STORM WATER AND EROSION CONTROL MANAGEMENT PLAN FOR THE PROPOSED STRUISBULT PV FACILITY

Project No. EIM-006

DRAFT

February, 2022

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STORM WATER AND EROSION CONTROL MANAGEMENT PLAN FOR THE PROPOSED STRUISBULT PV FACILITY

1 INTRODUCTION

Hydrologic Consulting has been appointed by Environmental Impact Management Services (EIMS) to develop a storm water and erosion control management plan for the proposed Struisbult PV Facility, located near Copperton in the Northern Cape Province of South Africa. The 288ha development area is located within farm Vogelstruis Bult 104. The storm water and erosion control management plan has been developed in association with a NEMA EMPr Amendment Process.

1.1 SCOPE OF WORK

The scope of work was achieved by undertaking the following:

- Storm Water Management Plan (SWMP) – this involved the simulation of the 1:50 year recurrence interval storm event and the addition of diversions to route storm water around and off the facility.
- Erosion Control – principles from the SWMP informed additional guidance recommended as part of erosion control
- A technical report detailing the achieved scope of work (this report).

1.2 REGIONAL SETTING AND LAYOUT

The proposed Struisbult PV Facility (hereafter also referred to as the site) is located at 22° 19' 55" E and 29° 56' 3" S. The regional setting of the site is illustrated in Figure 1-1 while the layout of the site is presented in Figure 1-2. The PV facility includes the panel array, control room, HV Substation, laydown area, spares container and various TRX stations. Access roads and electrical routes are not illustrated in Figure 1-2 since their positions were unavailable at the time of writing.

FIGURE 1-1: REGIONAL SETTING

FIGURE 1-2: LAYOUT

2 BASELINE ENVIRONMENT

Baseline information in this section includes discussions on rainfall, evaporation, land cover, terrain and hydrology.

2.1 RAINFALL

Various weather stations managed by both the South African Weather Services (SAWS) and the Department of Water and Sanitation (DWS) were considered in this project. These, together with their proximity to the site can be seen in Figure 2-1.

South African Weather Services (SAWS) and Department of Water and Sanitation (DWS) stations are located about the site. SAWS data requires purchasing and alternative sources of average monthly site-specific data were instead utilised, sourced from Pegram (2016). Table 2-1 presents the summary of the site-specific average monthly rainfall distribution while Figure 2-1 illustrates the variation of rainfall in the region.

TABLE 2-1: AVERAGE MONTHLY RAINFALL DISTRIBUTION (PEGRAM, 2016)

Month	Rainfall (mm)
Jan	27
Feb	34
Mar	41
Apr	26
May	10
Jun	6
Jul	5
Aug	6
Sep	6
Oct	12
Nov	18
Dec	21
Total	**212**

*Estimates were sourced at the centre of the site.

2.1.1 24-HOUR DESIGN RAINFALL DEPTHS

For the management of storm water, design rainfall is the most important rainfall variable to consider as it is the driver behind peak flows.

Design storm estimates for various recurrence intervals (RI) and storm durations were sourced from the Design Rainfall Estimation Software for South Africa (DRESSA), developed by the University of Natal in 2002 as part of a WRC project K5/1060 (Smithers and Schulze, 2002). This method uses a Regional L-Moment Algorithm (RLMA) in conjunction with a Scale Invariance approach to provide site-specific estimates of design rainfall (depth, duration and frequency), based on surrounding station records. WRC Report No. K5/1060 (WRC, 2002) provides more detail on the verification and validation of the method. Table 2-2 presents the 24-hour design rainfall depths for the site.

FIGURE 2-1: WEATHER STATIONS AND MEAN ANNUAL PRECIPITATION

TABLE 2-2: 24-HOUR DESIGN RAINFALL DEPTH (MM)

Recurrence Interval (Years)	DRESSA (Smithers/Schulze)*
2	43
5	63
10	78
20	93
50	114
100	131
200	149

*Estimates were sourced for the centre of the site

It is important to note, that no allowances for climate change have been made in this study. A risk analysis using the expected life of a structure or process will indicate the relevance of considering climate change (i.e. as the expected life increases the influence of climate change increases).

2.2 EVAPORATION

Evaporation data was sourced from the South African Atlas of Climatology and Agrohydrology (Schulze and Lynch, 2006) in the form of A-Pan equivalent potential evaporation. The average monthly evaporation distribution is presented in Table 2-3 and shows the site has an annual A-Pan equivalent potential evaporation of 2,724mm.

