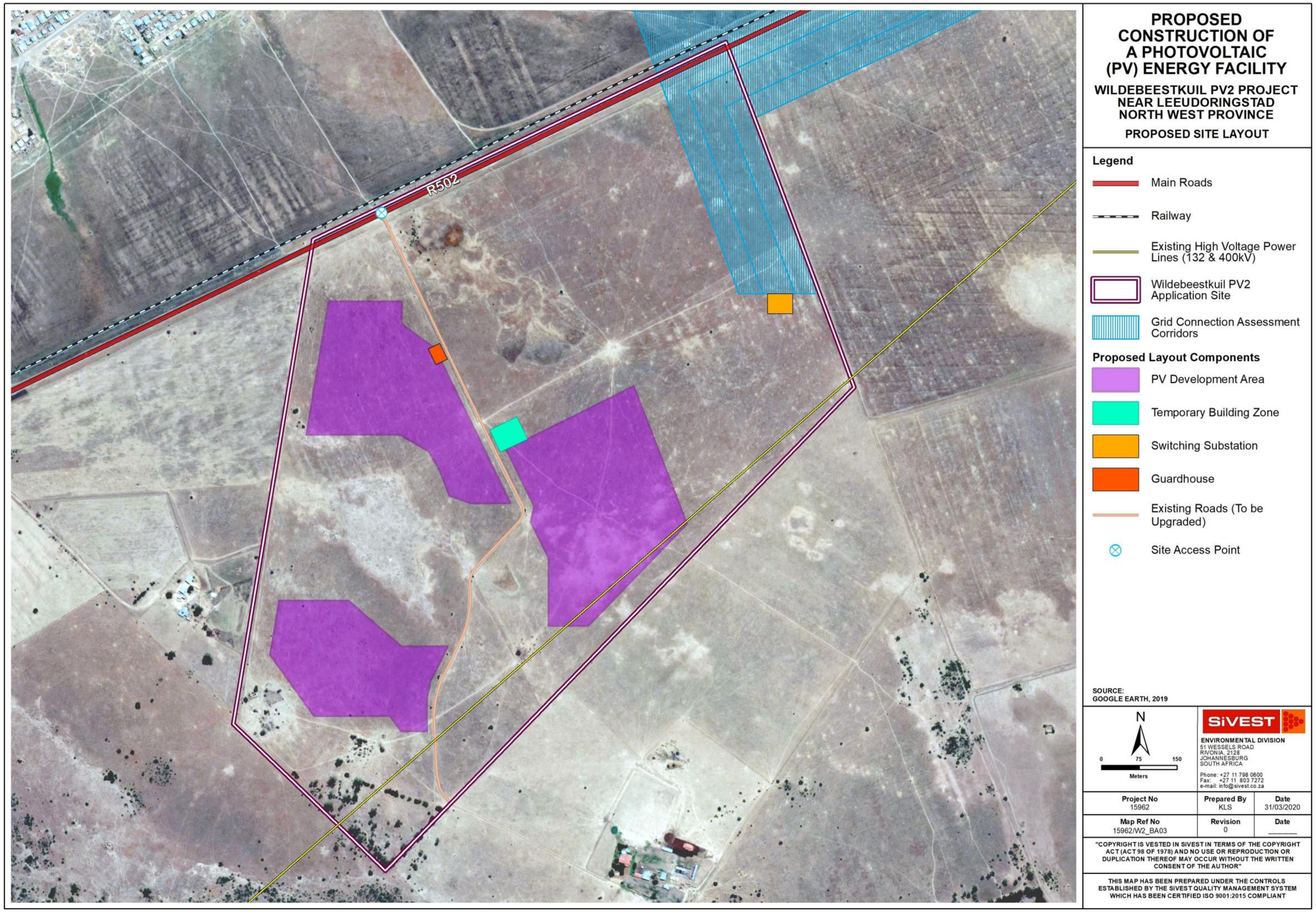


Figure 3-2: Wildebeestkuil PV2 Site Layout

4. STORMWATER MANAGEMENT PHILOSOPHY

Development is a process of change or growth that usually involves the construction of buildings, roads and infrastructure which leads to a change in the hydraulic properties of an area. Permeable layers become less permeable or impermeable resulting in increased surface runoff and flood volumes. Conduits are constructed to drain runoff more efficiently resulting in shorter catchment response times and increased peak flows. Natural vegetation is often removed, reducing interception and transpiration and exposing soil to the impact of rain which may lead to increased erosion.

In order to lessen the negative impacts and enhance the positive impacts on the environment as a result of development, responsible management of stormwater is required. This can be achieved through the implementation of various mitigation measures in accordance with drainage requirements and guidelines as set out by the local authority.

