Surface Water Hydrology Report for the Eloff Project – Phase 3

Report Prepared for

GCS (Pty) Ltd

Report Number GCS005

Report Prepared by

SD Hydrological Services (Pty) Ltd

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Acronyms and Abbreviations

Below a list of acronyms and abbreviations used in this report.

Acronyms / Abbreviations	**Definition**
DEM	Digital Elevation Model
DWAF	Department of Water Affairs and Forestry
MAE	Mean Annual Evaporation
MAMSL	Meters Above Mean Sea Level
MAP	Mean Annual Precipitation
PCD	Pollution Control Dam
WMA	Water Management Area
WRD	Waste Rock Dump

1 Introduction

SD Hydrological Services (Pty) Ltd has been appointed by GCS (Pty) Ltd, to undertake a surface water specialist study for the proposed Eloff Project – Phase 3, which lies adjacent to the existing Kangala Mining operations.

The section to follow briefly summarises the required scope of work.

2 Scope of Work

The scope of works includes the following:

- **Baseline hydrology** - Undertake a detailed desktop assessment which includes, review of all existing information for the project area including, mean annual runoff (MAR), mean annual precipitation (MAP), mean annual evaporation (MAE), catchment areas of interest, topography, identification of surface water resources (rivers, drainage paths etc.) and storm rainfall depths for various recurrence intervals.
- **Stormwater management plan** – Undertake a stormwwater management plan based on the Department of Water Affairs and Forestry (DWAF) (Best Practice Guidelines – G1: Storm Water Management, August 2006).
- **Waterbalance** – Develop a waterbalance for the project area based on the DWAF, (G2: Best Practice Guidelines, Water and Salt Balance, August 2006).
- **Floodline delineation**– Undertake floodline modelling for the section of the rivers/drainages which flows adjacent to the project infrastructure area
- **Surface water impact assessment** – Undertake a surface water impact assessment for the proposed Eloff project activities.
- **Surface water report** – Compilation of surface water report.

A locality map indicating the project location is shown in Figure 2-1 below.

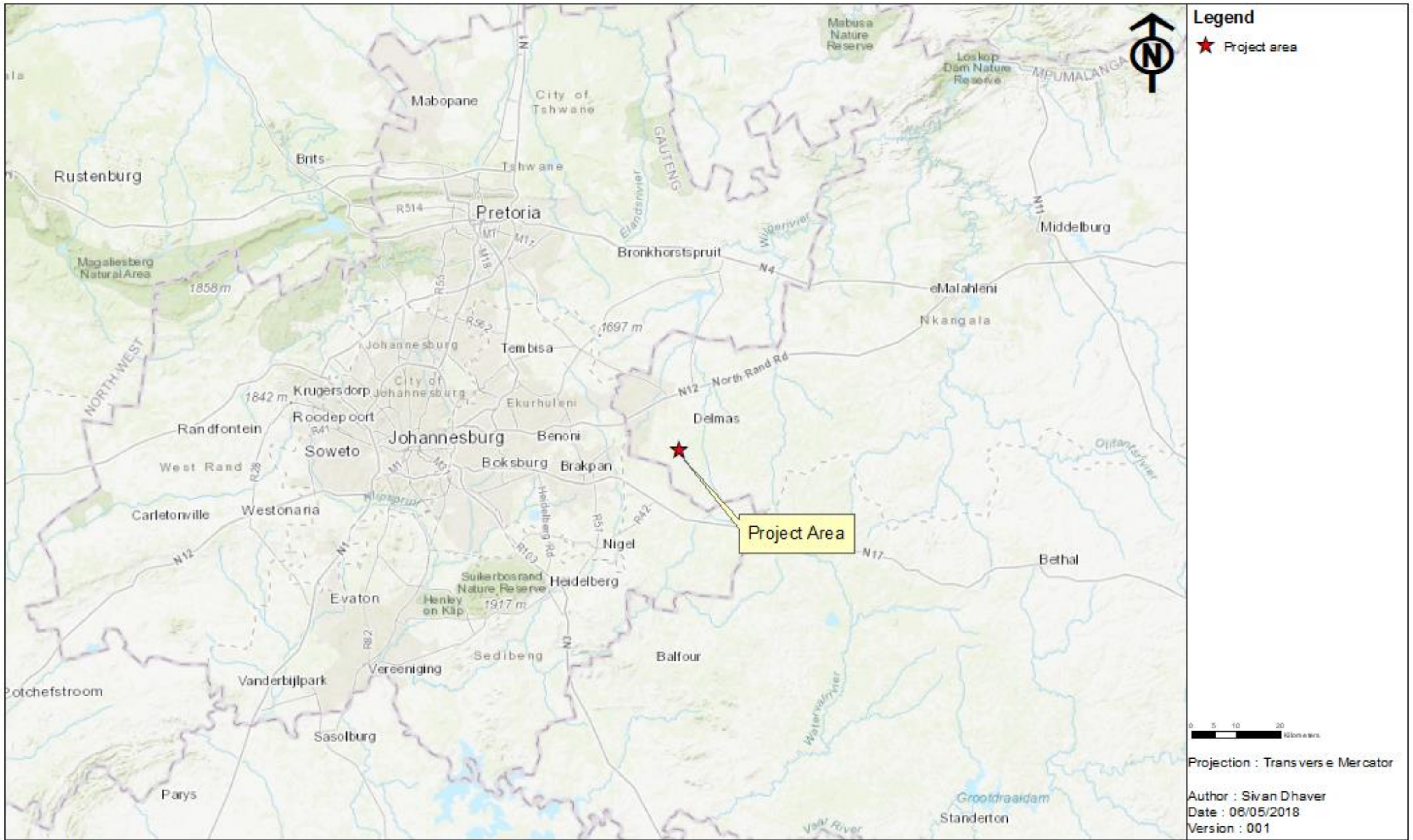

Figure 2.1

TITLE : Locality Map

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3 Baseline Hydrology

A baseline hydrological assessment was undertaken to inform sections relating to the waterbalance, stormwater management plan, waterbalance, and the floodline assessment study. The hydrology work undertaken specifically the baseline hydrology was obtained from (Surface Water Hydrology Report for the Eloff Project, SD Hydrological Services (Pty) Ltd, 2017)

3.1 Hydrological Settings

3.1.1 Introduction

South Africa is divided into 19 water management areas (National Water Resource Strategy, 2004), managed by its separate water board. Each of the water management areas (WMA) is made up of quaternary catchments, which relate to the drainage regions of South Africa, ranging from A – X (excluding O). These drainage regions are subdivided into four known divisions based on size. For example, the letter A represents the primary drainage catchment, A2 for example will represent the secondary catchment, A21 represents the tertiary catchment and A21D would represent the quaternary catchment, which is the lowest subdivision in the Water Resources 2005 Study (WR2012, 2015) manual. Each of the quaternary catchments have associated hydrological parameters including area, mean annual precipitation (MAP) and mean annual runoff (MAR) to name a few.

The project area falls within the Olifants WMA with the major river falling within the mentioned WMA being the Elands, Wilge, Steelpoort and the Olifants River. Majority of the runoff from the project area is eventually drained north into the Olifants River.

3.1.2 Regional Hydrology and Topography

The project area falls within the north western boundary of the B20A quaternary catchments. The quaternary catchment B20A has a net mean annual runoff (MAR) of 25.60 million cubic meters (mcm), and is based on the (WR2012, 2015).

The Bronkhorspruit River has its headwaters at the B20A quaternary catchment, and eventually flows into the Wilge River further downstream, which joins the larger Olifants River. The Olifants River then flows eastwards into Mozambique beyond the Olifants WMA. The project area is located on the joint upstream boundary of the Olifants WMA and quaternary catchment B20A. All runoff emanating from the upstream boundary of the project area contributes to flow in the downstream tributaries of the Bronkhorstspruit.