TABLE 2-3: AVERAGE MONTHLY A-PAN EQUIVALENT EVAPORATION

Month	Evaporation(mm)
Jan	370
Feb	278
Mar	232
Apr	166
May	131
Jun	96
Jul	109
Aug	150
Sep	210
Oct	277
Nov	334
Dec	371
Total	**2,724**

*Estimates were sourced at the centre of the proposed site

2.3 AVERAGE CLIMATE

The average climate for the site is presented in Figure 2-2 using the outcome of the investigation into rainfall and evaporation for the site. The combination of rainfall (Pegram, 2016) and evaporation and temperature (Schulze and Lynch, 2006) result in a cold arid desert climate according to the Köppen-Geiger climate classification[1].

[1] http://stepsa.org/climate_koppen_geiger.html

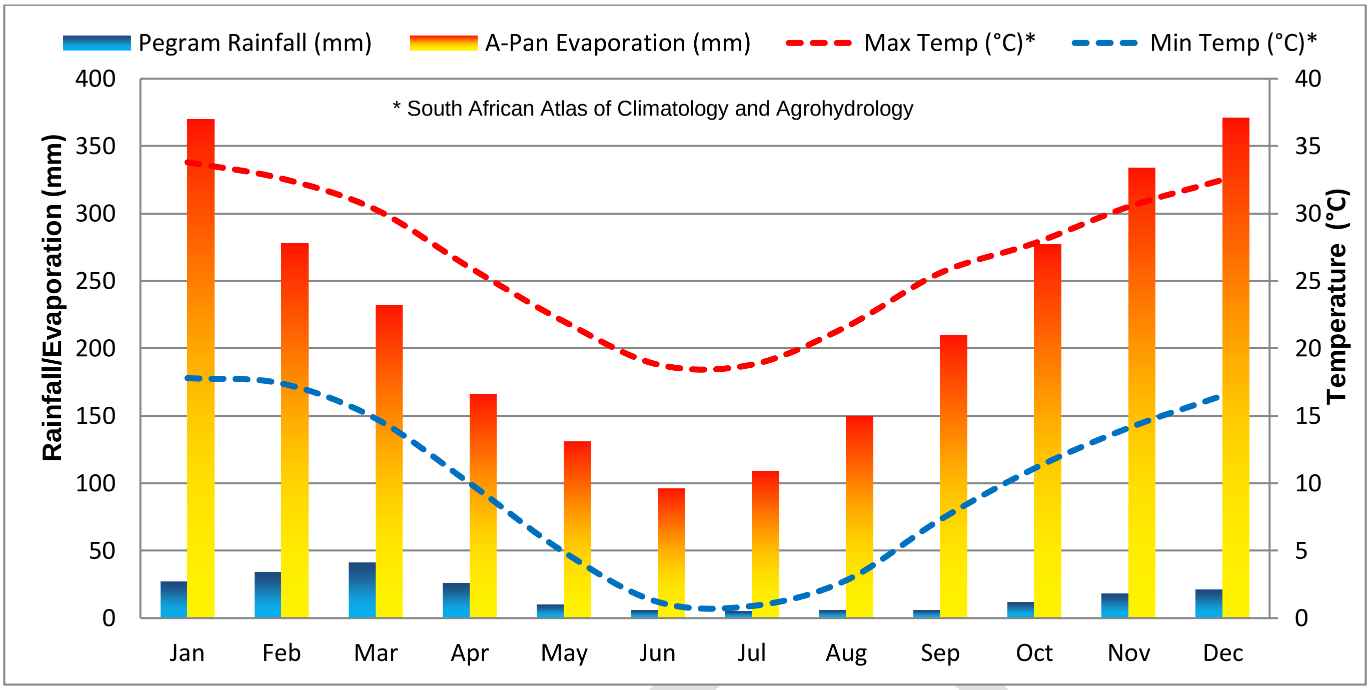

FIGURE 2-2: AVERAGE MONTHLY CLIMATE FOR THE SITE

2.4 TERRAIN

Two datasets were used to assess the terrain of the site and surrounds, namely:

1. 2m Digital Surface Model (DSM), purchased from the University of Stellenbosch with a year of capture of 2014; and
2. National Geo-spatial Information (NGI) 1:50,000 topographical map 5m contours.