Stormwater Management policies require that, for storms of similar recurrence intervals, the post-development runoff from an area may not exceed the runoff generated under the pre-development condition. The study area falls within The Maquassi Hills Local Municipality and, in the absence of site specific design guidelines, the stormwater drainage system should be designed in accordance with the criteria given in the "Red Book" [1] as well as the Drainage Manual[2]. This drainage system can be divided into minor and major stormwater systems.

The minor stormwater system comprises elements that aid in conveying stormwater runoff from within the development and road reserves to the major stormwater system. These elements include catch pits inlet structures, gutters, berms, canals, road verges, pipes and culverts.

The major stormwater system comprises elements of the minor system, road surfaces, natural low points, streams, rivers, wetlands, dams and flood attenuation structures necessary to control and drain stormwater or larger storms without damage and loss of life.

Stormwater runoff shall not be concentrated to an extent that would result in any damage to the downstream riverine ecology and/or built environment during storms with a recurrence interval exceeding 1:10 years and would result in only minor, repairable damage during storms with a recurrence interval exceeding 1:50 years.

To this end, the minor and major stormwater systems shall be designed to convey and withstand the 1:10 and 1:50 year flood events respectively. This is a guideline and the onus is on the design engineer to determine the risks associated with a storm with a specific recurrence interval. For areas where the risk of loss is unacceptably high, a higher recurrence interval and a higher level of service may need to be considered. For larger structures such as bridges and major culverts, the Department of Transport's specific requirements shall be considered.

Drainage systems must be maintained in a clean state, free of any rubbish, debris and matter likely to restrict the flow of stormwater or pose a pollution threat regulated by the departments of Water Affairs & Forestry, Environmental Affairs & Tourism and Health.

The Stormwater Management Philosophy for the development encourages the developer, the professional teams and contractors to do the following:

- Maintain adequate ground cover in all areas at all times to reduce the risk or erosion by wind, water and all forms of traffic;
- Prevent concentration of stormwater flow at any point where the ground is susceptible to erosion. Where unavoidable, adequate protection of the ground must be provided;
- Reduce stormwater flows as much as possible by providing effective attenuation measures;

[1] *Guidelines for Human Settlement Planning and Design compiled by CSIR Building and Construction Technology*
[2] *Drainage Manual 6th Edition, Published by The South African National Roads Agency SOC Ltd, 2013*

- Ensure that development does not increase the rate of stormwater flow above that which the natural ground can safely accommodate at any point;
- Ensure that all stormwater control works are constructed in a safe and aesthetic manner in keeping with the overall development;
- Prevent pollution of waterways and water features;
- Contain soil erosion by constructing protective works to trap sediment at appropriate locations. This applies particularly during construction; and
- Avoid situations where natural or artificial slopes may become saturated and unstable, both during and after the construction process.

The main stormwater management objectives and criteria that are considered to be relevant to the design and planning of stormwater drainage systems include:

- Minimising the threat of flooding;
- Minimising public inconvenience caused by frequent storms;
- Protecting the public and preventing the loss of life due to severe storms and/or malfunctioning drainage systems;
- Preventing erosion and siltation;
- Protection of receiving water bodies;
- Minimising costs;
- Sustainability of stormwater management systems; and
- Environmental and water pollution considerations.

5. HYDROLOGICAL ASSESSMENT

The methods described in the Drainage Manual were used to carry out hydrological assessments of the catchments and site.

5.1. CATCHMENT DESCRIPTION

The catchment is small (4.3km2) and flat (<1%) and falls within the C25A quaternary catchment. It is long and elongated with no evidence of clearly defined watercourses. Overland sheet flow occurs in a southerly direction through the site. The catchment runoff will eventually discharge into the Leeudoringspruit.