Average elevations at the upstream boundary of quaternary catchment B20A range from 1600 meters above mean sea level (mamsl) to 1690 mamsl, and decreases to between 1570 – 1590 mamsl further downstream at the banks of the downstream tributaries. Average slopes range between 1% and 3 % and is characterised as flat.

The hydrological setting of the project site is indicated in Figure 3-1. The digital elevation model (DEM) was sourced from the USGS website (http://hydrosheds.cr.usgs.gov/dataavail.php).

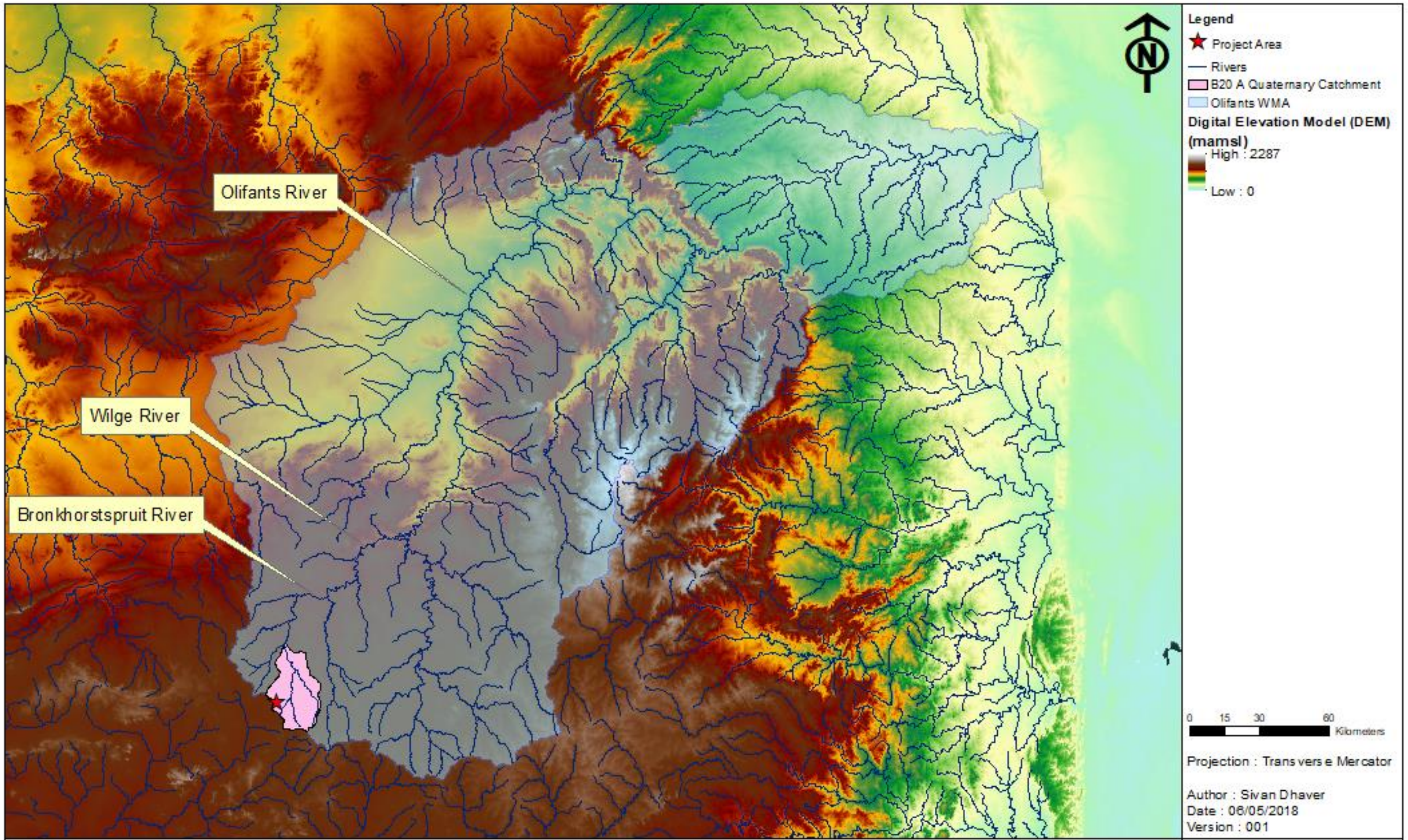

Figure 3.1

TITLE : Summary of Hydrological Setting

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3.2 Climate

3.2.1 Rainfall

Rainfall data was extracted from two sources, these include:

- The Daily Rainfall Extraction Utility program.
- Water Resources of South Africa 2005 Study (WR2005).

The Daily Rainfall Utility is a programme that was developed by Richard Kunz, from the Institute for Commercial Forestry Research (ICFR, 2004), in conjunction with the School of Bioresources Engineering and Environmental Hydrology (BEEH) at the University of KwaZulu-Natal, Pietermaritzburg, South Africa. The utility assists the user in extracting observed and in-filled daily rainfall values from a database which was developed by Steven Lynch in the course of a Water Resources Commission (WRC) funded research project (K5/1156) awarded to BEEH. The project, titled “The development of a raster database of annual, monthly and daily rainfall for southern Africa”, was completed in March 2003. The daily rainfall database consists of more than 300 million rainfall values derived from 11,269 daily rainfall stations. The data in the database originated from many different organisations and individuals, each having their own structure and level of quality control. The three main custodians of rainfall data in South Africa include, inter alia, the

- South African Weather Service (SAWS).
- Agricultural Research Council (ARC).
- South African Sugarcane Research Institute (SASRI).

Summary of the six nearest rainfall stations as per the output from the design rainfall program (described in section 4.1), together with the monthly rainfall obtained from WR2005 is shown below in Table 3-1.

Table 3-1 Summary of monthly rainfall

Months	Rietfontein 0476737 W	Vlakplaas 0477494 W	Strydpan 0477224 W	Droogefontein 0477191 W	Delmas (POL) 0477309 W	Rietkuil 0477459 W	WR2005
January	114	118	117	111	118	114	118
February	94	90	101	100	96	86	90
March	81	76	82	81	85	90	84
April	42	34	44	40	41	41	40
May	19	16	17	15	19	18	17
June	6	5	6	6	6	7	7
July	7	5	7	6	6	6	5
August	7	8	11	7	8	6	6
September	24	21	24	21	22	20	19
October	57	61	60	63	67	63	66
November	106	104	106	102	102	103	105
December	117	98	108	112	106	117	109
MAP (mm)	**674**	**637**	**682**	**664**	**676**	**671**	**669**

Based on the above estimations it is observed that the MAP ranges between 637 mm to 669 mm, with the average MAP of the six nearest stations estimated to be 671 mm. The MAP obtained from the WR2005 study for quaternary catchment B20A is slightly conservative (669 mm) when compared to the six stations, and is therefore selected as the adopted MAP for the project area.

Based on the rainfall pattern shown in Table 3-1, it is observed that the dry season extends between the months of April to September, with the wet season ranging from October to March. Majority of the total MAP falls within the wet season and accounts for greater than 85 percent of the MAP (see below Figure 3-2).