The two elevation datasets utilised are illustrated in Figure 2-3.

The 2m DSM provides an elevation (surface) dataset with a resolution of 2m and a vertical accuracy of 50cm and a horizontal accuracy of 1m. This is a moderately detailed elevation dataset that was purchased given the need for a reasonably accurate conceptual storm water management plan accounting for variations in site terrain.

A 2m DSM represents the general surface (including trees and buildings) but excludes smaller features that fall within the DSM's 2m horizontal detail. Most of the site is covered by shrubland (see Section 2.6), and the DSM is consequently indicative of the general 'bare earth' terrain (some localised differences are expected).

Figure 2-3 also includes a calculation of slope using the 2m DSM with slopes largely below 10% resulting in a relatively 'flat' site. Elevations on the site approximate 1,090mAMSL.

FIGURE 2-3: TERRAIN AND HYDROLOGY

2.5 HYDROLOGY

Figure 2-3 also illustrates the hydrological setting of the site, while Figure 2-1 presents the river network of the greater region. The site lies within quaternary catchment D54D, north of the primary watercourse draining the quaternary.

Localised hydrology (per Figure 2-3), illustrates a 1:50,000 topographical map non-perennial river intersecting the site. This non-perennial river terminates at a constructed ‘cut-off’ downstream of the site, with this cutoff collection runoff (or streamflow) and directing it to the west. Geoprocessing of the 2m DEM suggests a different route with regards to the intersecting non-perennial river. This route has been highlighted as a primary flow path in Figure 2-3 and happens to pass by a ‘dry pan’, suggesting that this primary flow path is more accurate than the defined non-perennial river. The primary flow path is noted as passing close to the proposed laydown area.

The catchment draining the site has been delineated in Figure 2-3, the watershed of which lies to the north and east (of the site). This watershed illustrates that the site’s catchment is separated from a defined 1:50,000 topographical map ‘dry watercourse’ further to the east. At the site’s western and southern boundary, the catchment is illustrated as terminating, on the basis that terrain slopes away from the site such that management of runoff over the site is not relevant (past the site’s eastern and southern boundary).

2.6 SOILS, VEGETATION AND LAND-COVER

According to the high-level soils data included in the Water Resources of South Africa 2012 (WR2012) study (Bailey and Pitman, 2015), soils on the site are classified as between sand and loamy sand. In considering the more detailed Soil Conservation Service for South Africa (SCS-SA) dataset of the site, soils are classified as being either within hydrological soil group A/B (low to moderately low runoff potential) or B (moderately low runoff potential)

The natural vegetation of the site is classified as Bushmanland Arid Grassland and Bushmanland Basin Shrubland (according to SANBI, 2012).

Land-cover of the site is mostly classified as ‘shrubland’ according to the Department of Environmental Affairs (DEA) 2018 dataset, with minor areas of ‘grassland’ and ‘forested land’.

The land-cover in the region about the site is illustrated in Figure 2-4 while Figure 2-5 presents the distribution of the SCS soil types (runoff potential) and natural vegetation.

FIGURE 2-4: LAND-COVER

FIGURE 2-5: VEGETATION AND RUNOFF POTENTIAL

3 STORM WATER MANAGEMENT AND EROSION CONTROL

The proposed solar project will alter the natural environmental state, thereby affecting the generation of storm water and the associated potential for erosion. Volumes of storm water generated over disturbed areas are generally expected to increase because of the reduction in natural vegetation or the addition of areas of hardstanding. The quality of the stormwater generated is also expected to be affected by the removal of vegetation and excavation of soils (i.e. potential erosion will increase. The movement of vehicles over the site will also introduce possible hydrocarbons, however, this section does not deal with possible chemical pollutants (focusing instead on potentially increased sediment loads with regards to water quality).

The purpose of this section is therefore to produce a conceptual level storm water management plan (SWMP) by which areas producing significant runoff quantities are managed appropriately and an erosion control management plan by which potential erosion can be limited.

