Stormwater, Wastewater and Erosion Management Plan for Naledi PV

Report Prepared for

Naledi PV (Pty) Ltd

Report Number 558582/Naledi PV

Report Prepared by

srk consulting

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Stormwater, Wastewater and Erosion Management Plan for Naledi PV

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Executive Summary

Naledi PV (Pty) Ltd. is proposing the development of a commercial solar Photo-Voltaic (PV) facility and associated infrastructure on a development area located approximately 20km south-west of Upington, within the Kai !Garib Local Municipality and the ZF Mgcawu District Municipality in the Northern Cape Province. The site borders the Dawid Kruiper Local Municipality.

This report documents the Stormwater, Wastewater and Erosion Management Plan (referred to as the SWMP) required for the proposed development. The SWMP aims to facilitate the protection of surface water resources and covers the total project development area.

Based on the potential impacts, as well as legal requirements and best practice guidelines, specific objectives were developed for stormwater and erosion management. A plan was then developed to address each objective to protect surface water resources.

The report concluded that stormwater impacts can be managed at the development area in a practical way that will protect water bodies and minimise erosion. It is recommended that the SWMP be further developed during detailed designs stage. The plan will be incorporated into an environmental specification for use during construction and be implemented during operation of the facility

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Disclaimer

The opinions expressed in this Report have been based on the information supplied to SRK Consulting (South Africa) (Pty) Ltd. (SRK) by Naledi PV (Pty) Ltd (the Client). The opinions in this Report are provided in response to a specific request from the Client to do so.

SRK has exercised all due care in reviewing the supplied information. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information and does not accept any consequential liability arising from commercial decisions or actions resulting from them.

Opinions presented in this report apply to the site conditions and features as they existed at the time of SRK's investigations, and those reasonably foreseeable. These opinions do not necessarily apply to conditions and features that may arise after the date of this Report, about which SRK had no prior knowledge nor had the opportunity to evaluate.

1 Introduction

SRK Consulting (South Africa) (Pty) Ltd. (SRK) was approached by Naledi PV (Pty) Ltd (the Client) to develop a Stormwater, Wastewater and Erosion Management Plan (referred to as the SWMP) for the proposed new development of a commercial solar Photo-Voltaic (PV) facility and associated infrastructure to be implemented for Naledi PV, in the Northern Cape of South Africa about 23 km South-West of Upington.

2 Objectives and Scope of the Report

2.1 Objectives

The objective of this report is to prepare a SWMP that protects the surface water resources, manages erosion risks and complies with the regulations and guidelines for the construction and operation phases of the Naledi PV facility.

2.2 Scope

This report covers the following scope:

- Delineation of the catchments draining to the development area;
- Determination of the type of catchment (clean or dirty area). This is required as the clean water needs to be diverted away from any dirty water areas and dirty water needs to be collected and reused. The clean water is also diverted away from Naledi PV to minimise the potential erosion that could occur along the pillars of the solar farm;
- Calculations of peak stormwater discharges from each catchment and sizing of required infrastructure associated with each catchment; and
- Presenting recommendations regarding the considerations that need to be considered during design, construction and operation phases of the proposed project.

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

The layout of the development area is shown in Figure 2-1.

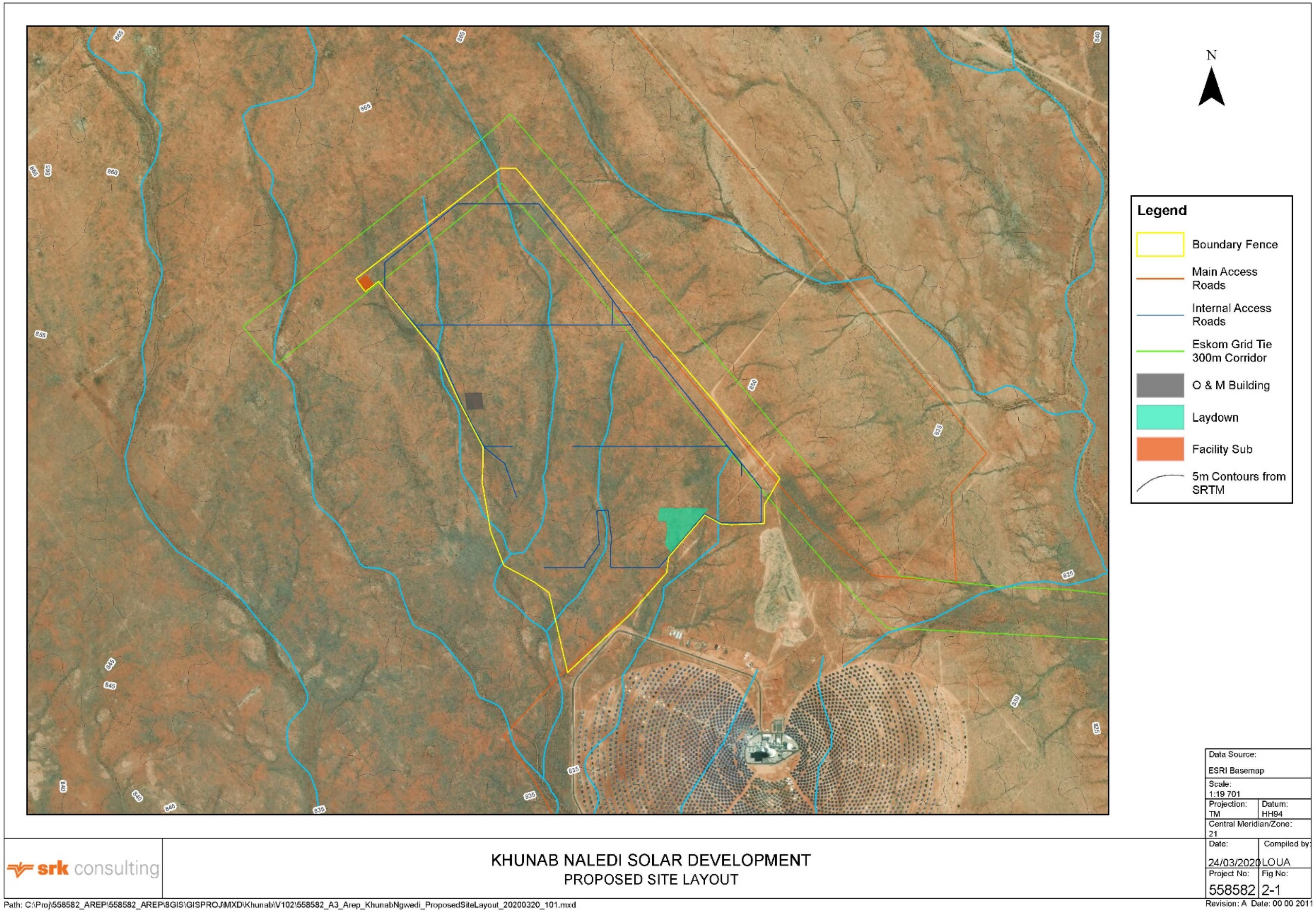


Figure 2-1: Naledi PV Conceptual Site Layout

3 Supporting Information

This section summarises all the information and assumptions upon which 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 on site, and hence the information is key to understanding the plan. The relevant information can be divided into:

- Project information;
- Guidelines and regulations; and
- Natural characteristics on site.