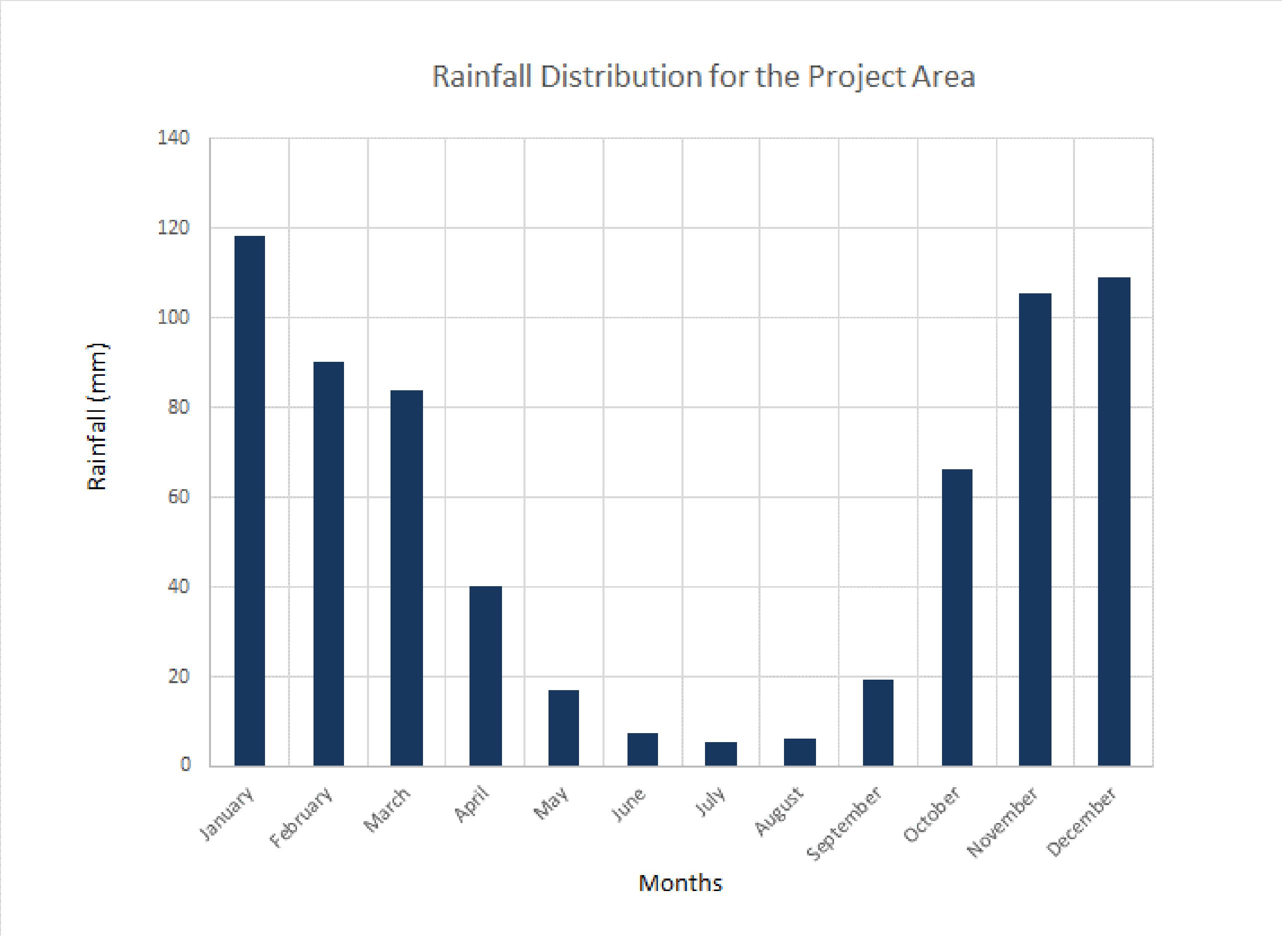

Figure 3-2 Summary of rainfall distribution

3.2.2 Evaporation

Monthly evaporation data was obtained from the Water Resources of South Africa manual, (WR2005, 2009). Evaporation was calculated using a Symons pan, which is a square shaped containment, filled with water and buried below the natural ground level as indicated in Figure 3-3. Change in water level as a result of evaporation losses is then measured daily and recorded.

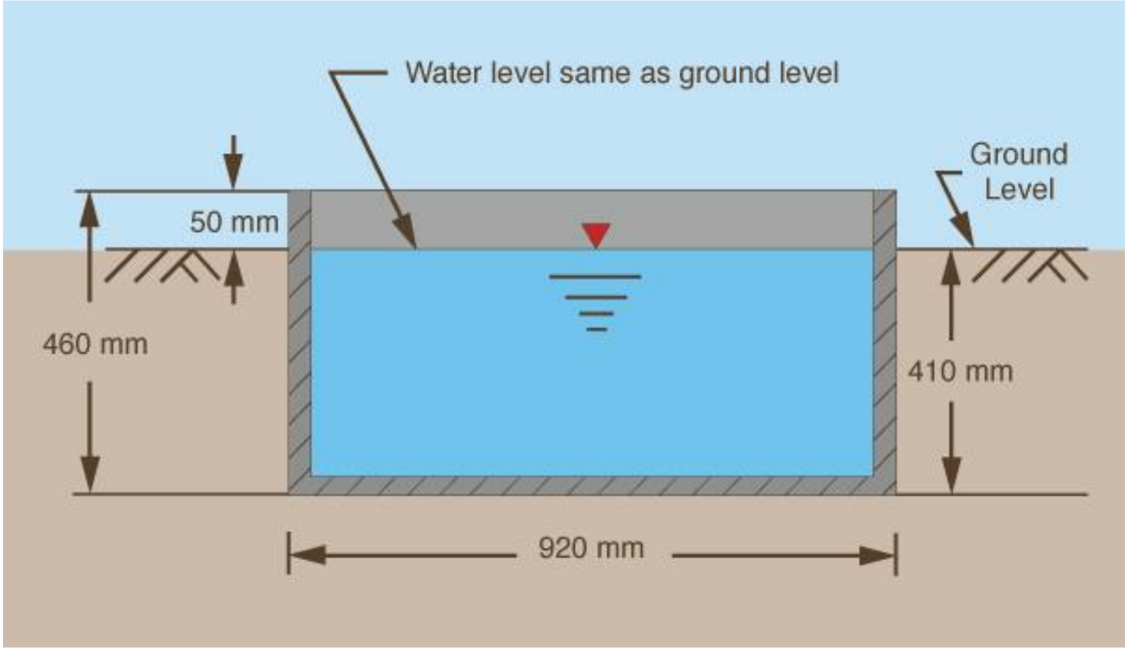

Figure 3-3 Symons Pan

The Symons pan evaporation obtained needs to be converted to lake evaporation, this this is due to the Symons pan being located below the ground surface, and painted black which results in the temperature of the water being higher than of a natural open water body. The Symons pan is then multiplied by a lake evaporation factor (WR2012, 2015) to obtain the adopted Lake evaporation to be used which is more representative of the evaporation rates from a natural body of water. Below in Table 3-2 is a summary of the adopted evaporation for the project site.

Table 3-2: Summary of evaporation data

Months	Symons Pan Evaporation (mm)	Lake Evaporation Factor	Lake Evaporation (mm)
January	182	0.84	152
February	151	0.88	133
March	149	0.88	131
April	115	0.88	101
May	97	0.87	84
June	79	0.85	67
July	86	0.83	71
August	114	0.81	92
September	148	0.81	119
October	178	0.81	144
November	168	0.82	138
December	185	0.83	153
Total	**1650**		**1387**

High evaporation rates are experienced between the months of October to March but decrease, with peak monthly evaporation of 153 mm occurring in December. Lower evaporation occurs between the months of May to August and range from 67 mm to 92 mm. It is observed that throughout the year evaporation rates exceeds the monthly rainfall, resulting in a negative climatic waterbalance.

4 Flood Hydrology

4.1 Storm Rainfall Depths

The design storm rainfall depths were obtained from the design rainfall software (Smithers and Schulze, 2002). The programme is able to extract the storm rainfall depths for various recurrence intervals for the six closest rainfall stations as shown below in Table 4-1 below.

Table 4-1 Summary of six closest SAWS stations as per the design rainfall software

Station Name	SAWS Number	Distance (Km)	Record length (Years)	Mean Annual Precipitation (mm)	Altitude (mamsl)
STRYDPAN	0477224 W	2.5	46	683	1603
DROOGEFONTEIN	0477191 W	5.1	61	664	1617
DELMAS (POL)	0477309 W	10.5	92	661	1555
RIETKUIL	0477459 W	16.1	41	658	1555
VLAKPLAAS	0477494 W	16.3	26	662	1578
RIETFONTEIN	0476737 W	17.0	48	702	1580

It should be noted that the MAP obtained for the six closest stations above, differ from the MAP of the same stations obtained using the Daily Rainfall Extraction Utility. The reason is, due to the extension of the existing record as a result of patched data being taken into account.