Relevant guidance that informs the above includes the following:

- National Environmental Management Act (Act No. 107 of 1998) as amended, which states that "Every person who causes, has caused or may cause significant pollution or degradation of the environment must take reasonable measures to prevent such pollution or degradation from occurring, continuing or recurring…"
- National Water Act (Act No. 36 of 1998) includes Section 21 water uses which require authorisation from the Department of Water and Sanitation (DWS).
- Government Notice 704 (Government Gazette 20118 of June 1999), which while it focuses on mining, includes some important principles by which clean and dirty water producing areas can be managed effectively;
- Department of Water and Sanitation (DWS) Best Practice Guideline G1 for Stormwater Management;
- Landcom Soils and Construction, Volume 1, 4th edition from 2004 (otherwise known as the Blue Book) has been used widely in the South African context in providing practical recommendations regarding the management of stormwater and associated erosion controls; and
- The South African Roads Agency Limited (SANRAL) 6'th edition Drainage Manual (2013) provides some valuable insight specific to the construction and operation of various roads, a network of which will be developed as part of this proposed project.

3.1 AREAS REQUIRING STORM WATER MANAGEMENT

In considering the site, some hardstanding areas are proposed in the form of support buildings, the laydown area, substation and solar panel pylons (including their foundation). The solar panels themselves do not qualify as hardstanding since they do not limit infiltration beneath them. Some compaction of soils on site is expected, particularly with regards to areas of travel, such as the internal access roads and laydown area.

The development of the solar farm will likely consequently be associated with a limited change to the natural land-cover when the full site is considered, assuming disturbed land-cover (i.e. soils and vegetation) is rehabilitated. The implication of this rehabilitation (of the areas between panel foundations), is that most of the site can retain a naturalised hydrological response where both the quantity and quality of storm water is similar to the natural baseline environment. This does not consider solar panel washing or other maintenance that may introduce pollutants such as hydrocarbons.

Soils on and surrounding the site are expected to have high to moderately high infiltration potential (SCS soil group A/B to B). Combined with the flat terrain and low rainfall of the region, runoff is only expected to occur during storms. The dominant occurrence of shrubland in a desert climate means that areas of poor vegetation coverage are possible (i.e. bare areas). These areas would increase the potential for runoff due to the absence of vegetation that may otherwise slow down runoff (and promote infiltration).

3.1.1 HYDROLOGICAL EFFECT OF SOLAR FARMS

A study by Cook and McCuen (2013) is of relevance to this report as it describes the hydrological effect of solar farms and whether storm water management is required to control runoff rates and volumes. This study considered a solar farm before and after the installation of panels. The study found that the solar panels did not have a significant effect on existing runoff rates, runoff volumes or time to peak of runoff. The presence of gravel or bare ground under the panels could, however, significantly increase the amount of runoff generated, while the kinetic energy of runoff falling from panels was a possible cause of erosion (at the base of panels). The study recommended that the grass beneath the panels be well maintained or that a buffer strip be placed after the most downgradient row of panels.

Gravel strips are consequently only recommended below panels where grass cannot be cultivated (to limit possible increased erosivity of runoff falling from panels).

3.1.2 MANAGEMENT APPROACH

Figure 3-1 presents the conceptual storm water management plan for the site.

The availability of a 2m DEM covering the full catchment of interest enabled the delineation of relevant subcatchments draining to or from within the site. The approach to subcatchment delineation was based upon the position of the proposed infrastructure and the natural drainage (informed by the 2m DEM). Areas downslope of proposed infrastructure were not considered since storm water generated from these locations would not influence the proposed infrastructure.

A 50ha minimum subcatchment area informed an approach whereby diversions (to route storm water) are proposed, given the potentially significant volume and rate of runoff (from a contributing area larger than 50ha). This 50ha threshold is, however, not a limitation to the addition or reduction in the proposed diversions and this threshold should be reviewed during the detailed design phase (to be informed by this report). It is recommended that diversions incorporate soft engineering approaches with grassed swales being an option that would likely integrate well with the recommended diversions.

The proposed diversions (routing runoff generated within the site), are also important to the protection of the spares container and laydown area due to the route of the primary flow path draining the site near these two areas.

FIGURE 3-1: STORM WATER MANAGEMENT PLAN

Diverting upslope areas (generating run-on) around the site, was adopted to limit the potential management of storm water within the site. This resulted in two perimeter diversions along the northern and eastern boundary of the site.

Outfalls, at the termination of proposed diversions, will require consideration of the velocity (and thereby erosivity) of channelled flow. Baffles or a small detention basin may be relevant to the reduction in flow velocities. This should be considered during the detailed design.