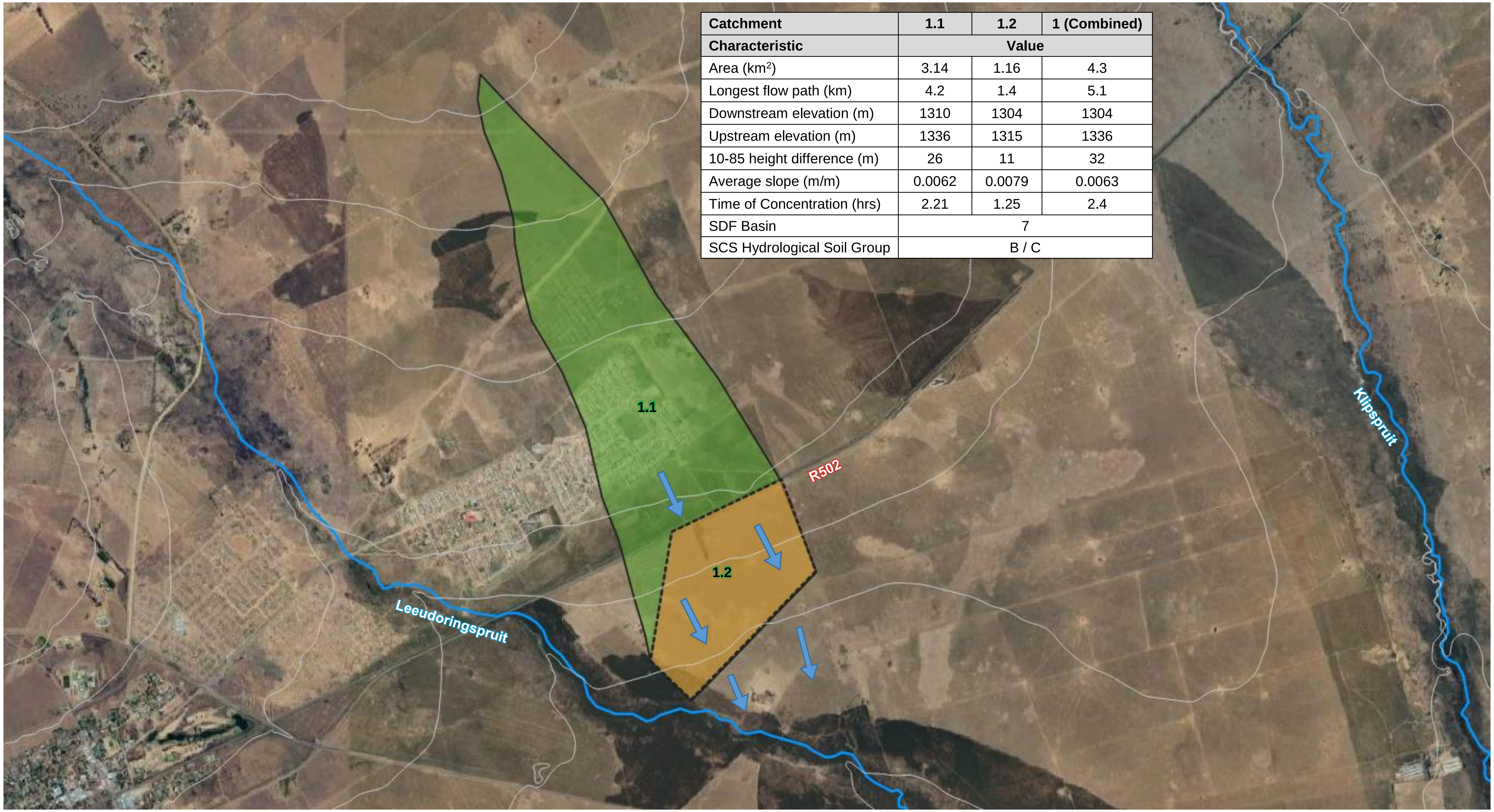
The landuse is predominantly rural grasslands and grazing fields. A small portion is made up of residential and commercial farming. Soils were classed under the SCS hydrological soil groups and found to be a mix of groups B and C. Group B soils have a moderately low stormflow potential (moderate infiltration rates, soil depths and slightly restricted permeability). Group C soils have a moderately high stormflow potential (slow infiltration rates, shallow soil depths and restricted permeability).

The catchment was subdivided to separate the application site from the upper catchment. This would help determine the runoff entering and leaving the site which may be used in the design of mitigation measures if/where needed.

The site is located safely away from any rivers or floodplains and will therefore not impact on or be impacted by a floodline.

5.2. CATCHMENT CHARACTERISTICS

The contributing catchments and their characteristics were determined using the existing 5m contours and aerial imagery. The catchment characteristics and delineations are illustrated in Figure 5-1 below.



Catchment	1.1	1.2	1 (Combined)
Characteristic	Value		
Area (km²)	3.14	1.16	4.3
Longest flow path (km)	4.2	1.4	5.1
Downstream elevation (m)	1310	1304	1304
Upstream elevation (m)	1336	1315	1336
10-85 height difference (m)	26	11	32
Average slope (m/m)	0.0062	0.0079	0.0063
Time of Concentration (hrs)	2.21	1.25	2.4
SDF Basin	7		
SCS Hydrological Soil Group	B / C		

Figure 5-1: Catchments

5.3. CLIMATE

According to the Köppen-Geiger map updated by the CSIR to quantify the current South African climatic conditions, the site is given a BSk classification. This is indicative of a semi-arid climate, with cool, dry winters and warm to hot summers.

December and January are the hottest months of the year with an average temperature of approximately 30°C. June and July are the coldest months of the year with an average temperature of approximately 17°C.

The mean annual precipitation is approximately 550mm with most rainfall occurring mainly during summer. The Design Rainfall Estimation[3] software was used to obtain the rainfall data (tabulated below) required for the runoff calculations.