The summary of the rainfall depths for the 5 minute duration up to the 1 day storm duration for various recurrence intervals are shown below in Table 4-2, and will be used in the calculation of peak flows for all catchments required in the development of the floodline assessment study.

Table 4-2 Summary of storm rainfall depths

Duration	Rainfall Depth (mm)						
(m/h/d)	1:2 year	1:5 year	1:10 year	1:20 year	1:50 year	1:100 year	1:200 year
5 m	9.8	13	15.3	17.6	20.8	23.3	25.9
10 m	14.5	19.3	22.7	26.2	30.9	34.6	38.6
15 m	18.3	24.4	28.7	33	39	43.7	48.6
30 m	23.2	30.9	36.3	41.8	49.3	55.3	61.6
45 m	26.6	35.4	41.7	48	56.6	63.5	70.7
1 h	29.4	39.1	46	52.9	62.5	70	77.9
1.5 h	33.7	44.8	52.8	60.7	71.7	80.4	89.5
2 h	37.2	49.5	58.2	67	79.1	88.7	98.7
4 h	43.8	58.3	68.5	78.9	93.1	104.4	116.2
6 h	48.2	64.1	75.4	86.8	102.5	114.9	127.9
8 h	51.6	68.6	80.7	92.9	109.7	123	136.9
10 h	54.3	72.3	85.1	97.9	115.6	129.6	144.3
12 h	56.7	75.5	88.8	102.2	120.7	135.3	150.6
16 h	60.7	80.8	95	109.4	129.2	144.8	161.2
20 h	64	85.2	100.2	115.3	136.1	152.7	169.9
24 h	66.8	88.9	104.6	120.4	142.1	159.4	177.4
1 d	55.6	73.9	87	100.1	118.2	132.5	147.5

4.2 Peak Flow Methodology

Due to the size of the project area and associated catchments delineated (section 5 and section 6), the Rational method was adopted. Below is a brief summary on the mentioned peak flow estimation methodology.

4.2.1 Rational Method

The Rational Method is a hydrological method used to predict peak runoff with the equation being shown below.

$$Q_T = \frac{C\ I\ A}{3.6}$$

Where:

Q_T = Peak Flow (m^3/s for specific return period);

C = Runoff Coefficient (%);

I = Rainfall Intensity (mm/hr); and

A = Area (km^2).

The runoff coefficient C is based on a number of different physical characteristics of the site. These include the vegetation type and the slope drainage properties of the oil. The percentage of land used for residential or industrial development or under paved roads is also taken into account. The Rational Method is suitable for small catchments and is a method used extensively around the world.

A spreadsheet calculation using the Rational Method (as presented in the SANRAL Drainage Manual) was used to estimate peak flows to be used in undertaking the floodline delineation and stormwater management plan. The runoff coefficients for each catchment were estimated using the SANRAL Drainage Manual, summarised in Table 4-3 and Table 4-4.

Table 4-3 Recommended value for runoff factor (SANRAL, 2006)

Rural (C_1)					Urban (C_2)	
Component	Classification	Mean annual rainfall (mm)			Use	Factor
		< 600	600 - 900	> 900		
Surface slope (C_s)	Vleis and pans (<3%)	0,01	0,03	0,05	*Lawns*	
	Flat areas (3 to 10%)	0,06	0,08	0,11	- Sandy, flat (<2%)	0,05 - 0,10
	Hilly (10 to 30%)	0,12	0,16	0,20	- Sandy, steep (>7%)	0,15 – 0,20
	Steep areas (>30%)	0,22	0,26	0,30	- Heavy soil, flat (<2%)	0,13 – 0,17
					- Heavy soil, steep (>7%)	0,25 – 0,35
Permeability (C_p)	Very permeable	0,03	0,04	0,05	*Residential areas*	
	Permeable	0,06	0,08	0,10	- Houses	0,30 – 0,50
	Semi-permeable	0,12	0,16	0,20	- Flats	0,50 – 0,70
	Impermeable	0,21	0,26	0,30		
					Industry	
					- Light industry	0,50 – 0,80
Vegetation (C_v)	Thick bush and plantation	0,03	0,04	0,05	- Heavy industry	0,60 – 0,90
	Light bush and farm lands	0,07	0,11	0,15	*Business*	
					- City centre	0,70 – 0,95
	Grasslands	0,17	0,21	0,25	- Suburban	0,50 – 0,70
	No vegetation	0,26	0,28	0,30	- Streets	0,70 – 0,95
					- Maximum flood	1,00

Table 4-4 Adjustment factor for C (SANRAL, 2006)

Return period (years)	2	5	10	20	50	100
Factor (Ft) for steep and impermeable catchments	0,75	0,80	0,85	0,90	0,95	1,00
Factor (Ft) for flat and permeable catchments	0,50	0,55	0,60	0,67	0,83	1,00

The time of concentration was estimated for channel flow using the equations below:

$$T_{c\ channel} = \left(\frac{0.87L^2}{1000\left(\frac{H_{0.85L} - H_{0.10L}}{(1000)(0.75L)}\right)} \right)^{0.385}$$

Where:

$T_{c\ channel}$ = time of concentration for channel flow (hours);

L = hydraulic length of catchment (km);

$H_{0.10L}$ = elevation height at 10% of the length of the watercourse (m);

$H_{0.85L}$ = elevation height at 85% of the length of the watercourse (m);

The worst case rainfall event for each catchment (i.e. duration = time of concentration) was taken from the storm rainfall depth estimates presented in Table 4-2.

To determine the anticipated peak flows at the respective catchment outlets using the Rational method, the catchment hydrology of the project area will have to be assessed, this involves:

- Delineation of catchment areas for identified outlets at the identified rivers/watercourses.
- Determining the appropriate runoff coefficient (C-Factor) which best represents the specific catchment, and is based on site visit observations and/or areal imagery and topography data.
- Determining the length of longest flow path, which is the identified flow path within the specific catchment from the upstream catchment boundary down to the outlet.
- Calculate the time of concentration (Tc). This is the time taken for a single drop of water to flow from the furthest point in a specific catchment to the outlet.

A summary of the catchment hydrology and peak flow calculations are presented in the sections to follow which include the proposed stormwater management plan and the floodline modelling sections, namely sections 5 and 6 respectively.

5 Stormwater Management Plan

A stormwater management plan is required so as to ensure there is adequate clean and dirty water separation such that, all water emanating from the mine area (dirty water) is captured, conveyed and safely contained, whilst the clean water emanating from the upstream environment is diverted away to the nearest watercourse or downstream environment.

The regulation which allows for the management of clean and dirty water within a mining environment is Government Notice 704, and is described in the section below.

5.1 Government Notice 704

GN 704 (Government Gazette 20118 of June 1999) was established to provide regulations on the use of water for mining and related activities aimed at the protection of water resources. The five main principle conditions of GN 704 applicable to this project are:

- Condition 4 which defines the area in which, mine workings or associated structures may be located, with reference to a watercourse and associated flooding. Any residue deposit, dam, reservoir together with any associated structure or any other facility should be situated outside the 1:100 year flood-line. Any underground or opencast mining, prospecting or any other operation or activity should be situated or undertaken outside of the 1:50 year flood-line. Where the flood-line is less than 100 metres away from the watercourse, then a minimum watercourse buffer distance of 100 metres is required for infrastructure and activities.
- Condition 5 which indicates that no residue or substance which causes or is likely to cause pollution of a water resource may be used in the construction of any dams, impoundments or embankments or any other infrastructure which may cause pollution of a water resource.
- Condition 6 which describes the capacity requirements of clean and dirty water systems. Clean and dirty water systems must be kept separate and must be designed, constructed, maintained and operated to ensure conveyance the 1:50 year peak flow. Clean and dirty water systems should not spill into each other more frequently than once in 50 years. Any dirty water dams should have a minimum freeboard of 0.8m above full supply level.
- Condition 7 which describes the measures which must be taken to protect water resources. All dirty water or substances which may cause pollution should be prevented from entering a water resource (by spillage, seepage, erosion etc) and ensure that water used in any process is recycled as far as practicable.
- Condition 10 which describes the requirements for operations involving extraction of material from the channel of a watercourse. Measures should be taken to prevent impacts on the stability of the watercourse, prevent scour and erosion resulting from operations, prevent damage to in-stream habitat through erosion, sedimentation, alteration of vegetation and flow characteristics, construct treatment facilities to treat water before returning it to the watercourse, and implement control measures to prevent pollution by oil, grease, fuel and chemicals.