3.1 Project information

The site information was provided by the client, and information for the area in general was obtained from the Background Information Document (supplied by the Client), and Draft Basic Assessment Report (Cape EAPrac, 2019). Further site information was provided by the Client in the form of electronic maps, photographs and GIS information.

The proposed infrastructure and the associated potential pollutants are as follows:

- Fixed-tilt or tracking solar PV panels with a maximum height of 3.5 m;
- An O&M building, inclusive of laydown area, toilet facilities connected to a conservancy tank for wastewater collection and a chemical storage area;
- An electrical substation including transformers containing oil;
- On-site inverters and inverter transformers (containing oil) located between the panels to step up the power;
- Cabling between the project's components, to be laid underground where practical;
- Fencing around the development area;
- An access road to the development area;
- Internal access roads:
    - Existing roads will be used as access roads where possible; and
    - Existing roads will be extended to create access to the Naledi PV facility where possible.
- During construction, a temporary laydown area and a workshop will be added.

Fuel and acids (generally considered high risk contaminants to stormwater) have been ruled out as potential threats as neither will be stored or used on site. General waste will only be stored temporarily and taken off site regularly for disposal to landfill.

3.2 Legislation and guidelines

SWMPs are generally required as part of the Environmental Management Programme (EMPr) and for Water Use License Applications. The general principal that was used in the design is:

- Divert clean water away from the Naledi PV to minimise the potential for erosion of any of the infrastructure;
- Contain any dirty water emanating from the site (silt laden material) and discharge the settled water from the site; and

- Isolate the dirty water areas (hydrocarbons).

Municipal regulations, which usually determine specific standards for each municipality, but still adhere to the overall principles of the regulations and guidelines above, will be consulted during detailed design.

3.3 Natural conditions

3.3.1 Climate

The development area lies in an arid to semi-arid climatic region with average rainfall below 200 mm per year. The average evaporation rate in the area is 2 281 mm. In summer months temperatures can be in excess of 42°C and in winter months dip to below 4°C.

3.3.2 Design rainfall

The rainfall analysis was based on the “Design Rainfall Estimation in South Africa” (DRE) program developed by JC Smithers and RE Schulze (Smithers & Schulze, 2002). The program implemented procedures from the Water Research Commission (WRC) project entitled “Rainfall Statistics for Design Flood Estimation in South Africa” (WRC Project K5/1060).

The rainfall data was obtained from 6 closest rainfall stations (Smithers and Schulze - Design Rainfall in South Africa). The rainfall stations for the catchment area were selected based on criteria such as altitude relative to the area of interest, the record history of the weather stations and proximity to the study area.

The catchment has a mean annual precipitation of 152 mm. The rainfall station closest to the development area is Geelkop (0283098W), which is approximately 12 km from the site catchments.

Table 3-1: Design Rainfall (mm) Data Interpolated from the Six Closest Stations

Mean Annual Rainfall	**152 mm**		**Latitude**	**-28.587237**		**degrees**	
Altitude	**775 mamsl**		**Longitude**	**21.040049**		**degrees**	
Storm Duration	**Return Period (Years)**						
	2	**5**	**10**	**20**	**50**	**100**	**200**
5 minutes	5.9	9.3	11.8	14.4	18.1	21.1	24.4
15 minutes	11.1	17.3	22.0	26.8	33.7	39.3	45.4
1 hour	16.5	25.9	32.9	40.1	50.3	58.8	67.9
1.5 hours	18.6	29.2	37.0	45.1	56.6	66.1	76.4
2 hours	20.2	31.7	40.2	49.0	61.6	71.9	83.0
8 hours	26.2	41.2	52.1	63.3	79.9	93.3	107.7
24 hours	32.2	50.6	64.1	78.2	98.2	114.6	132.4
5 day	36.8	57.8	73.2	89.3	112.2	131.0	151.3

3.4 Potential Stormwater, Wastewater and Erosion Impacts

An overall analysis of the available data and the development plans reveal the following potential impacts:

- The facility presents a very low risk to adversely impacting surface water resources because:

    - Except for the necessary bush clearing and trampling to construct the Naledi PV, the development will leave the natural vegetation (including all dale riparian vegetation), soil conditions and topography largely undisturbed;
    - The development area and roads have been well placed, as they lie mostly outside of the natural water ways and most river crossings are over very small drainage lines or rivers, characterised with small catchments and low flows;
    - Sewage and landfill waste will be disposed offsite;
    - Rainfall in the area is low and few steep slopes exist to generate high flow velocities.
- Some potential impacts do exist, including:
    - Possible contamination of stormwater by:
        - Sediment that is collected in the runoff due to disturbance of the ground;
        - Oil leaks from the transformers;
        - Oil and lubricant in wash down water from the workshop; and
        - Overflow of wastewater from the conservancy tanks.
    - Potential for erosion:
        - Where any stormwater drains discharge into rivers or onto the natural land surface; and
        - At river / road crossing.
    - Potential exists to impede and disrupt flow if infrastructure is placed within water courses;
    - Potential exists to damage infrastructure and exacerbate erosion if infrastructure is placed within areas that are inundated in floods.

4 Project Specific Objectives

The project specific objectives were developed based on the laws and guidelines mentioned in Section 3.2 and are as follows:

- Keep clean water clean by constructing diversions or bunds. This prevents any clean runoff from entering any potentially dirty areas and minimises the potential for erosion along the disturbed areas. The bunds or diversions should be designed for a 1:50-year flood event;
- Collect and treat discharge water or runoff from any dirty areas. Dirty water should not spill into clean water systems more than once in a 50-year return period;
- Bund any areas housing hazardous substances or pollutants, including any oils;
- Do not impede surface or subsurface water flows more than what is required to implement the required clean – dirty water separation:
    - Minimise disturbed areas such that surface and subsurface movement of water along the drainage lines is not reduced; and
    - Ensure any engineered clean stormwater drainage directs water to the naturally receiving drainage line.
- Erosion control:

  - Prevent erosion in general, and minimize the potential for erosion in large storm events of 1:50-year flood events or greater; and
  - Dissipate stormwater energy at all drainage outlets to velocities that are unlikely to cause erosion in storm events less than 1:50-year flood events (i.e. <1 m/s).
- Monitoring and management:
  - Inspect and monitor performance and integrity of all SWMP infrastructure on an annual basis;
  - Include an erosion monitoring plan that ensures that the onset of erosion is detected and rehabilitated within 6 months, and any acute erosion due to large storm events is detected within 2 weeks; and
  - Include a monitoring system for spills and leaks such that they are detected and remediated, as soon as practically possible.
- General:
  - Ensure no infrastructure, except road crossings and solar panel supports (solar panel mounting structures could possibly clip the edges of low sensitivity drainage lines) are built within the water courses;
  - Conduct a pre-development and post development survey to ensure that the pre-development natural ground level is maintained or rehabilitated, if required;
  - No cement stabilisation of piles shall be used within the low sensitivity drainage features. Foundation could rather utilise longer piles in these areas to achieve adequate structural stability;
  - Do not build infrastructure, in particular infrastructure containing potential pollutants, within 300 m of natural drainage lines; and
  - Review and improve the stormwater management plan regularly.