Table 5-1: Design Rainfall

Return Period		2yr	5yr	10yr	20yr	50yr	100yr	200yr
Duration		**Rainfall Depth (mm)**						
5	m	9.40	12.70	14.90	17.20	20.30	22.70	25.10
10	m	13.90	18.80	22.20	25.55	30.10	33.70	37.30
15	m	17.55	23.70	28.00	32.20	37.95	42.45	47.05
30	m	22.20	30.00	35.40	40.80	48.05	53.75	59.55
45	m	25.50	34.45	40.65	46.80	55.15	61.70	68.35
60	m	28.10	38.00	44.85	51.65	60.85	68.05	75.40
90	m	32.30	43.60	51.45	59.30	69.85	78.10	86.55
120	m	35.60	48.10	56.75	65.40	77.05	86.15	95.45
240	m	41.65	56.25	66.40	76.45	90.15	100.75	111.65
360	m	45.65	61.65	72.75	83.85	98.75	110.45	122.40
480	m	48.70	65.85	77.65	89.45	105.40	117.85	130.65
600	m	51.25	69.25	81.65	94.10	110.85	123.95	137.40
720	m	53.40	72.15	85.15	98.05	115.55	129.15	143.20
960	m	57.00	76.95	90.85	104.65	123.30	137.80	152.80
1200	m	59.95	80.95	95.55	110.05	129.70	145.00	160.70
1440	m	62.45	84.35	99.55	114.70	135.10	151.10	167.50
1	d	51.95	70.15	82.80	95.40	112.40	125.60	139.30
2	d	63.85	86.35	101.85	117.35	138.20	154.55	171.30
3	d	72.15	97.45	115.00	132.45	156.05	174.45	193.40
4	d	78.25	105.70	124.80	143.70	169.35	189.30	209.85
5	d	83.40	112.65	132.90	153.10	180.45	201.65	223.60
6	d	87.80	118.60	140.00	161.25	190.05	212.40	235.50
7	d	91.75	123.90	146.25	168.50	198.55	221.90	246.00

[3] *Design Rainfall Estimation in South Africa Version 3 developed by MJ Gorven, JC Smithers and RE Schulze*

5.4. PEAK RUNOFF FLOWS

The runoff peak values were calculated using the widely-used Rational Method, which is considered appropriate for catchments less than 15km2. The Rational Method is based on a simplified representation of the law of conservation of mass and the hypothesis that the flow rate is directly proportional to the size of the contributing area and the rainfall intensity, with the latter a function of the return period. It is a method of estimating the runoff in a drainage basin at a specific point in time by means of the rational formula,

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

Where, *C* is a runoff coefficient based on the type of surface,
I is the rainfall intensity in mm per hour, and
A is the area in km^2.

Three phases of the project were considered and assessed. These included the pre-development, construction and post-development scenarios.

5.4.1. Pre-Development

The adopted peak flows are tabulated below with the detailed calculations included in Appendix A

Table 5-2: Adopted Pre-Development Peak Runoff Flows

Return Period	1:2	1:5	1:10	1:20	1:50	1:100
Catchment	**Peak Runoff (m^3/s)**					
1.1	6.02	8.12	9.58	11.04	13.01	14.54
1.2	2.57	3.47	4.10	4.72	5.56	6.22
1	7.33	9.89	11.69	13.46	15.87	17.74

5.4.2. Construction Phase

During construction the site will be highly susceptible to erosion and other stormwater-related impacts. Activities such as site clearance, topsoil removal, excavation and compaction of soils due to plant and vehicular traffic all contribute towards reducing infiltration and permeability and increasing stormwater runoff. The construction site will be deemed to be highly impermeable during this phase.

The allowance for the PV2 site amounts to just under a 30Ha footprint which is roughly 25% of the area of Catchment 1.2.

The adopted peak flows are tabulated below with the detailed calculations included in Appendix A

Table 5-3: Adopted Construction Phase Peak Runoff Flows

Return Period	1:2	1:5	1:10	1:20	1:50	1:100
Catchment	**Peak Runoff (m^3/s)**					
1.1	6.02	8.12	9.58	11.04	13.01	14.54
1.2	3.66	4.94	5.84	6.72	7.92	8.86
1	7.88	10.64	12.56	14.47	17.06	19.07

5.4.3. Post-Development

As there are no design plans or details available at this stage of the project, research on similar facilities was undertaken in order to make reasonable assumptions regarding the design of the PV facility. The final detailed design will influence the layout and arrangement of the PV arrays and therefore its footprint. The client has advised that approximately 10Ha will be required to construct a 5MW PV Facility.