5.2 Stormwater Management Plan

5.2.1 Introduction

As mentioned a stormwater management plan is required as per GN 704 of the National Water Act no 36 of 1998, with the main objective of the proposed stormwater management plan being to ensure the separation of clean and dirty water during the proposed mining operation.

The section below details the proposed stormwater management

5.2.2 Conceptual sizing of clean and dirty water channels

The proposed project infrastructure is positioned such that the upstream clean and dirty water catchment occurs in a south easterly direction.

All clean water channels are to be placed upstream of all infrastructure areas to ensure the runoff collected is diverted to the downstream clean water environment or the nearest watercourse. All dirty water channels are to be placed around the waste/stockpile dump area so that runoff is collected in a sump, and conveyed to the Open Pit. All dirty water will then be pumped to the existing Kangala PCD.

It is proposed that all clean water channels be unlined vegetated trapezoidal channels of which an example is shown below in Figure 5-1, whilst all dirty water channels constructed as concrete lined rectangular channels.

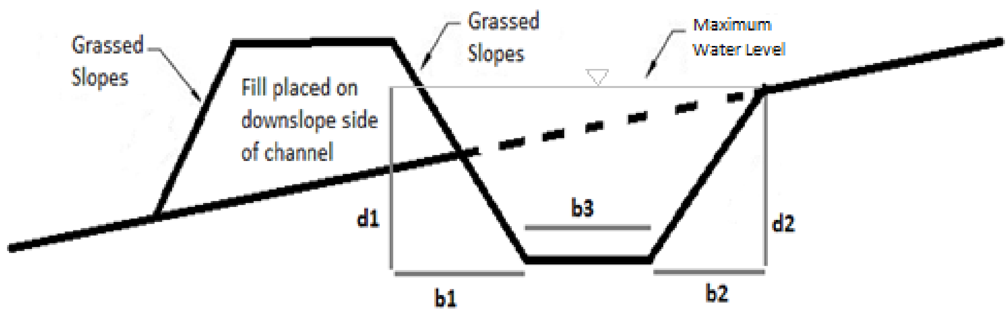

Figure 5-1 Clean water diversion channel conceptual design

Summary of the catchment hydrology was based on an average estimation of catchment sizes applicable to the project area, which represents both the clean and dirty water environments.

Summary of the catchment hydrology, peak flow estimations and clean and dirty water conceptual sizing of the channels are shown below in Table 5-1, Table 5-2 and Table 5-3 respectively.

Table 5-1 Summary of catchment hydrology

Name	Area (km^2)	Length of longest watercourse (m)	Height Difference (m)	Rainfall Intensity (Q_{50})	Tc (hours)	C-Factor
Clean water catchment	1.6951	3812	28.82	56	1.22	0.29
Dirty water catchment	0.2850	1676	13.5	86	0.63	0.54

Table 5-2 Summary of peak flows for clean water catchments

Name	Peak flows for various recurrence intervals (years)					
	2 year	5 year	10 year	20 year	50 year	100 year
Clean water catchment	1.79	2.62	3.37	4.33	6.33	8.55
Dirty water catchment	1.56	2.14	2.58	3.08	3.93	4.76

Table 5-3 Summary of clean water channel sizing

Channel Section	Q (m^3/s)	left and right slope (1:X)	Bottom width (m)	Calculated Top width (m)	Calculated depth (m)	Velocity (m/s)	Design depth (m)	Type
Clean water channels	6.33	3	4.0	8.56	0.76	1.33	1.0	Trapezoidal
Dirty water channels	3.93	N/A	2.0	2.00	0.61	3.23	1.0	Rectangular

As mentioned all dirty water will be captured and contained in the proposed Open Pit where it will then be pumped to the existing Kangala PCD.

Summary of the stormwater management plan is shown below in Figure 5-2 below.

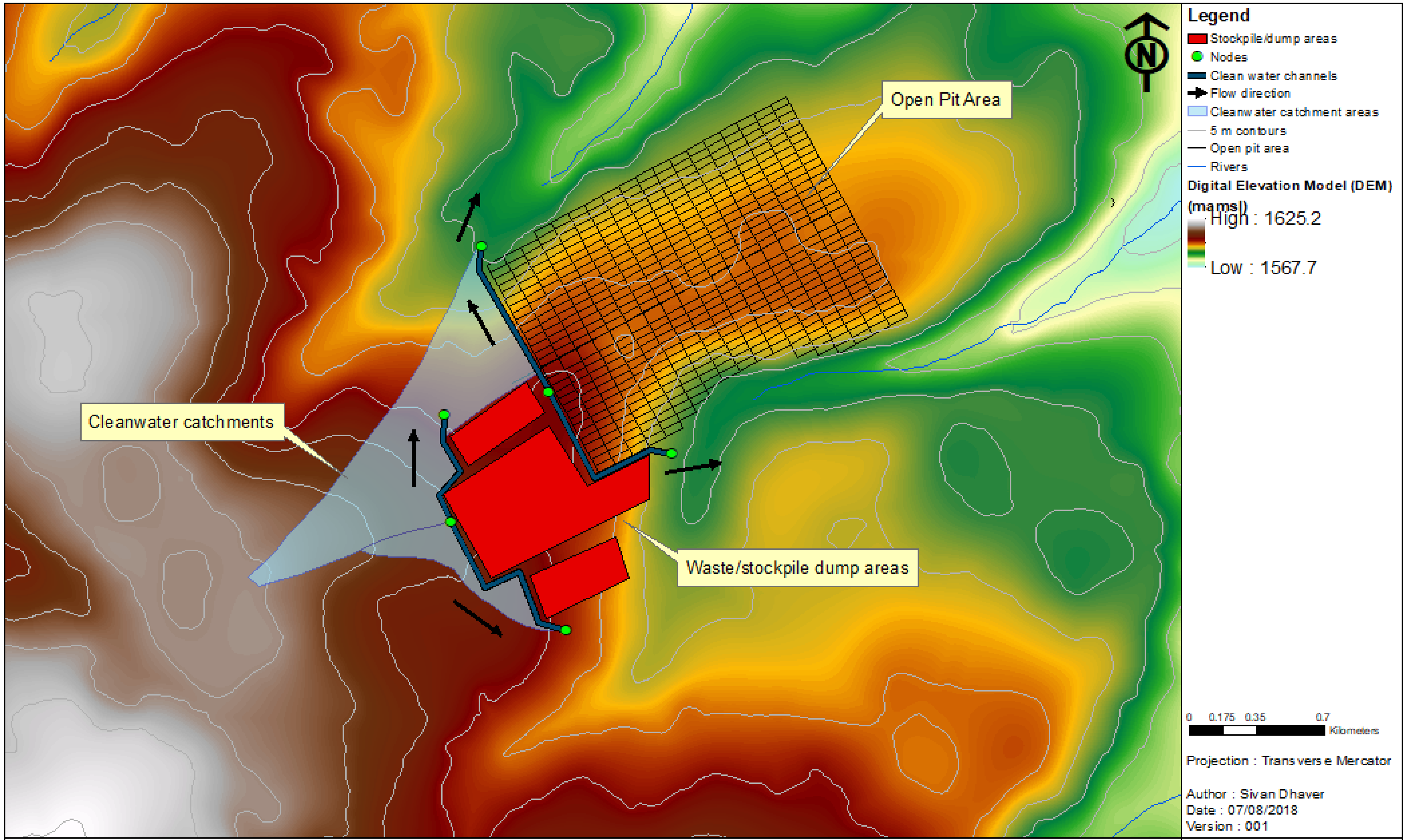

Figure 5.2

TITLE : Summary of Stormwater Management Plan

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5.3 Stormwater Maintenance Plan and Monitoring

The primary purpose of the stormwater maintenance plan is to ensure proper functioning of the stormwater controls. The stormwater maintenance plan is to be carried out during specific periods of the year, these periods include pre wet season, pre dry season and peak wet season months.