5 Hydrology Study

The first step in the SWMP development is an analysis of the development area and the proposed facility. The analysis found that the proposed facility is likely to have an intrinsically low impact on the surface water resources due to:

- The vegetation, soil and topography will remain mostly undisturbed;
- The development footprint and roads are well placed, as they lie mostly outside of the natural watercourses and most river crossings will have low flows;
- Water use on site, with the potential to generate runoff, such as solar panel washing, is negligible in volume compared to stormflows;
- Sewage and landfill waste will be taken offsite for disposal; and
- Rainfall in the area is low and few steep gradients exist.

Despite the low impact on surface water resources, some potential impacts are possible including:

- Dirty areas will exist, which could contribute to contamination including:
  - Transformers, which could leak oil;

  - The workshop, which may store oils or lubricants that could contaminate wash down water; and
  - The sewage conservancy tank, which could leak or overflow.
- Erosion, where stormwater drains discharge to the natural environment or around stockpiles – estimated stormflows indicate that erosion could be significant in such localised areas without proper detailed design to mitigate for higher flow velocities;
- Potential road crossings, which could exacerbate erosion without proper design, were identified –these crossed relatively small drainage lines but will need to be confirmed during a detail design, based on a detailed land survey of the project area; and
- Disruption of natural flow, and possibly erosion, where solar panels are located within watercourses and flood prone areas.

5.1 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. The workshop will only be temporary (during the construction phase). 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;
  - The medium-voltage transformers (at the inverter stations) placed around the development area, as these will contain oil;
  - Transformers at the substation, as these will contain oil;
  - The conservancy tanks, as this will contain sewage; and,
  - Vehicle wash bay that has a hardstanding surface on which vehicles are washed, containing the dirty water and draining to a sump.
- Clean areas are deemed to be all areas outside of those stated above as dirty areas.

5.2 Identification of road crossings

Potential road crossings were identified for all the roads that will be upgraded or built as part of the project, considering that the road / river crossings are conceptual at this stage, and their locations are approximate. Any internal road crossings will be minor and conceptual designs provided in this report can be used as a basis for such crossings.

The crossings are shown in Figure 5-1.

It is extremely unlikely that minor modifications in road position will change the assessments and conclusions in this report. Also note that most of the road crossings are over minor natural drainage lines near the source of their flow.

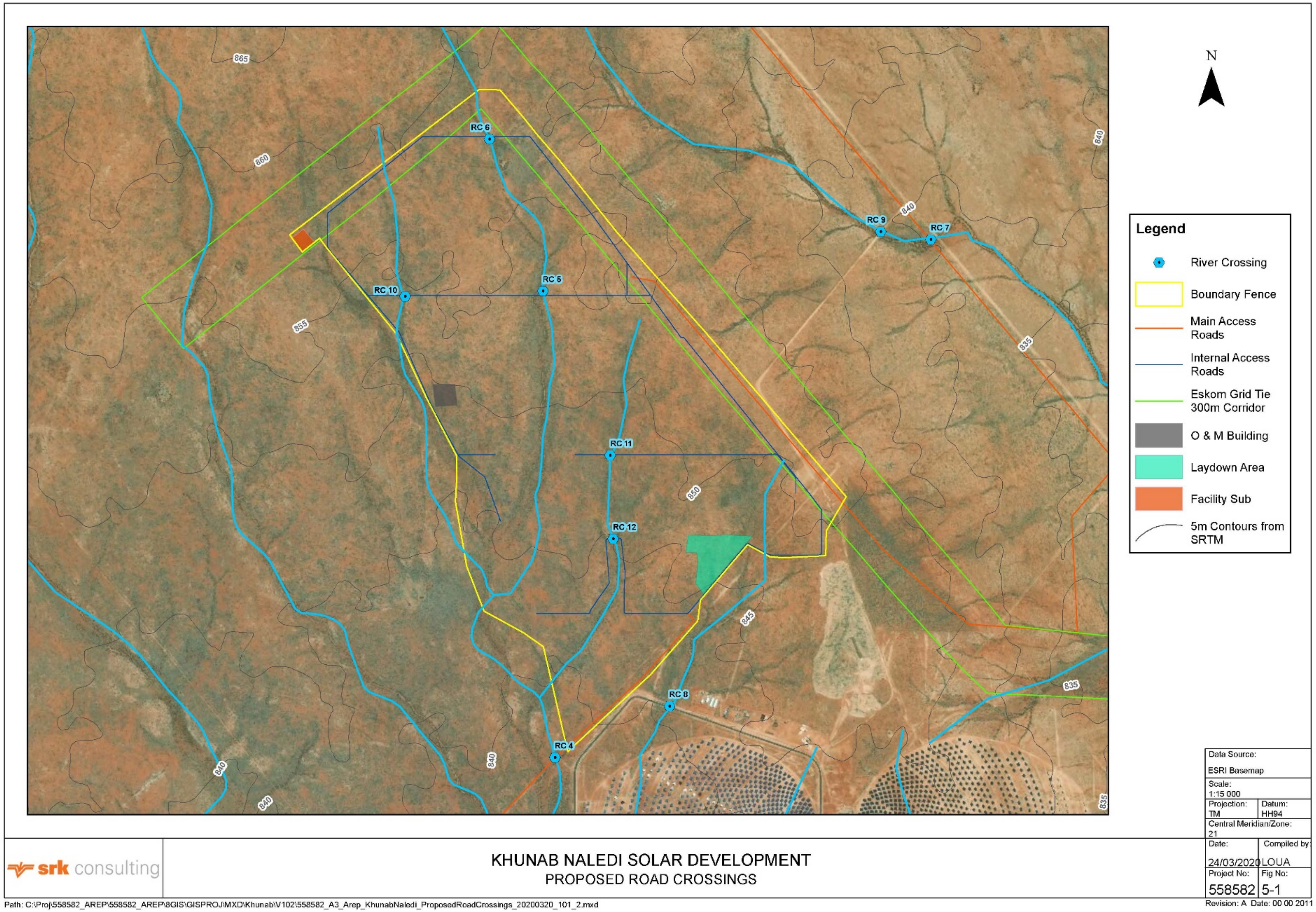


Figure 5-1: Conceptual Road Crossings

5.3 Delineation of catchments

In order to delineate the catchments, a Digital Terrain Model (DTM) had to be created in order to use GIS techniques to determine these delineations and characterisation of the various catchments. No detailed survey information was available at the time of the study, so Shuttle Radar Terrain Model (SRTM) data was used to develop the DTM.