Buffer strips are proposed downslope of panel 'blocks' which don't include a diversion. These buffer strips are envisaged as well vegetated areas (ideally continuous grass cover) that will assist in the slowing down of runoff, and the promotion of infiltration.

The natural land-cover and drainage of the site should be retained insofar as is possible (as a general guideline).

3.2 FUELS, LUBRICANTS AND CHEMICALS

The storage/handling of fuel, lubricants and chemicals will require special attention due to their hazardous nature as is the case with the diesel and oil bay. These areas are required to be managed on impermeable floors with appropriate bunding, sumps and roofing. This is regarded as localised management and does not form part of this conceptual SWMP.

3.3 STORM WATER MANAGEMENT INFRASTRUCTURE

Figure 3-1 illustrates the conceptual SWMP while Appendix A presents details relating to the development of the SWMP using PCSWMM, which is based on the Storm Water Management Model (Rossman, 2008). Storm water management infrastructure has been conceptually designed using the 1:50 year, 24-hour RI event. No account has been taken of climate change and any potential future increases in rainfall depth or intensity. These will need to be considered depending on the expected life of the structure.

3.3.1 AVAILABLE INFORMATION

The following information was used to develop the SWMP:

- Climate Data: Particularly design rainfall depths;
- Elevation Data: The 2m DEM as outlined in Section 2.4 was used to define flow routes and subcatchment divisions; and
- Catchment characteristics: Soil characteristics, land-cover and slopes were used to define catchment characteristics.

3.3.2 APPLICABLE SUBCATCHMENTS

Catchments exceeding the 50ha threshold have been identified in Figure 3-1 (labelled) while Appendix A presents the results of the storm water modelling (for these identified subcatchments). Smaller subcatchments (falling below 50ha) have not been reported on unless they influence proposed storm water diversions. An exception to this is subcatchment 'C9' which drains to the southern boundary of the site. This subcatchment has an area approximating 46ha and was included in reporting to enable consideration of design runoff (peak flows) that may originate from a subcatchment approaching 50ha in size. It should be noted that the results of the storm water modelling do not account for the influence of buffer strips or proposed changes to the site from the development (runoff estimates are based upon existing terrain and land-cover). The addition of buffer strips and retention of the majority of the site's vegetation (between pylons) would likely reduce runoff rates and volumes (for subcatchments not managed by diversions proposed in this section).

3.3.3 DIVERSIONS

Figure 3-2 represents a typical diversion channel consisting of a berm and channel component. The side slopes for all berms and channels have been kept constant at 1 vertical: 3 horizontal, while a minimum channel dimension of 0.5m channel depth and 1.0m channel base breadth has been used to simplify design.

The channel component has been sized using PCSWMM storm water modelling software to meet the requirement of accommodating the 1:50 year RI event. A Manning's 'n' roughness coefficient of 0.035 (grass) was used in the sizing of the diversions channels and would consequently also simulate the hydraulic response of a grass swale. Figure 3-2 illustrates this drainage channel where:

- a = Channel Depth
- b = Channel Base Breadth

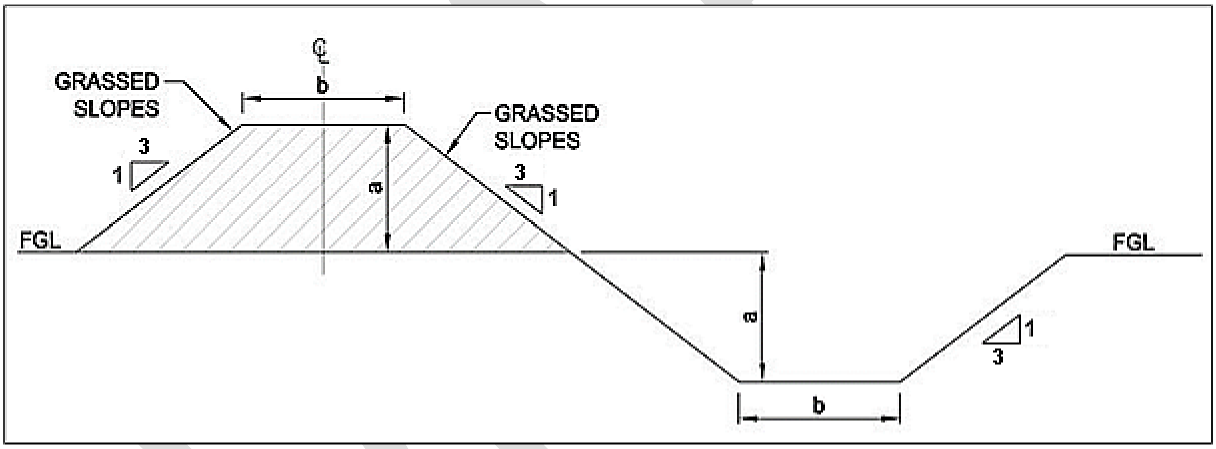

FIGURE 3-2: TYPICAL BERM AND CHANNEL FOR STORMWATER DIVERSION SYSTEM

Table 5-1 presents the dimensions of the clean area diversions, including the average longitudinal slope. The indicated dimensions and flows may differ from final, depending on the construction method, the location of diversions and the added detail included in the detailed design. The channel dimensions should consequently be reviewed during the detailed design phase.

TABLE 3-1: DIMENSIONS FOR CLEAN AREA DIVERSIONS (1:50 RI EVENT)

Diversion	a (m)	b (m)	Average Longitudinal Slope (%)	Peak Flow (m^3/s)	Comment
J1 to J2	1.0	1.0	0.5	2.7	Passes beneath road (requires culvert or crossing)
J2 to OF1	1.0	3.0	0.8	7.5	Includes outfall. Possibly requires velocity reduction
J3 to J5	1.0	1.0	1.2	0.7	
J4 to J5	1.0	1.0	0.8	3.3	
J5 to J7	1.0	1.0	1.1	3.5	
J6 to J7	1.0	1.0	1.1	3.4	

J7 to J9	1.0	3.0	0.9	6.5	
J8 to J9	1.0	1.0	1.1	2.8	
J9 to OF2	1.0	4.0	0.6	9.6	Passes beneath road (requires culvert or crossing) Includes outfall. Possibly requires velocity reduction
J10 to OF3	1.0	1.0	1.2	3.5	Includes outfall. Possibly requires velocity reduction

Two of the proposed diversions intersect the road passing through the site. These diversions will require consideration as to how channelled flow will pass by the road. This may require the addition of suitability sized culverts or the construction of a suitability sized low-level crossing. SANRAL (2013) provides some valuable insight specific to the construction of culverts and crossings.

The outfalls will direct concentrated channel flow to specific points of discharge and may require a reduction in velocity to limit potential erosivity of water (through the use of baffles, detention basins or similar).

3.3.4 SUBCATCHMENT ‘C9’

A threshold subcatchment area of 50ha was used to inform the addition of diversions. Subcatchment ‘C9’ has been identified as a subcatchment of interest since it falls beneath this threshold, having an area of approximately 46ha. The accumulation of runoff over the subcatchment results in the combined runoff exiting at a point on the site’s southern boundary. The peak flow for this runoff (per the 1:50 year RI event) is estimated as 3.7m^3/s. This is the peak flow estimate for the baseline environment, without alterations to the site which may modify existing flow paths and without the runoff attenuating influence of buffer strips, three of which are proposed over subcatchment ‘C9’. The results from ‘C9’ nevertheless present the upper limit of potential peak flows for subcatchments on the site which do not drain to one of the proposed diversions.

3.4 EROSION CONTROL

Erosion control has partly been considered in this section with regards to storm water management and the addition of buffer strips. Retention or rehabilitation of the natural land-cover and drainage of the site (post construction or decomissioning) will also serve to limit potential increases in erosions.

Additional principles are, however, included in the following (a combination of the various guidelines), and should be adhered to where possible:

- Clearing of vegetation and associated excavation areas should be kept to a minimum, particularly in areas where soils are unstable.
- The construction of any roads will create areas prone to erosion due to soils being exposed. Roads should therefore be constructed in a manner to rapidly stabilise soils, while roadside drainage should be included where necessary. For more information, please refer to the SANRAL (2013).
- Construction should be scheduled to take place during the dry seasons when rainfall and associated erosion potential is at its least.
- Excavated soils should be stockpiled and separated into separate material types to enable replacement in the same order as excavated, during rehabilitation.
- Natural vegetation should be re-established to represent the previously undisturbed environment as closely as possible.