The rationale behind these key periods is listed below:

- Pre wet season - During the period leading up to the wet season various activities are required to ensure that all stormwater controls are functioning effectively. These activities include undertaking a site inspection to assess blockages/debris within key locations including main channels (clean and dirty water). Levels of siltation should also be checked and the appropriate action taken to ensure sufficient storage is available for the wet period. The pre wet season site inspection should occur towards the end of September.
- Peak wet season – During this period site inspections should be undertaken as a follow up on the initial pre wet season site inspection. This is undertaken so as to determine if the preceding rains resulted in any damages to the stormwater controls, and if any blockages had occurred at key locations mentioned. Peak wet season month site inspections should occur towards the end of December and January.
- Pre dry season – During this period, a site inspection should be undertaken to assess and rectify any damages as a result of the rainfall for the remainder of the wet season following January. Although during the dry season no major rainfall is anticipated, there may be short duration high intensity rainfall events that could produce high peak flows at the stormwater control outlets. It is therefore necessary to undertake a site visit to ensure all stormwater controls are functioning correctly. Pre dry season site inspection should be undertaken towards the end of April. Summary of the stormwater maintenance plan is indicated below:

Table 5-4 Summary of stormwater maintenance plan

Months	Dry Season	Wet Season	SITE INSPECTION AND REMEDIATION		
			Pre Wet Season	Pre Dry Season	Peak Wet Season
January					
February					
March					
April					
May					
June					
July					
August					
September					
October					
November					
December					

A monitoring programme is essential as a management tool to detect negative impacts as they arise and to ensure that the necessary mitigation measures are implemented. It also ensures that storm water management structures are in working order. Monitoring should be implemented throughout the project life.

6 Floodline Modelling

6.1 Introduction

The floodline modelling was undertaken for two river/drainage sections, located within close proximity of the project area. The main objective of the floodline model assessment is to delineate the 1:50 and 1:100 year floodline for the section of the mentioned rivers/drainages located within close proximity to the project area.

GN 704 (Government Gazette 20118 of June 1999) was established to provide regulations on the use of water for mining and related activities aimed at the protection of water resources. The main principle condition of GN 704 applicable to this project is:

- **Condition 4** which defines the area in which, mine workings or associated structures may be located, with reference to a watercourse and associated flooding. Any residue deposit, dam, reservoir together with any associated structure or any other facility should be situated outside the 1:100 year flood-line. Any underground or opencast mining, prospecting or any other operation or activity should be situated or undertaken outside of the 1:50 year flood-line. Where the floodline is less than 100 metres away from the watercourse, then a minimum watercourse buffer distance of 100 metres is required for infrastructure and activities.

It should also be noted, that **Condition 3** of GN 704 relates specifically to exemptions, which can be applied for, if the proposed activity falls within the flood inundated area. This report however provides only the results of the floodline modelling.

6.2 Model Development

6.2.1 Adopted Software

HEC-RAS 5.0 was used for the purposes of routing the peak flows resulting from the 1:50 year and 1:100 year storm event through the identified watercourses/rivers. HEC-RAS is a hydraulic programme used to perform one-dimensional hydraulic calculations for a range of applications, from a single watercourse to a full network of natural or constructed channels. The software is used worldwide and has consequently been thoroughly tested through numerous case studies.

HEC-GeoRAS is an extension of HEC-RAS which utilises the ArcGIS environment. The HEC-GeoRAS extension is used to extract the cross sections and river profiles from a Digital Elevation Model (DEM) for export into HEC-RAS for modelling, and is used again to project the modelled flood levels back onto the DEM to generate the extent of flooding.

6.2.2 Roughness Coefficients

The Manning's roughness factor n is used to describe the frictional characteristics of a specific surface. Selection of the Manning's roughness factor is based on the surface characterisation of the river section being modelled. The surface characteristics investigated includes vegetation cover and also the degree of meandering of the river. According to (Chow, 1959), meandering rivers can increase the Manning's roughness factor by as much as 30 percent.

6.3 Peak Flow Estimation and Model Setup

The summary of the catchment hydrology and peak flows used to delineate the 1:50 and 1:100 year floodline for the three identified rivers/drainages are shown below in Table 6-1 and Table 6-2 respectively.

Table 6-1 Summary of catchment hydrology for floodline modelling

Name	Area (km^2)	Length of longest watercourse (m)	Height Difference (m)	Rainfall Intensity (Q_{50})	Tc (hours)	C-Factor
Catchment 1	18.7	8599	40.7	34	2.73	0.29
Catchment 2	8.1	4590	20.9	44	1.71	0.29

Table 6-2 Summary of peak flows (m^3/s) for floodline modelling

Name	Peak flows for various recurrence intervals (years)					
	2 year	5 year	10 year	20 year	50 year	100 year
Catchment 1	11.86	17.37	22.27	28.64	41.88	56.58
Catchment 2	6.76	9.89	12.70	16.32	23.87	32.25

The summary of the model setup, which includes amongst others, the digitised drainages and cross sections are shown in Figure 6-1 below.