The following catchments were delineated:

- Catchments of the watercourses where they cross any of the proposed development area;
- The receiving catchments close to where the catchment discharges.

The catchments are as shown in Figure 5-2 below.

5.4 Catchment Parameters

The slope of a catchment is a very important characteristic in the determination of flood peaks. Steep slopes cause water to run faster and to shorten the critical duration of flood inducing storms, thus leading to the use of 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 even higher.

Also required is the land use and associated Manning's N-value for the various land uses. These contribute to the estimation of volume of water stored, infiltrated and ultimately resulting in runoff for each catchment.

The average slope and other critical parameters for the catchments under consideration are presented in Table 5-1.

Table 5-1: Conceptual Catchment Characteristics

Catchment Name	Longest Watercourse Length (m)	Cumulative Area (m2)	Cumulative Area (km2)	Width (m)	% Catchment Slope	% impervious	Impervious Area Manning n-value	Pervious Area Manning n-value
Catchment_1	2740	2204456	2.204	885	1.983	3	0.013	0.03
Catchment_2	33515	154132811	154.133	973	1.175	3	0.013	0.03
Catchment_3	26880	119859162	119.859	2130	1.130	3	0.013	0.03
Catchment_5	2653	2207379	2.207	965	0.934	3	0.013	0.03
Catchment_6	1753	958968	0.959	1243	0.957	3	0.013	0.03
Catchment_7	26168	118138294	118.138	650	0.922	3	0.013	0.03
Catchment_8	22170	106456123	106.456	1425	0.961	3	0.013	0.03
Catchment_9	22876	110299303	110.299	4327	0.780	3	0.013	0.03
Catchment_10	24124	112625953	112.626	735	0.984	3	0.013	0.03
Catchment_11	24814	115574225	115.574	565	1.105	3	0.013	0.03
Catchment_12	20755	90592194	90.592	562	1.564	3	0.013	0.03
Catchment_13	8905	14045399	14.045	1450	2.092	3	0.013	0.03
Catchment_14	4024	2423732	2.424	6723	1.177	3	0.013	0.03
Catchment_15	19826	89164630	89.165	930	0.935	3	0.013	0.03
Catchment_16	7350	9615988	9.616	727	0.830	3	0.013	0.03
Catchment_17	3040	2029034	2.029	8946	0.887	3	0.013	0.03
Catchment_18	1531	770390	0.770	847	0.865	3	0.013	0.03
Catchment_19	1717	882952	0.883	735	0.854	3	0.013	0.03
Catchment_20	23469	127901704	127.902	1286	1.197	3	0.013	0.03
Catchment_21	9308	8698196	8.698	529	0.966	3	0.013	0.03
Catchment_22	6144	4094616	4.095	581	1.043	3	0.013	0.03
Catchment_23	5214	5088667	5.089	529	1.043	3	0.013	0.03
Catchment_24	2339	1773212	1.773	1346	1.840	3	0.013	0.03
Catchment_25	3663	2420808	2.421	2421	1.193	3	0.013	0.03
Catchment_26	4327	5207077	5.207	1250	0.719	3	0.013	0.03

Catchment_27	1782	869796	0.870	964	1.107	3	0.013	0.03
Catchment_28	1392	742615	0.743	9590	1.114	3	0.013	0.03
Catchment_29	1567	799627	0.800	1350	1.494	3	0.013	0.03
Catchment_30	18218	104299648	104.300	1644	1.343	3	0.013	0.03
Catchment_31	18619	106346446	106.346	3445	1.209	3	0.013	0.03
S1	3116	2815539	2.816	161	0.401	3	0.013	0.03
External Catchments								
S10	1653	1041112	1.041	739	1.081	3	0.013	0.03
S11	22418	121571934	121.572	4170	1.059	3	0.013	0.03
S12	31026	150030886	150.031	3032	1.317	3	0.013	0.03
S13	1997	1485451	1.485	888	1.426	3	0.013	0.03
S2	2439	2864830	2.865	1385	0.900	3	0.013	0.03
S3	1100	774121	0.774	789	1.092	3	0.013	0.03
S4	18901	79457764	79.458	4534	1.127	3	0.013	0.03
S5	1937	1187749	1.188	11879	1.383	3	0.013	0.03
S7	17393	101994325	101.994	6025	1.229	3	0.013	0.03
S8	3145	1489091	1.489	533	1.462	3	0.013	0.03

5.5 Storm peaks

The hydrological and hydraulic parameters of all the catchments contributing towards the study area were calculated and the overland peak flow rates were determined along the study area. The magnitude of the flood peak depends on the catchment characteristics and the rainfall intensity. PCSWMM was used as a flood analysis modelling tool to determine peak discharges at each sub-catchment.

PCSWMM is a dynamic rainfall-runoff simulation model, based on the SCS-SA method, used for single event or long-term simulation of runoff quantity. The model was set up for the site and used to calculate the 1:2 year, 1:5 year, 1:10 year, 1:20 year, 1:50 year, 1:100 year and the 1:200 year recurrence interval flood peaks based on the design rainfall depths calculated in Section 3.3.2 above.

Manning's 'n' coefficient used in the model for the impervious and pervious areas were 0.013 and 0.035 respectively. The Manning's n for the pervious areas is based on the arid grassland, shrubs with freely drained soils type vegetation found within the project drainage areas. Imperviousness within the catchments is very low (3 -5%) due to the fact that the catchments are highly undeveloped, soils are drained, and high percolation rates are expected.

The available land cover was obtained from the topographical information, satellite images available on Google Earth, site visit feedback from the client, as well as the relevant literature for the SCS method.

The SCS-SA hydrological modelling uses deterministic modelling techniques to aid in the estimation of peak flow rates. The model parameters include:

- Catchment slope, size and shape for each of the catchments. The catchments extended up to the origin of the drainage paths;
- Land-use information regarding current and potential future development conditions;
- Soil condition and Antecedent Moisture Conditions (AMC);
- Drainage size; and
- Storm rainfall estimated from the available daily rainfall records.

Storm peaks were calculated for the catchments shown in Figure 5-2 using the PCSWMM model and peak flows generated within each sub-catchment are considered conceptual due to lack of detailed contour data (topographical survey data).

The conceptual peaks are given in Table 5-2. The peaks are both pre-development and post-development scenarios, because the vegetation, topography and soil conditions will largely be the same, except where the main buildings (O&M building, stores, etc.) are placed, and this accounts for a negligible proportion of the development area from a surface area viewpoint.

Note that the wash water was not considered in the storm peaks, because solar panel washing is unlikely to be done in the rainy season, which will be negligible in comparison to storm volumes.