It may comprise the following infrastructure:

- Photovoltaic (PV) Panels
- PV mounting structures
- Switching substation
- Transformers
- Internal underground electrical reticulation
- Auxiliary buildings (guardhouse, office etc.)
- Temporary laydown area for the construction phase
- Internal roads (gravel) and perimeter fencing
- Access road off the R502

The estimated portion of land each component will typically occupy is summarised below.

Table 5-4: Typical Landuse Proportions for PV Facility

Component	% of footprint	Area (Ha)	% of Farm (116Ha)
PV Arrays	90%	9	7.8%
Buildings Substations Transformers	5%	0.5	0.4%
Internal and Access Roads	5%	0.5	0.4%

The layout of the PV facility and associated infrastructure will impact on the runoff distribution patterns. It is assumed that the facilities orientation and configuration will be designed to minimise the impact on the natural drainage patterns.

Whilst the PV panels are impervious and occupy the majority of the site area, they will not significantly impact on the runoff volume. They will be mounted on a structure (typically a modular frame or vertical poles) which will keep them elevated above and off the ground. The structure will either be pile driven or require concrete strip footings depending on the soil conditions. The impact of these mounting structures on the effective pervious area is deemed to be negligible.

The hardened (impervious) area of the site amounts to approximately 1Ha which is less than 1% of the total farm portion area, therefore there will be no significant change in the runoff volume post-development.

The adopted peak flows are tabulated below with the detailed calculations included in Appendix A.

Table 5-5: Adopted Post-Development Peak Runoff Flows

Return Period	1:2	1:5	1:10	1:20	1:50	1:100
Catchment	**Peak Runoff (m^3/s)**					
1.1	6.02	8.12	9.58	11.04	13.01	14.54
1.2	2.57	3.47	4.10	4.72	5.56	6.22
1	7.33	9.89	11.69	13.46	15.87	17.74

6. STORMWATER MANGEMENT POLICY

The following rules are to be observed by the owner, developer, professional team, contractors and sub-contractors:

- Development designs must include measures for attenuating the concentration of and, increase in stormwater runoff. The post-development peak flows are to be attenuated back to pre-development conditions;
- Before the commencement of any construction activities, a plan must be agreed upon which details the measures to be implemented to control and prevent erosion during and after construction;

- On-site stormwater control systems, such as swales, berms and attenuation ponds are to be constructed before any other construction commences. These systems are to be monitored and appropriately adjusted as construction progresses to ensure complete stormwater, erosion and pollution control at all times;
- All embankments to be formed must be adequately stabilized;
- Stormwater must not be allowed to pond in close proximity to building foundations;
- An approved landscaping and re-vegetation plan must be implemented immediately after building works have reached a stage where newly established ground cover is not at risk from the construction works;
- No work is to commence without an approved Stormwater Control Plan (SCP). The SCP must describe what stormwater control measures are to be implemented before, during and after construction. Plans must indicate all persons responsible for the design and on-site monitoring during each stage of the implementation of the control measures;
- The SCP must show that all the provisions, regulations and guidelines contained in this document have been considered;
- In the event of a failure to adequately implement the approved SCP, the contractor shall be responsible for making good all consequential damage at his own cost. The developer is therefore advised to ensure that all members of the professional team and contractors are competent to undertake the development work and are adequately insured;
- The management of stormwater run-off during construction will be controlled by the Environmental Management Plan (EMP) as produced by the Environmental Control Officer (ECO). All construction activities within the development must comply with the EMP. This document is supplementary to the EMP and the control measures set out herein are not to be considered all-encompassing as the contractor will also have to adapt his control measures to the varying onsite conditions;
- All elements of the minor stormwater system shall be designed to safely accommodate and convey the 1:10 year storm event to the major stormwater system elements, which will be designed to accommodate the 1:50 year storm event. Exceptions to these capacities are to be made by the design engineer after assessing the risks;
- Attenuation/Detention facilities will be located at appropriately selected sites based on geotechnical, environmental and topographical conditions, including wetland conservation;
- Where conditions permit, open ditches, drains and channels will be used instead of pipes. On steeper slopes, where high flow velocities are anticipated, appropriate linings for all channels must be provided to withstand erosion. Such linings will vary from vegetated earthen to stone pitching and reinforced concrete;
- Flow velocities must be reduced wherever possible to reduce the erosion potential in channels, natural ground and points of flow concentration (typically at outlets);
- Silt, trash and oil traps must be strategically provided to ensure water quality is not compromised and to prevent blockages in the drainage systems;
- Areas within the proposed development that bound on stormwater attenuation areas, near road crossings, watercourse confluences and water features might be subject to flooding. In these situations, all development should take place above the outfall levels with an appropriate freeboard allowance;
- For areas flowing into the development area, potential future development in these sub-catchments should be considered and any stormwater attenuation requirements should be identified. Likewise, consideration must be given to the stormwater flowing out of the development which may impact on the downstream areas and watercourses. Appropriate measures must be taken to ensure any upstream development does not result in an increased flood damage risk downstream; and
- All natural and unlined channels should be inspected for adequate binding of soil by sustainable ground cover. Stone pitching should be used to reinforce channel inverts on steep slopes. Existing wetlands and stormwater attenuation areas should be protected from encroachment by the development.