- A practical erosion control handbook should be developed, based on the principles developed in this report and given to the construction contractors to ensure the impact on receiving water resources is limited.
- Regular inspection of the site to assess erosion which may result from a loss in vegetation or cavitation from soil slumping, with intervention to prevent erosion where it is noticed.
- Watering to ensure wind erosion is limited during construction and to assist in the establishment of vegetation.
- Maintenance and/or cleaning of all diversions, roadside drainage and buffer strips as required.
- The storm water management plan as outlined in this report will be an integral part of the control of possible erosion.

3.4.1 SILT FENCES

Silt fences may be suitable in the control of potential erosion from areas disturbed during construction or decommissioning, particularly the concentrated areas of disturbance such as the control room, HV substation, laydown area and spare container.

The United States Environmental Protection Agency (EPA) provides a detailed guide on the installation and maintenance of silt fences and the reader is referred to the following online document[2]. As defined by the EPA guide, a silt fence "*is a temporary sediment barrier made of porous fabric. It's held up by wooden or metal posts driven into the ground, so it's inexpensive and relatively easy to remove. The fabric ponds sediment-laden stormwater runoff, causing sediment to be retained by the settling processes".* A silt fence is possibly a cost-effective approach to erosion control management and suits the temporary nature of the construction phase of the project. The EPA guide can be consulted as to recommended design standards in this regard. Figure 3-8 illustrates a typical silt fence.

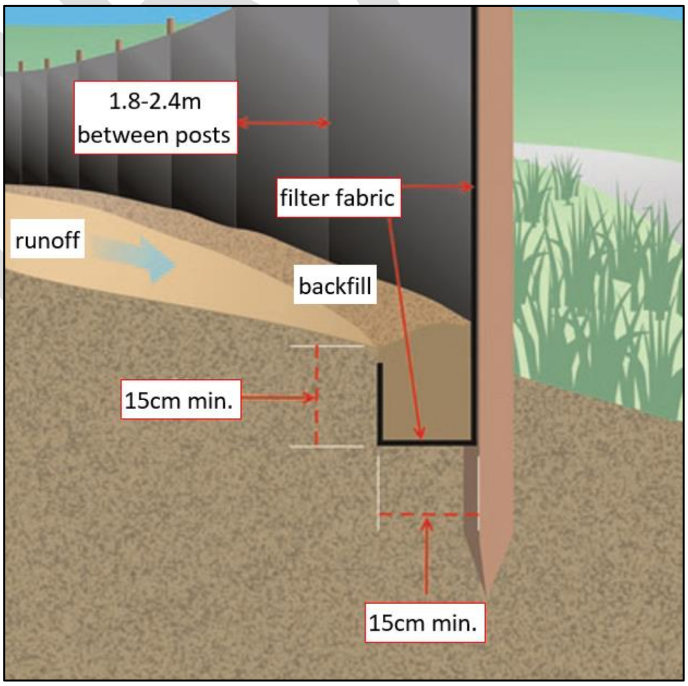

FIGURE 3-3: TYPICAL SILT FENCE (AFTER ENVIRONMENT PROTECTION AGENCY[3])

[2] https://www3.epa.gov/npdes/pubs/siltfences.pdf).

[3] Illustration of a silt fence installation detail, from U.S. EPA publication, "Developing Your Stormwater Pollution Prevention Plan: A Guide for Construction Sites." Document No. EPA-833-R-060-04.

4 RECOMMENDATIONS AND CONCLUSION

A baseline assessment, including the sourcing and processing of data pertaining to rainfall, evaporation, topography, land-cover, soils as well as regional and local hydrology, has been undertaken to determine the hydrological aspects relating to the proposed Struisbult PV Facility.

The proposed solar project will alter the natural environmental state, thereby affecting the generation of storm water and the associated potential for erosion. Volumes of storm water generated over disturbed areas are generally expected to increase because of the reduction in natural vegetation or the addition of areas of hardstanding. The quality of the stormwater generated is also expected to be affected by the removal of vegetation and excavation of soils (i.e. potential erosion will increase). The purpose of this report is therefore to produce a conceptual level storm water management plan (SWMP) by which areas producing significant runoff quantities are managed appropriately and an erosion control management plan by which potential erosion can be limited.