Table 5-2: Peak Flows for Conceptual Catchments

Catchment Name	2yr Peak	5yr Peak	10yr Peak	20yr Peak	50yr Peak	100yr Peak	200yr Peak
Catchment 1	1.0	1.5	1.9	2.3	2.8	3.4	3.9
Catchment 2	44.2	71.5	96.9	131.1	177.1	230.9	284.4
Catchment 3	26.2	42.1	54.5	66.0	79.0	96.6	124.5
Catchment 5	1.0	1.4	1.8	2.2	2.7	3.4	3.9
Catchment 6	0.5	0.7	0.9	1.1	1.3	1.5	1.8
Catchment 7	25.8	40.9	53.6	65.0	76.3	94.0	122.0
Catchment 8	25.6	38.2	48.3	59.7	74.4	92.9	111.1
Catchment 9	25.2	37.6	47.4	59.1	71.4	90.4	107.7
Catchment 10	24.6	37.5	48.2	58.4	71.5	91.0	110.5
Catchment 11	25.2	38.9	50.6	60.1	72.1	92.2	115.8
Catchment 12	20.9	30.9	39.1	49.9	60.3	75.5	89.8
Catchment 13	3.5	6.3	6.8	7.7	9.5	12.1	14.3
Catchment 14	0.9	1.4	1.8	3.2	4.4	4.3	5.3
Catchment 15	18.8	29.1	37.8	48.5	58.7	72.5	85.8
Catchment 16	2.6	3.9	5.1	6.4	8.0	10.0	11.7
Catchment 17	0.9	1.3	1.6	2.0	2.4	3.0	3.5
Catchment 18	0.4	0.5	0.7	0.9	1.0	1.2	1.4
Catchment 19	3.5	5.9	8.1	10.7	12.9	16.0	18.8
Catchment 20	30.1	49.8	68.1	89.8	116.7	151.8	183.3
Catchment 21	3.0	3.0	5.2	5.9	8.0	10.9	12.4
Catchment 22	1.4	2.1	3.1	3.4	4.2	5.3	6.2
Catchment 23	1.6	2.4	2.7	3.9	4.8	6.0	7.0
Catchment 24	0.8	1.1	1.8	1.8	2.2	2.7	3.1
Catchment 25	1.0	1.4	1.5	2.3	2.8	3.5	4.1
Catchment 26	2.1	3.1	3.9	4.9	6.0	7.4	8.7
Catchment 27	0.3	0.5	0.5	0.7	0.9	1.1	1.3
Catchment 28	0.3	0.4	0.6	0.6	0.8	1.0	1.2
Catchment 29	0.4	0.5	0.7	0.8	1.0	1.2	1.4
Catchment 30	26.5	41.8	55.7	71.9	92.0	117.9	140.2
Catchment 31	27.7	44.0	58.7	75.9	96.9	123.5	147.4
External Catchments							
S10	0.4	0.6	1.6	2.3	2.5	2.2	2.8
S11	28.1	45.5	61.8	81.0	104.9	135.5	163.1
S12	26.9	44.2	60.8	80.8	107.0	141.7	174.5
S13	0.7	1.0	1.3	1.6	1.9	4.7	7.4
S2	1.1	1.6	2.0	2.5	3.1	3.8	4.5
S3	0.4	0.5	2.1	3.0	6.5	4.2	5.0
S4	18.3	27.8	36.1	45.5	58.0	74.2	88.8
S6	1.2	1.7	2.1	2.5	3.1	3.8	4.3
S7	24.5	38.2	50.6	65.0	82.9	105.5	124.9
S8	0.7	1.0	1.3	1.5	1.8	2.3	2.6

The implications of the storm peaks calculated, and their impact on the SWMP, are discussed in Section 6.

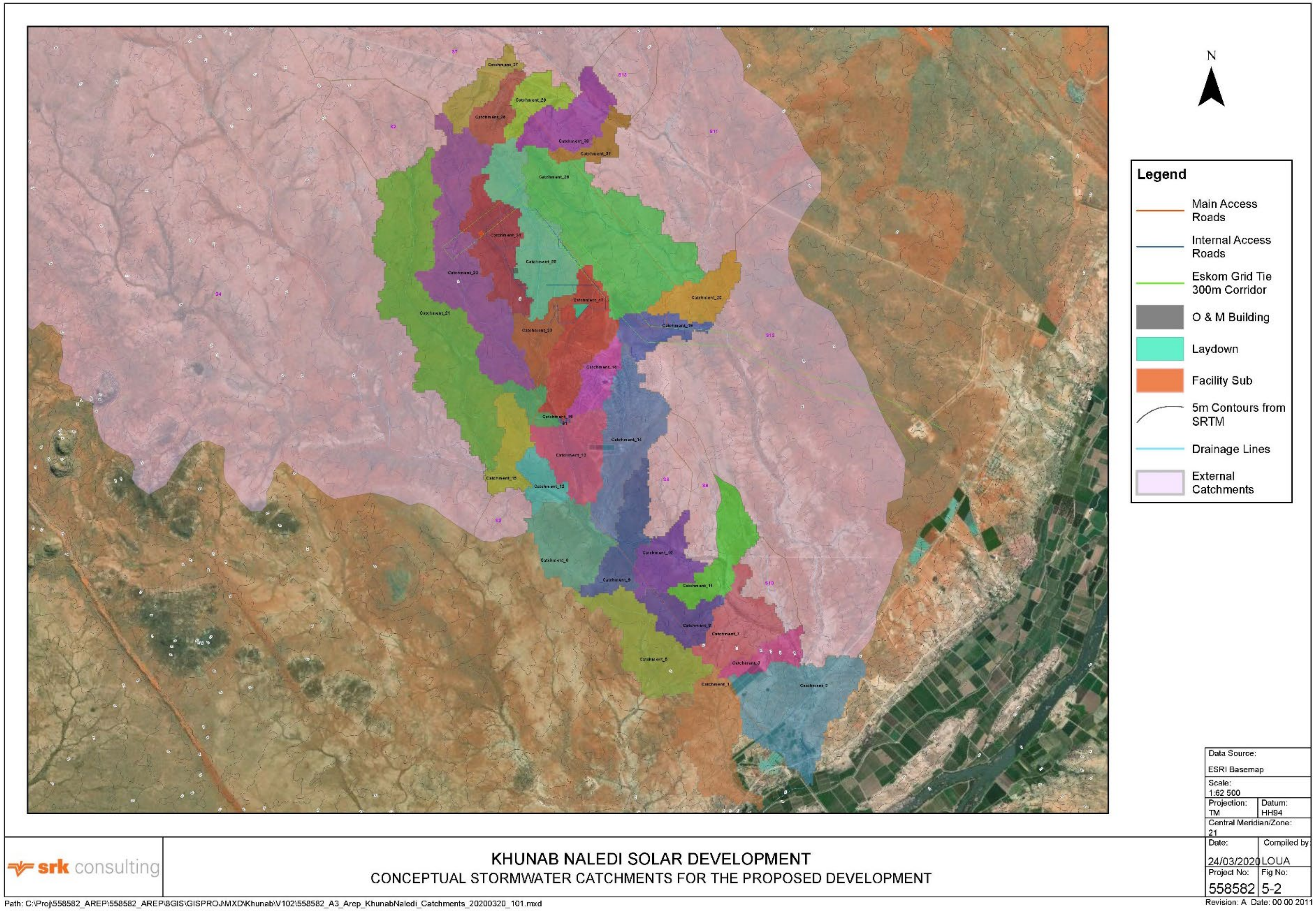


Figure 5-2: Conceptual Stormwater Catchments for the Proposed Development

6 Conceptual Design and Review

This section provides detail on why management approaches were selected, any alternatives that should be considered, and further steps required to confirm or improve the conceptual plan.