7. GUIDELINES FOR OWNERS AND DEVELOPERS

The buildings/structures within the development will be required to control stormwater runoff in accordance with the stormwater management philosophy and policies of the local authority / municipality. The following guidelines are intended to assist in the design of the major and minor stormwater systems infrastructure, and to ensure that the objectives of this SWMP are met during the planning, design, construction and operational phases of all developments.

7.1. BUILDINGS

Any building will inevitably result in some degree of flow concentration, or deflection of flow around the building. The developer/owner shall ensure that all stormwater flow paths are protected against erosion. Discharge from the site must be attenuated back to the pre-development state.

Any inlet to a piped system shall be fitted with a screen, or grating to prevent debris and refuse from entering the stormwater system. This must be installed immediately on installation of the infrastructure.

No building works, earthworks, walls or fences may obstruct or encroach on a watercourse inside or outside the site without approved plans that do not compromise the objectives of the Stormwater Management Plan.

7.2. ROOF DRAINAGE

Building designs must ensure that rainfall runoff from roofing and other areas, not subjected to excessive pollution, be efficiently captured for re-use where possible for on-site irrigation and non-potable water uses.

Where storage for re-use and where ground conditions permit, rainwater runoff should be connected to detention areas to maximize groundwater recharge. These detention areas must be designed to contain at least the first hour of a minor storm's runoff without before overflowing.

7.3. PARKING AND PAVED AREAS

Parking or paved areas should be designed to attenuate stormwater runoff to an acceptable degree by allowing ponding or infiltration. Stormwater from such areas must be discharged in a controlled manner either as overland sheet flow or to larger attenuation facilities.

7.4. ROADS

Roads should be designed and graded to avoid concentration of flow along and off the road. Where flow concentration is unavoidable, measures to incorporate the road into the major stormwater system should be taken, with the provision of attenuation storage facilities at suitable points.

Culverts must be designed to ensure that the capacity of the culvert does not exceed the pre-development stormwater flow at that point and attenuation storage should be provided on the upstream side of the road crossing.

Outlet and culvert discharge points into the natural watercourse must be designed to dissipate flow energy and any unlined downstream channel must be adequately protected against soil erosion.

7.5. SUBSURFACE DISPOSAL OF STORMWATER

Any construction providing for the subsurface disposal of stormwater should be designed to ensure that such disposal does not cause slope instability, or areas of concentrated saturation or inundation. Infiltration structures should be integrated into the terrain so as to be unobtrusive and in keeping with the natural surroundings.

7.6. CHANNELS

Channels may be constructed to convey stormwater directly to a natural watercourse where deemed necessary and unavoidable. The channels must be suitably lined to prevent erosion and scour and provide maximum possible energy dissipation of the flow. Such linings will vary from vegetated earthen to stone pitching and reinforced concrete.

7.7. ENERGY DISSIPATION

Measures should be taken to dissipate flow energy wherever concentrated stormwater flow is discharged down an embankment or erodible slope.

7.8. OPEN TRENCHES

Open trenches should not be left open and unprotected for extended periods and should be progressively backfilled as construction proceeds. Excavated material to be used as backfill must be placed close to the trench on the upstream side to avoid loose material from washing away.

7.9. STOCKPILES

Material is to be stockpiled away from drainage paths. Loose material such as stone, sand or gravel must be covered or kept damp to minimise dust. Temporary silt screens are to be positioned immediately downstream of stockpiles to intercept loose material which may be washed away.

7.10. PHOTOVOLTAIC PANELS

Orientation of panels shall be considered with respect to drainage pattern, flow concentration, drainage area and velocity. Rows perpendicular to the contours may result in higher runoff concentrations, therefore the configuration should be designed and constructed such that the runoff remains as sheet flow across the entire site.

The panels shall be designed and constructed in such a manner as to allow vegetative growth and maintenance beneath and between panels. If the lowest vertical clearance of the panels above the ground is greater than 3m, non-vegetative control measures will be required to prevent/control erosion and scour along the drip line or otherwise provide energy dissipation from the water running off the panels.