In considering the site, some hardstanding areas are proposed in the form of support buildings, the laydown area, substation and solar panel pylons (including their foundation). The solar panels themselves do not qualify as hardstanding since they do not limit infiltration beneath them. Some compaction of soils on site is expected, particularly with regards to areas of travel, such as the internal access roads and laydown area. The development of the solar farm will likely be associated with a limited change to the natural land-cover when the full site is considered, assuming disturbed land-cover (i.e. soils and vegetation) is rehabilitated.

A study by Cook and McCuen (2013) is of relevance to this report as it describes the hydrological effect of solar farms and whether storm water management is required to control runoff rates and volumes. This study informred the approach to storm water management as outlined in this report.

Grass strips are proposed beneath panels to limit the erosivity of runoff falling from panels. Where grass cannot be cultivated, gravel strips are recommended, however, this will increase runoff rates and volumes to a degree.

A 50ha minimum subcatchment area informed an approach whereby diversions (to route storm water) are proposed, given the potentially significant volume and rate of runoff (from a contributing area larger than 50ha). This 50ha threshold is, however, not a limitation to the addition or reduction in the proposed diversions and this threshold should be reviewed during the detailed design phase (to be informed by this report). It is recommended that diversions incorporate soft engineering approaches with grassed swales being an option that would likely integrate well with the recommended diversions.

Diverting upslope areas (generating run-on) around the site, was adopted to limit the potential management of storm water within the site. This resulted in two perimeter diversions along the northern and eastern boundaries of the site. Outfalls, at the termination of proposed diversions, will require consideration of the velocity (and thereby erosivity) of channelled flow. Baffles or a small detention basin may be relevant to the reduction in flow velocities. This should be considered during the detailed design. Buffer strips are proposed downslope of panel ‘blocks’ which don’t include a diversion. These buffer strips are envisaged as well-vegetated areas (ideally continuous grass cover) that will assist in the slowing down of runoff, and the promotion of infiltration. The natural land-cover and drainage of the site should be retained insofar as is possible (as a general guideline).

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APPENDIX A: STORM WATER CALCULATIONS

A.1 MODEL CHOICE

PCSWMM is a model package that makes use of the USEPA Storm Water Management Model (SWMM), which is a computer program that computes dynamic rainfall-runoff from developed urban and undeveloped or rural areas (Rossman, 2008).

The SWMM model suits application to this project since it can account for:

- Time-varying rainfall;
- Rainfall interception in depression storage;
- Infiltration of rainfall into unsaturated soil layers;
- Evaporation of standing surface water;
- Routing of overland flow; and
- Capture and retention of rainfall/runoff.

The development of SWMP's using SWMM have been undertaken for many thousands of studies throughout the world including (Rossman, 2008) South Africa.

A.2 DESIGN HYDROGRAPHS

A.2.1 DESIGN STORM

In assessing the storm water management, it was necessary to define the associated rainfall that would cause this flooding. A hypothetical storm consequently needed to be developed which utilised the depth-duration-frequency (DDF) data provided by DRESSA (see Section 2.2). This hypothetical storm is the design rainfall that will produce the highest peak flow at each location independent of catchment response time (which is the index of the rate at which stormflow moves through a catchment). To calculate the hypothetical storm, the DRESSA 1:50 year RI rainfall depth for various durations (e.g. 5 minutes, 30 minutes and 2 hours) was transformed into a synthetic rainfall distribution or design hyetograph.

A.2.2 MODEL PARAMETERISATION

The 2m DEM was used to define flow paths, subcatchments and diversions. Land cover parameters were estimated according to the surface infrastructure layout with the baseline land cover and soil type being set according to Section 2.6.

TABLE A-1: SUBCATCHMENT CHARACTERISTICS FOR THE 1:50 YEAR EVENT

Name	Area (ha)	Precipitation (mm)	Infiltration (mm)	Runoff Coefficient	Runoff Volume (ML)	Peak Runoff (m^3/s)
C1	105.4	114	55	0.45	53.8	7.0
C2	40.9	114	56	0.46	21.4	3.5
C3	5.8	114	55	0.47	3.1	0.8
C4	43.2	114	55	0.46	22.8	4.2
C5	42.5	114	55	0.46	22.4	4.3
C6	2.7	114	51	0.50	1.6	0.4
C7	35.9	114	54	0.47	19.3	3.3
C8	18.9	114	50	0.49	10.6	1.3
C9	46.3	114	55	0.46	24.4	3.7
C10	61.0	114	56	0.45	31.5	4.7
LD	3.5	114	48	0.53	2.1	0.6