6.1 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 (and disposed of) regularly 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 stormwater. 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 (See Section 6.5 for bunding requirements) as per legal requirements and hence, this was recommended without any alternatives.

6.2 Channels, diversions and dissipaters

It is recommended that channels be placed on the upgradient side of any roads to control erosion, as well as around any of the dirty areas to divert clean water around these areas. In most cases, diversions can be used to direct clean water around dirty areas.

Solar panel areas are not considered dirty, and upstream catchment areas are small and thus stormwater does not generally need to be diverted around these solar panel areas.

Using the conceptual infrastructure layout plans and regional contours (obtained from the STRM programme), high-level conceptual designs were developed (i.e. typical drain and dissipater types). These were based on the following preliminary conclusions:

- Peak flows for the stormwater catchments are low;
- Most of the area is under 2% grade, and it is potentially possible to design earth or gravel drains rather than concrete drains, because low erosion potential exists at these low flow gradients; and
- Even though engineering designs might achieve low velocity flows in the drains, dissipaters are recommended at any outlets to control the transition of water from concentrated channel flow to overland dispersed flow or in-river flow – in addition, it is possible that outlets (e.g. adjacent to road/river crossings) could be locally steep.

Typical generic conceptual designs, based on the above discussions, were compiled as shown in Figure 7-1.

6.3 Road crossings

Using the conceptual infrastructure layout plans and regional contours, high-level conceptual designs were developed. These were based on the following preliminary conclusions:

- Most crossings are small and on areas with low gradients, and thus the roads are well-placed to generally avoid erosion at crossings; and
- Drifts would be the best crossing design from a practical, economic and environmental point of view for the road crossings;

Typical conceptual designs, based on the above discussions, were compiled for information purposes and are shown in Figure 7-1.

6.4 Erosion and sediment transport

The main erosion risks are drain outlets (Section 6.1), road crossings (Section 6.3) and stockpiles.

Permanent stockpiles should be avoided. However, material excavated during construction of the panels might be significant (cumulative volume). In that case, a suitable area should be selected for the stockpile such that it is unlikely to erode and result in sediment transport. Silt traps and diversion drains should also be designed for the stockpile. Where possible, the stockpiled material should be used in the construction of diversions and bunds.

6.5 Bunding

Requirements for bunding of potential contaminants are specified in detail in the National Norms and Standards for the Storage of Waste (Notice 926 of 29 November 2013, 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 contents 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 sealed to ensure spilled contaminants cannot leak out of the bunded areas.

6.6 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;
- 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 fulltime environmental manager on site (which may not be feasible) including:
    - Automatic alert systems for the wastewater conservancy tank (e.g. a float driven switch alert system);
    - Brief, annual refresher training that should not take more than half an hour for each staff member; and
    - Well placed signs that remind staff members of reporting of incident / issues, as soon as possible and reduce the likelihood that forgetfulness or confusion will prevent reporting.

7 Stormwater, Wastewater and Erosion Management Plan

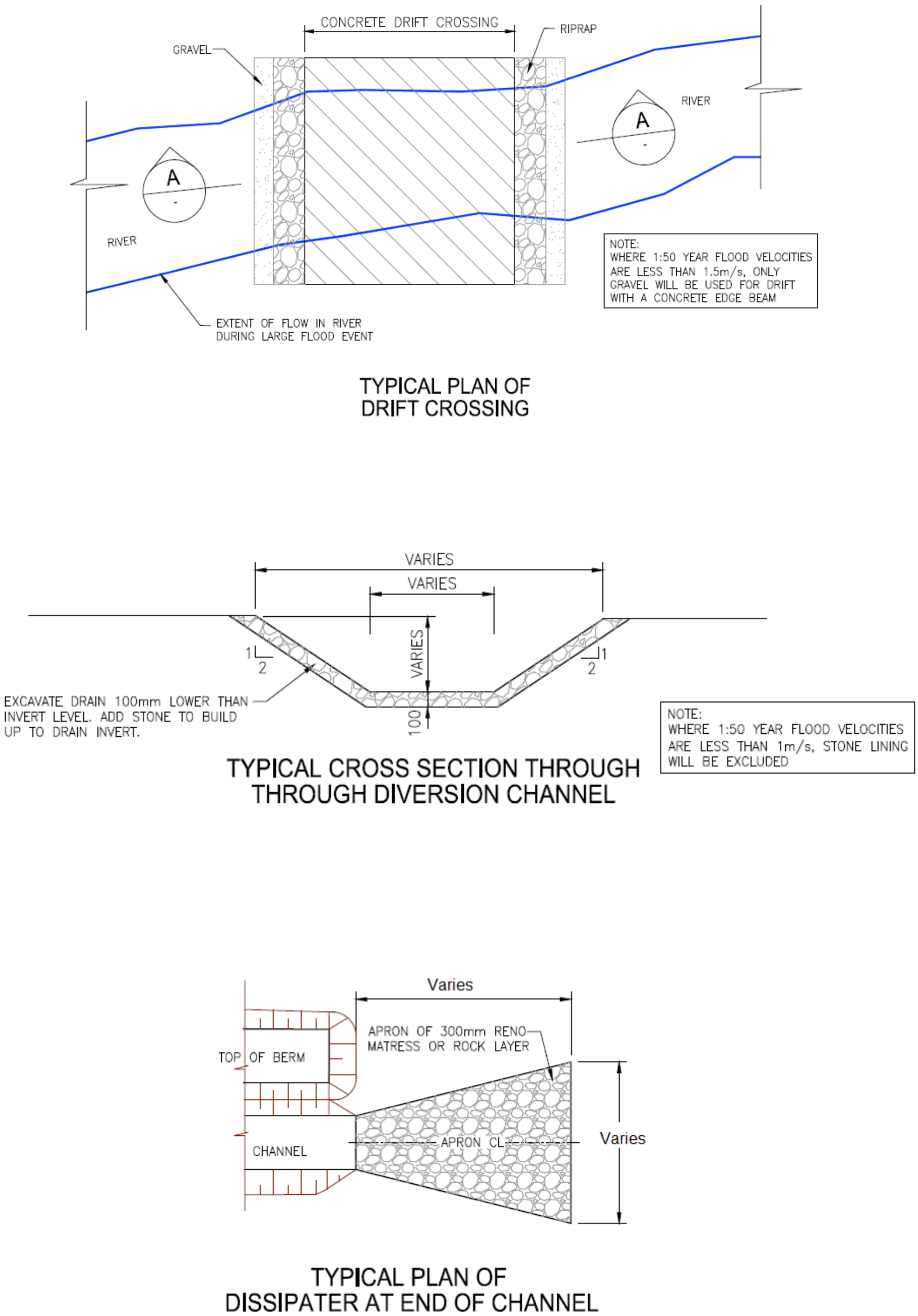
The SWMP, including wastewater management, is summarised in Table 7-1 and Figure 7-1 with supporting information and discussions of alternatives, where relevant, is provided in Section 3 and Section 3.4.