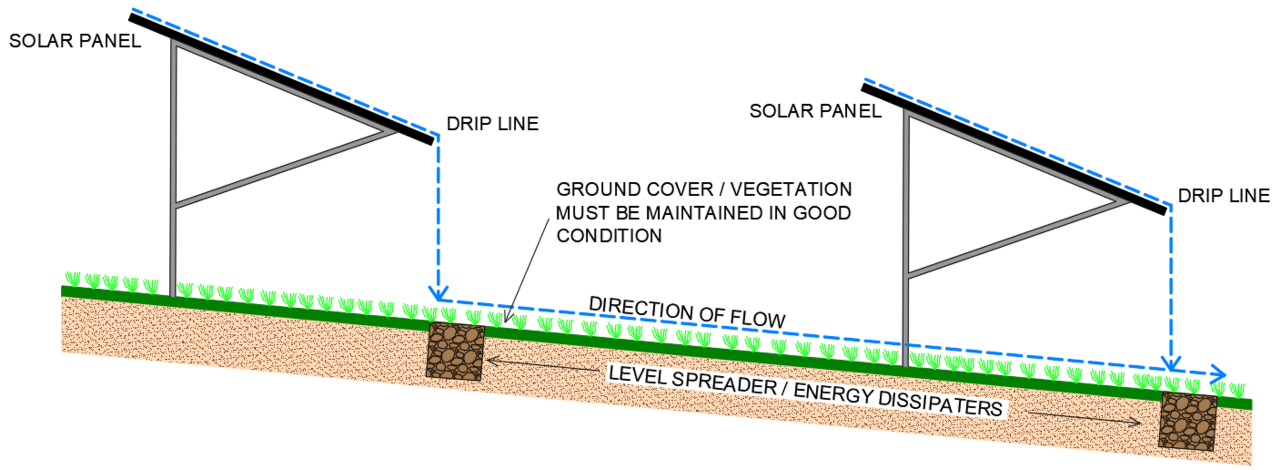


Figure 7-1: Stormwater control of PV panel runoff

7.11. STORMWATER POLLUTION CONTROL

The stormwater systems should be free from any materials that could have a detrimental effect on the fauna, flora and aquatic life in the water systems.

Sites which generate “dirty” (Grey or Black) water must have measures in place that separates the clean and “dirty” water. Depending on the nature of the “dirty” water, this must either be discharged into the wastewater system or contained on site for treatment or packaging before being re-used or disposed of. It is important that the wastewater system does not flood and overflow into the stormwater systems and designers must ensure there is sufficient capacity for the wastewater system to receive this “dirty” water.

Any site that is required to store substances that could be regarded as hazardous in terms of water pollution must take measures to ensure spillages of such substances can be adequately contained and prevent contamination of the water resources within the development area.

8. COMPLIANCE WITH STORMWATER MANGEMENT POLICY

This document should be read in conjunction with the EMP. The developer, owner and professional team, shall be responsible for ensuring that the requirements and conditions as set out in the EMP are to be adhered to.

The developer, owner and the professional team shall be responsible for the performance of all stormwater control measures implemented on the site and the impact such works may have on downstream or neighbouring properties. Approval of any plan or document shall not be construed as absolving the developer, owner, and professional teams of this responsibility.

9. CONCLUSIONS & RECOMMENDATIONS

The following may be concluded:

- The hydrological assessment (Section 5) reveals that the proposed development/infrastructure will have a minimal impact on the stormwater quality and quantities post-development (operational phase).
- The highest impact will occur during the construction phase and it is important that these impacts are strictly managed under the advisement of the guidelines set out in this document.
- The need for formal stormwater interventions can be minimised if the development is designed to maintain the existing drainage patterns. Overland flow via poorly-defined drainage paths will be the primary form of conveyance.
- A detailed stormwater management plan describing and illustrating the proposed stormwater and erosion control measures must be prepared by the Civil Engineers during the detailed design phase.

It is recommended that:

- The policy described in Section 6 be implemented.
- The guidelines described in Section 7 be incorporated into the detailed design of the development.

Annexure A:

Calculations

Pre-Development Runoff Calculations

Catchment 1.1

Return Period	Tc (hrs)	Rainfall (mm)	Intensity (mm/hr)	A (Km^2)	C	Q (m^3/s)
1:2yr	2.21	36.3	16.43	3.14	0.42	6.02
1:5yr	2.21	49	22.17	3.14	0.42	8.12
1:10yr	2.21	57.8	26.15	3.14	0.42	9.58
1:20yr	2.21	66.6	30.14	3.14	0.42	11.04
1:50yr	2.21	78.5	35.52	3.14	0.42	13.01
1:100yr	2.21	87.7	39.68	3.14	0.42	14.54