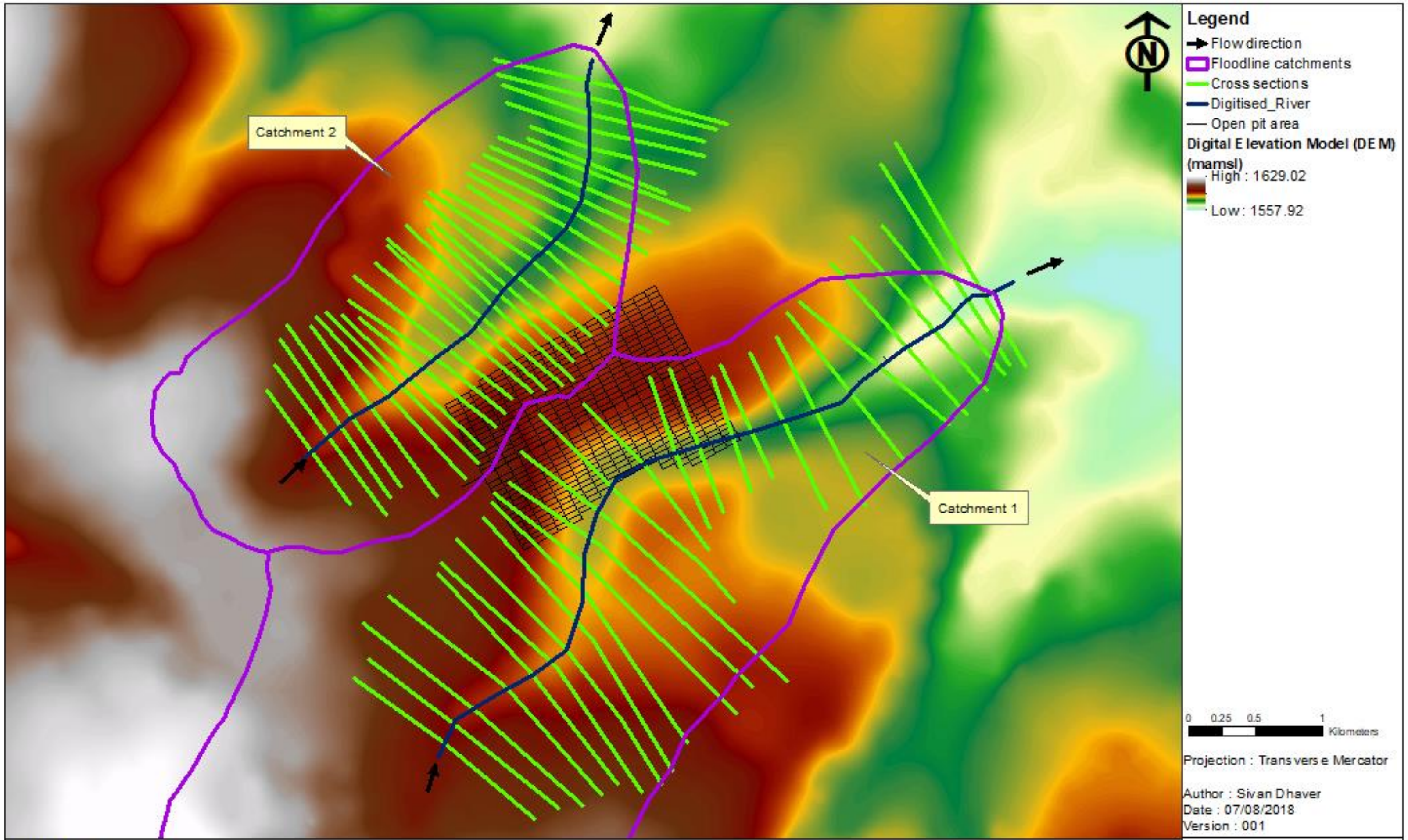

Figure 6.1

TITLE : HEC-RAS model setup

6.3.1 Assumptions and Limitations

The following assumptions are made:

- The topographic data provided was of a sufficient accuracy to enable hydraulic modelling at a suitable level of detail.
- A 5 m contour dataset was used to model the two river sections.
- A sub-critical flow regime, steady state hydraulic modelling was selected for the running of the model.
- No storage facilities where modelled.
- No flood protection infrastructure was modelled.
- The floodlines produced should only be used for indicative and environmental purposes, and not for detailed engineering design, unless signed off by a registered engineer

6.3.2 Results

Summary of the key results are listed below:

- Infrastructure footprint areas that fall within the 1:100 year floodline need to be repositioned outside of the mentioned floodline. Summary of the delineated 1:50 year and 1: 100 year floodline is indicated in Figure 6-2 below

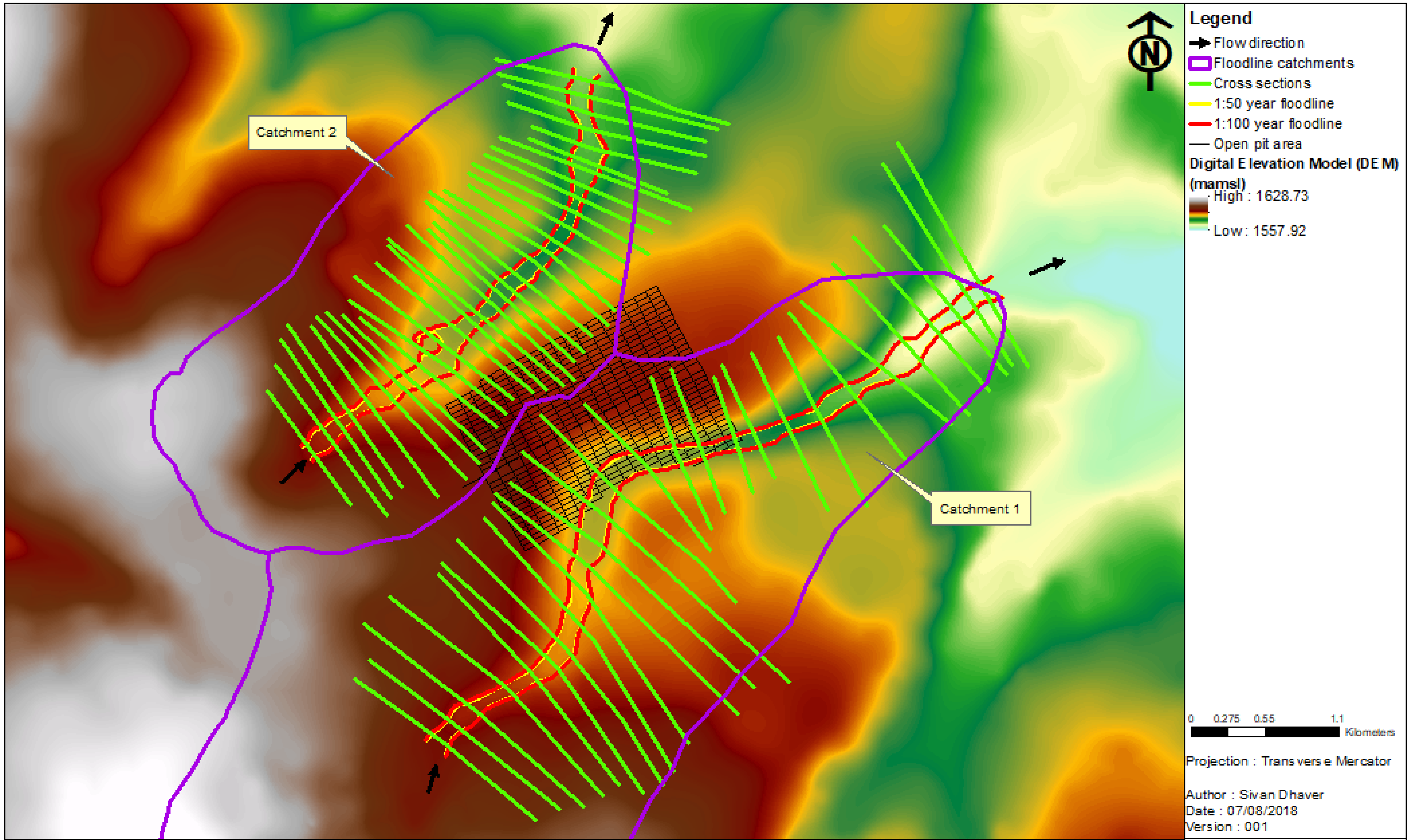

Figure 6.2

TITLE : Summary of the 1:50 year and 1:100 year delineated floodlines

SD Hydrological Services (Pty) Ltd

7 Waterbalance

7.1 Introduction

A site wide waterbalance process flow diagram (pfd) has been prepared to understand flows within the proposed Eloff project.

The water balance was developed using an excel spreadsheet model, taking into consideration average dry and average wet periods. The average dry periods are based on the three driest months (June – August), whilst the average wet period is based on the three wettest months (November - January).

The waterbalance was developed in accordance with the Best Practice Guideline G2 – Water and Salt Balances (DWAF, 2010).

7.2 Assumptions and Input Parameters

The waterbalance assumes the following:

- Rainfall related inflows and evaporation related losses for the wet and dry season scenarios were estimated based on: i) average values during the three driest months of the year; and ii) average values during the three wettest months of the year.
- Runoff coefficients for each surface were fixed and not influenced by antecedent moisture conditions.
- Catchment and surface areas for the wet and dry periods are constant.
- The summary of areas and runoff factors are listed below:
  - Open pit area - 2 213 900 m^2 (year 10 strip mining area), runoff factor of 0.5.
  - WRD surface area - 638 000 m^2, runoff factor of 0.25.
  - Sump surface area – 110 695 m^2 (5 % of open pit area).
- The Open Pit assumes a total groundwater ingress rate of 280 m^3/day when developing the waterbalance based on the 8th year total water influx into the Open Pit.