Table 7-1: Construction and Operations / Maintenance SWMP

General principle	Specific outcomes	When	Ref No.	Focus area	Action	By whom
Separate clean - and dirty water to ensure clean water remains uncontaminated	Temporary containments and diversion (designed for a 1 in 5-year event)	During contractors site establishment	1	• Stockpiles; • Laydown areas; • Workshops; and • Any other area likely to generate sediment during a storm event or contain contaminants that can be disbursed.	Clean water diversions or bunds: Construct stormwater drains or bunds to divert clean runoff around dirty areas. The diversion should be sized for 1 in 5-year event. Typical design will be an excavated earth channel or berms.	Construction contractor's onsite environmental officer/representative
	Permanent containments and diversions (designed for a 1 in 50-year event)	Constructed prior to operation	2	• The workshop and chemical stores; • Transformers, inverters and substations; and • Wastewater conservancy tank.	Clean water diversions or bunds: Construct stormwater drains or bunds to divert clean runoff around the workshop, chemical stores, transformers, inverters, substations and wastewater conservancy tank. The diversion should be designed for a 1 in 50-year event.	Included in detailed designs of design engineer and carried out by contractor appointed for construction
Collect and, where required, treat dirty water or runoff from any dirty areas.	Dirty water should not have the potential to spill into clean water systems more than once every fifty years (where influenced by stormwater)	Before stockpiles are deposited	3	Stockpiles	Construct silt fences or berms: to prevent the sediment transport into rivers.	Included in detailed designs of design engineer and carried out by contractor appointed for construction
		Throughout construction	4	Waste	Dispose of landfill, oils and other contaminants offsite	
		During site establishment	5	Sewage	Supply chemical toilets	
		Constructed prior to operation	6	Workshop	Workshop collection drain with oil and grease trap: Construct a small concrete drain collecting all water, potentially containing oils and lubricants, from workshop floor and directing it through an oil and grease trap before discharge (or removing to offsite facility). Floor to be sloped such that all water will collect in drains.	
		Inspected every 3 months for first 2 years and then revise	7	Workshop	Clean the oil and grease trap: The oil and grease traps are to be inspected and, when necessary, cleaned and waste taken to a registered offsite facility	Workshop manager and assurance by environmental manager
		As required when the tank is full	8	Transformers	Dispose of transformer oil offsite: Dispose of any spent oil, removed from transformers during maintenance, to a registered offsite facility	
		As required when the tank is full	9	The sewage conservancy tank	Transport sewage to municipal works: Regularly collect sewage in the conservancy tank and disposed of at a licensed municipal sewage treatment plant.	
	Bund any hazardous substance or pollutant storage areas (including any oils), as per regulations	Throughout construction	10	General	Construct temporary bunds for any chemicals such as oils or fuel stored on sited during construction. Bunds must contain at least 100% of the volume of the container. If all containers are stored together the bund must store at least 110% of the largest container or 25% of the total storage capacity, whichever is greater. Suitability of the material of bund must be investigated whenever a new substance is added to the bund	Included in detailed designs of design engineer and carried out by contractor appointed for construction
		Constructed prior to operation	11	Transformers	Transformer bunds: All transformers will be bunded with bund capacity of at least 110% of the maximum volume of oil in the transformer. Transformers and bund will be protected from rainfall by small covers or roof or housed in containers, as applicable.	
			12	The sewage conservancy tank	Sewage conservancy bund: The sewage conservancy tank will be a closed tank with an automatic alert system.	
		During operation: as and when containers are purchased	13	Workshop	Small trays for workshop chemicals: Bund any containers with oils and lubricants by placing them in plastic trays that is at least 100% of the volume of the container. If all containers are stored together the bund needs to store at least 110% of the largest container or 25% of the total storage capacity, whichever is greater. Suitability of the bund must be investigated whenever a new substance is added to the bund.	Workshop manager and assurance by environmental manager
Do not impede surface and subsurface flow along drainage lines	Minimise dirty areas such that surface and subsurface movement of water along the drainage lines is not impeded	Constructed prior to operation	14	The workshop, transformers, wastewater conservancy tank	Diversion channels placed to minimised dirty areas: Place diversion channels directly upstream of dirty areas such that dirty area catchments are minimised in footprint	Included in detailed designs of design engineer and carried out by contractor appointed for construction
		Throughout construction	15	• Laydown areas; and • Stockpiles	Minimise laydown areas and stockpiles.	
	Ensure any engineered clean stormwater drainage directs water to the closest naturally receiving drainage line		16	All drains	Ensure that any temporary stormwater drains or diversion berms direct water towards the drainage line to which it would naturally flow	
		Constructed prior to operation	17	Along roads, the workshop, transformers, wastewater conservancy tank	Drains to follow natural topography: Ensure outlets drain towards the natural drainage line that would originally have received flow from that area	