Catchment 1.2

Return Period	Tc (hrs)	Rainfall (mm)	Intensity (mm/hr)	A (Km^2)	C	Q (m^3/s)
1:2yr	1.25	30.2	24.16	1.16	0.33	2.57
1:5yr	1.25	40.8	32.64	1.16	0.33	3.47
1:10yr	1.25	48.2	38.56	1.16	0.33	4.10
1:20yr	1.25	55.5	44.40	1.16	0.33	4.72
1:50yr	1.25	65.4	52.32	1.16	0.33	5.56
1:100yr	1.25	73.1	58.48	1.16	0.33	6.22

Catchment 1 (Combined Catchment)

Return Period	Tc (hrs)	Rainfall (mm)	Intensity (mm/hr)	A (Km^2)	C	Q (m^3/s)
1:2yr	2.4	36.8	15.33	4.3	0.4	7.33
1:5yr	2.4	49.7	20.71	4.3	0.4	9.89
1:10yr	2.4	58.7	24.46	4.3	0.4	11.69
1:20yr	2.4	67.6	28.17	4.3	0.4	13.46
1:50yr	2.4	79.7	33.21	4.3	0.4	15.87
1:100yr	2.4	89.1	37.13	4.3	0.4	17.74

Construction Phase Runoff Calculations

Catchment 1.1

Return Period	Tc (hrs)	Rainfall (mm)	Intensity (mm/hr)	A (Km^2)	C	Q (m^3/s)
1:2yr	2.21	36.3	16.43	3.14	0.42	6.02
1:5yr	2.21	49	22.17	3.14	0.42	8.12
1:10yr	2.21	57.8	26.15	3.14	0.42	9.58
1:20yr	2.21	66.6	30.14	3.14	0.42	11.04
1:50yr	2.21	78.5	35.52	3.14	0.42	13.01
1:100yr	2.21	87.7	39.68	3.14	0.42	14.54

Catchment 1.2

Return Period	Tc (hrs)	Rainfall (mm)	Intensity (mm/hr)	A (Km^2)	C	Q (m^3/s)
1:2yr	1.25	30.2	24.16	1.16	0.47	3.66
1:5yr	1.25	40.8	32.64	1.16	0.47	4.94
1:10yr	1.25	48.2	38.56	1.16	0.47	5.84
1:20yr	1.25	55.5	44.40	1.16	0.47	6.72
1:50yr	1.25	65.4	52.32	1.16	0.47	7.92
1:100yr	1.25	73.1	58.48	1.16	0.47	8.86

Catchment 1 (Combined Catchment)

Return Period	Tc (hrs)	Rainfall (mm)	Intensity (mm/hr)	A (Km^2)	C	Q (m^3/s)
1:2yr	2.4	36.8	15.33	4.3	0.43	7.88
1:5yr	2.4	49.7	20.71	4.3	0.43	10.64
1:10yr	2.4	58.7	24.46	4.3	0.43	12.56
1:20yr	2.4	67.6	28.17	4.3	0.43	14.47
1:50yr	2.4	79.7	33.21	4.3	0.43	17.06
1:100yr	2.4	89.1	37.13	4.3	0.43	19.07

Post-Development Runoff Calculations

Catchment 1.1

Return Period	Tc (hrs)	Rainfall (mm)	Intensity (mm/hr)	A (Km^2)	C	Q (m^3/s)
1:2yr	2.21	36.3	16.43	3.14	0.42	6.02
1:5yr	2.21	49	22.17	3.14	0.42	8.12
1:10yr	2.21	57.8	26.15	3.14	0.42	9.58
1:20yr	2.21	66.6	30.14	3.14	0.42	11.04
1:50yr	2.21	78.5	35.52	3.14	0.42	13.01
1:100yr	2.21	87.7	39.68	3.14	0.42	14.54

Catchment 1.2

Return Period	Tc (hrs)	Rainfall (mm)	Intensity (mm/hr)	A (Km^2)	C	Q (m^3/s)
1:2yr	1.25	30.2	24.16	1.16	0.33	2.57
1:5yr	1.25	40.8	32.64	1.16	0.33	3.47
1:10yr	1.25	48.2	38.56	1.16	0.33	4.10
1:20yr	1.25	55.5	44.40	1.16	0.33	4.72
1:50yr	1.25	65.4	52.32	1.16	0.33	5.56
1:100yr	1.25	73.1	58.48	1.16	0.33	6.22

Catchment 1 (Combined Catchment)

Return Period	Tc (hrs)	Rainfall (mm)	Intensity (mm/hr)	A (Km^2)	C	Q (m^3/s)
1:2yr	2.4	36.8	15.33	4.3	0.4	7.33
1:5yr	2.4	49.7	20.71	4.3	0.4	9.89
1:10yr	2.4	58.7	24.46	4.3	0.4	11.69
1:20yr	2.4	67.6	28.17	4.3	0.4	13.46
1:50yr	2.4	79.7	33.21	4.3	0.4	15.87
1:100yr	2.4	89.1	37.13	4.3	0.4	17.74

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