General principle	Specific outcomes	When	Ref No.	Focus area	Action	By whom
Control, monitor and manage erosion	Prevent erosion in general	Constructed prior to operation	18	All areas	Maintain natural topography: Do not disturb the natural topography or vegetation between the solar panel installations	Included in detailed designs of design engineer and carried out by contractor appointed for construction
		During operation	19		No stockpiles if possible: Do not stockpile (during operation). If spoil from pilings is likely to be significant, a dedicated stockpile location must be identified, and stormwater protection measures designed when detailed layouts are available.	Assurance by environmental manager
	Minimize erosion in large storm event of 1 in 50- years or greater	Constructed prior to operation	20	All drains	Engineer low velocity drains: Drains sloped and sized such that velocities do no exceed 1 m/s	Included in detailed designs of design engineer and carried out by contractor appointed for construction
			21	Road crossings	Engineered drifts: Line all major drifts on road crossings with concrete to protect from traffic damage and high flow velocities (For smaller drifts gravel might suffice). Place a section of riprap (larger rocks) underlain by gravel and with gravel on either side to facilitate a smooth flow transition. Detailed modelling and design of road crossings such that erosion is controlled to be a feature of the detailed design.	
	Dissipate stormwater at all drainage outlets to velocities unlikely to cause erosion in natural soils for a 1 in 50-year storm event		22	All drains	Dissipaters: At drain outlets widen the channel and use riprap (can be sourced from spoil during construction) or reno mattresses to dissipate stormwater flows	
			23	Road crossings	Dissipation at road crossings: Detailed modelling and design of road crossings including riprap (can potentially be sourced from spoil during construction) or reno-mattresses.	
	Prevent erosion in general	Throughout construction	24	All	Maintain natural topography and vegetation: Do not disturb the natural topography or vegetation where possible	Construction contractors onsite environmental officer/representative
	Minimize erosion in large storm event of 1 in 5-years or greater		25	All drains	Engineer low velocity temporary drains: Drains sloped and sized such that velocities do no exceed 1 m/s in a 1 in 5-year event	
		Early in construction	26	Road crossings	Engineered temporary drifts: Build roads and road crossings before other infrastructure.	
	Ensure that any chronic erosion is detected and rehabilitated within 6 months	Every 3 months for the first 2 years and annually thereafter	27	• PV cell blocks; • Drains; • Outlet of all Drains; and • All-natural drainage lines that cross the access road.	Inspect and remediate noticeable erosion: Inspect all focus areas for erosion. If erosion is found, remediate and redesign the drainage in the area. If erosion is found in a natural drainage line, conduct an assessment and determine the cause. Develop a plan to prevent future erosion.	Environmental manager or hydrologist/engineer/environmental scientist appointed by the environmental manager
	Ensure that any acute erosion due to large storm events is detected within 2 weeks.	Install prior to operation	28	Main office	Install a rain gauge that can measure greater than 115 mm (100-year, 24-hour event)	Included in detailed designs of design engineer and carried out by contractor appointed for construction
		After a rain event of greater than 65 mm in one day (a 10 year - 24-hour rain event) or when staff notice flood damage.	29	All-natural drainage lines that run through the site	Inspect and remediate acute erosion: Inspect all focus areas for erosion. If erosion is found remediate and redesign the drainage in the area. If erosion is found in a natural drainage line conduct and assessment and determine the cause and develop a plan to prevent future erosion.	Environmental manager or hydrologist/engineer/environmental scientist appointed by the environmental manager
		Design and development prior to operation	30	All	Set up rain data system: Build or buy a basic rain program, preferably electronic, that allows site staff to enter rain data from the rain gauge. Ideally the system should alert the environmental manager and site manager when a rainfall event in excess of 65 mm per day is entered.	
		Daily	31	Main office	Record rain data: Read and record rain gauge daily;	Onsite staff member tasked by the Environmental manager
		Update annually in case of staff change	32		Signs at main office to aid problem reporting: Ensure that a sign providing the following is posed in the reception area, the control room, on each transformer and in the workshop: The name, telephone number and email address of the environmental manager. The sign should state: "If you notice any leaks or spills or erosion anywhere on the property please phone or email the environmental manager on ……."	Environmental manager
	Training	Annually	33	All	Training: Provide a short briefing to all construction staff on the dynamics of erosion and leaks that covers at least: • How to identify erosion; • How to identify a leak, including car leaks;	Environmental manager or hydrologist/engineer/environmental scientist appointed by the environmental manager

General principle	Specific outcomes	When	Ref No.	Focus area	Action	By whom
					• Where to find contact details of the environmental officer/representative in case of leaks or erosion.	
	Ensure that any erosion is detected and rehabilitated	After rain events	34		Inspect the site for erosion after rain events. If erosion is found, remediate and redesign the drainage in the area. If erosion is found in a natural drainage line, conduct an assessment to determine the cause and develop a plan to prevent future erosion.	Contractors environmental officer/representative
		During site establishment	35		Install a rain gauge that can measure greater than 115 mm (100-year, 24-hour event). This rain gauge will also be used during operation.	
Monitor and manage stormwater system	Include a monitoring system for spills and leaks such that they are detected as soon as possible.	Once every 2 weeks	36	All	Leak inspection: regularly check for leaks and for any breaches or evidence of spills or any other problems not in adherence to this SWMP. All cars should also be checked for oil leaks and any leaks found should be stopped immediately, the cause of the leak identified, the problem remediated such that no further leaks occur, and any contaminated soil or water assessed and remediated.	Contractors environmental officer/representative
	Include a monitoring system for spills and leaks such that they are detected as soon as possible.	Every 3 months for the first 2 years and annually thereafter	37		Leak inspection: regularly check for leaks and for any breaches or evidence of spills or any other problems that would indicate that it is not in adherence to this plan. All cars should also be checked for oil leaks during the inspection. Any leaks found should be stopped immediately, the cause of the leak sought, the problem remediated such that no further leaks occur, and any contaminated soil or water assessed and remediated.	Environmental manager or hydrologist/engineer/environmental scientist appointed by the environmental manager
		Continuous	38		Data capture, training and signs: see 32, 33, 34, 35, 36, & 37	Environmental manager and staff in general
		Construct prior to operation	39	The sewage conservancy tank	Sewage conservancy tank alert system: Install a float switch-controlled alarm that will alert the control room when the conservancy tank has less than 2 weeks of capacity remaining.	Included in detailed designs of design engineer and carried out by contractor appointed for construction
			40	Transformers	Signs at transformers: Post a sign on transformers stating “If you notice any leaks or spills or erosion anywhere on the property please phone reception on ……and report it”	
General	Do not build infrastructure within near to watercourses	Detailed design	41	All	Ensure no infrastructure except roads, solar panels and solar panel supports are built within 300 m of a water course. In particular, ensure no dirty areas, that may contain pollutants, are within 300 m of the water course	Design engineer or engineer appointed by the design engineer
	Do not build infrastructure containing potential pollutants in any of the natural drainage lines.		42		Ensure that final infrastructure plans do not propose any potentially polluting infrastructure, such as transformers, workshops or conservancy tanks in the natural drainage lines (currently none are proposed)	
	Review and improve stormwater management plan regularly.	Once every 5 years	43		Review and improve the stormwater plan	Environmental manager or engineer appointed by the environmental manager
	Review and inspect	Once every 2 months depending on the construction schedule	44		Inspect the site to ensure adherence to the stormwater management plan	Clients environmental representative or engineer
	Do not place stockpiles or other potentially polluting construction items within 300 m of the watercourse	Detailed design and throughout construction	45		Do not place laydown areas, stockpiles within 300 m of the watercourse	Design engineer or engineer appointed by the design engineer
	General	Detailed design	46		Develop a specific environmental specification for any construction including, but not limited to, the actions in this stormwater management plan and its principles	Clients environmental representative or specialist



srk consulting	TYPICAL CONCEPTUAL DESIGNS OF STORMWATER INFRASTRUCTURE (TO BE CONFIRMED IN DETAILED DESIGN)	Project No. 558582

Figure 7-1: Typical Conceptual Designs of Stormwater Infrastructure

8 Conclusions and Recommendations

In conclusion:

- The proposed facility will have an intrinsically low impact on surface water resources;
- The potential stormwater impacts that do 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 layouts were made available at the time of the study.

It is recommended that the SWMP be developed further during the detailed design by:

- Conducting a detailed topographic survey;
- Delineating floodlines for major rivers and assessing any safety requirements due to flooding;
- Developing a stormwater layout and conceptual designs based on the above information and infrastructure layout plan;
- Sizing the culverts or drifts associated with the proposed road crossings such, that it can handle at least the 1:2-year flood event, or a minimum of 600mm diameter or height (for maintenance purposes);
- Developing conceptual designs into detailed designs with sufficient detail to support construction; and
- The plan should be incorporated into an environmental specification for use during construction and incorporated into the operational environmental management of the site.

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All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

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