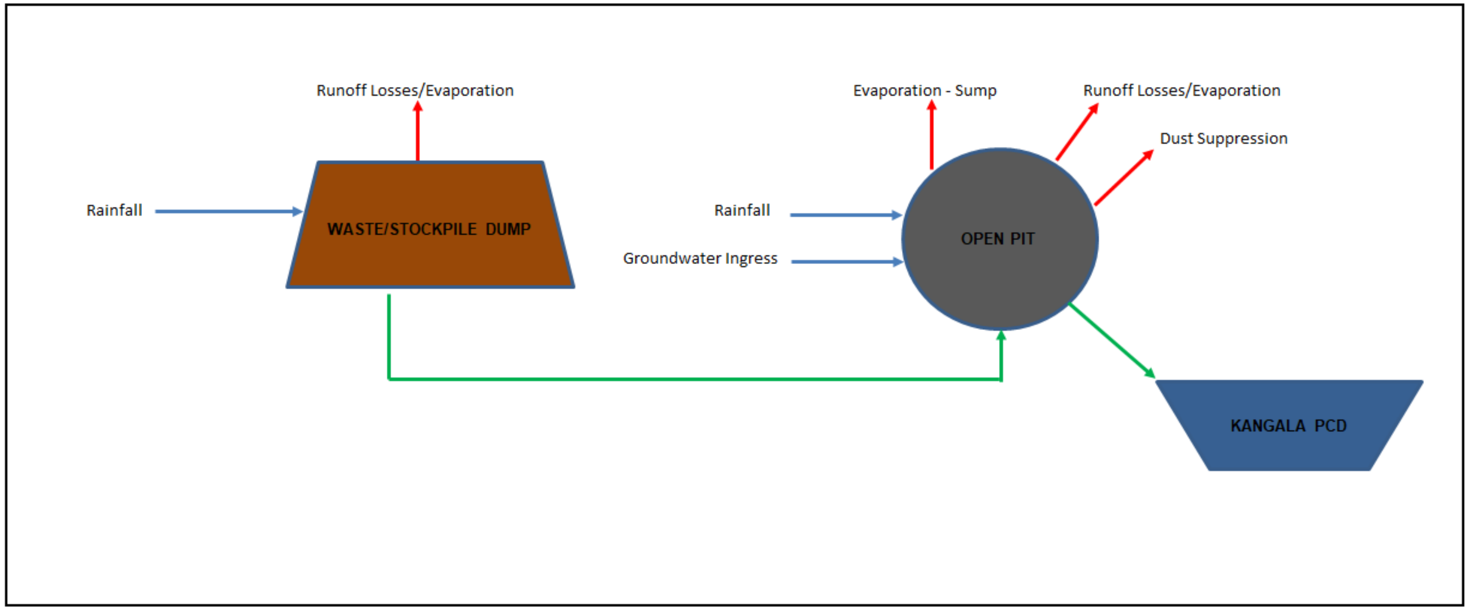

Figure 7-1 Summary of PFD

Table 7-1 Summary of waterbalance for average conditions

Facility Name	Water In		Water Out		Balance
	Water Circuit/stream	Quantity (m^3/month)	Water Circuit/stream	Quantity (m^3/month)	
OPEN PIT	Rainfall	123 425	Evaporation	12 546	
	Groundwater Ingress	8 528	Evaporation/runoff losses	61 534	
	Runoff - waste/stockpile dump	8 892	Kangala PCD	56 068	
			Dust Suppression	10 698	
	Total	**140 845**		**140 845**	**-**
WASTE /STOCKPILE DUMPS	Rainfall	35 569	Evaporation/runoff losses	26 676	
			Open Pit	8 892	
	Total	**35 569**		**35 569**	**-**
Total Water Balance		**176 414**		**176 414**	

Table 7-2 Summary of waterbalance for wet conditions

Facility Name	Water In		Water Out		Balance
	Water Circuit/stream	Quantity (m^3/month)	Water Circuit/stream	Quantity (m^3/month)	
OPEN PIT	Rainfall	245 714	Evaporation	16 362	
	Groundwater Ingress	8 587	Evaporation/runoff losses	122 857	
	Runoff - waste/stockpile dump	17 702	Kangala PCD	121 784	
			Dust Suppression	11 000	
	Total	**272 003**		**272 003**	**-**
WASTE /STOCKPILE DUMPS	Rainfall	70 810	Evaporation/runoff losses	53 107	
			Open Pit	17 702	
	Total	**70 810**		**70 810**	**-**
Total Water Balance		**342 813**		**342 813**	

Table 7-3 Summary of waterbalance for dry conditions

Facility Name	Water In		Water Out		Balance
	Water Circuit/stream	Quantity (m^3/month)	Water Circuit/stream	Quantity (m^3/month)	
OPEN PIT	Rainfall	13 972	Evaporation	7 501	
	Groundwater Ingress	8 587	Evaporation/runoff losses	6 273	
	Runoff - waste/stockpile dump	1 007	Kangala PCD	-	
			Dust Suppression	9 791	
	Total	**23 565**		**23 565**	**-**
WASTE /STOCKPILE DUMPS	Rainfall	4 026	Evaporation/runoff losses	3 020	
			Open Pit	1 007	
	Total	**4 026**		**4 026**	**-**
Total Water Balance		**27 591**		**27 591**	

7.3 Summary of Results

Summary of results are presented below:

- Average volumes pumped from the open pit range from 56 068 m^3/month to around 121 784 m^3/month during the average and wet season respectively. During the dry season it is anticipated that no water will be pumped to the Kangala PCD, due to the monthly abstractions exceeding the inflows into the open pit.

8 Surface Water Impact Assessment

The aim of this section is to identify the potential surface water impacts that are likely to arise as a result of the proposed project.

8.1 Impact Assessment Methodology

To ensure uniformity, the assessment of potential impacts is addressed in a standard manner so that a wide range of impacts are comparable. For this reason a clearly defined rating methodology has been used to assess the impacts identified in each specialist study.

The significance (quantification) of potential environmental impacts have been determined using a ranking scale, based on the following (terminology has been taken from the Guideline Documentation on EIA Regulations, by the Department of Environmental Affairs and Tourism, April 1998):

Status of Impact	
+: Positive (A benefit to the receiving environment)	
N: Neutral (No cost or benefit to the receiving environment)	
-: Negative (A cost to the receiving environment)	
Magnitude:=M	***Duration:=D***
10: Very high/don't know	5: Permanent
8: High	4: Long-term (ceases with the operational life)
6: Moderate	3: Medium-term (5-15 years)
4: Low	2: Short-term (0-5 years)
2: Minor	1: Immediate
0: Not applicable/none/negligible	0: Not applicable/none/negligible
Scale:=S	***Probability:=P***
5: International	5: Definite/don't know
4: National	4: Highly probable
3: Regional	3: Medium probability
2: Local	2: Low probability
1: Site only	1: Improbable
0: Not applicable/none/negligible	0: Not applicable/none/negligible

The environmental significance of each potential impact is assessed using the following formula:

Significance Points (SP) = (Magnitude + Duration + Scale) x Probability

The maximum value is 100 significance points (SP). Potential environmental impacts were rated on the following basis:

Significance	***Environmental Significance Points***	***Colour Code***
High (positive)	>60	H
Medium (positive)	30 to 60	M
Low (positive)	<30	L
Neutral	0	N
Low (negative)	>-30	L
Medium (negative)	-30 to -60	M
High (negative)	<-60	H

Table 8-1 Summary of Impact Assessment (Construction Phase)

POTENTIAL ENVIRONMENTAL IMPACT	APPLICABLE AREA	ACTIVITY	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION							RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION							ACTION PLAN	PHASE	PERSON	ANNUAL MANAGEMENT COST
			M	D	S	P	TOTAL	STATUS	SP		M	D	S	P	TOTAL	STATUS	SP				
CONSTRUCTION PHASE																					
HYDROLOGY																					
Sedimentation of downstream drainage/watercourses	Pit Area, and related infrastructure, WRD	During the construction phase, loose or disturbed material as a result of construction activities such as soil and debris may be washed into the nearest downstream drainages/watercourses during normal to heavy infrequent rainfall events. This will result in sedimentation of the downstream affected drainage/watercourse.	6	2	2	3	30	-	M	To reduce the risk of sedimentation to downstream drainages/watercourses from dirty water areas such as temporary topsoil/ material stockpile areas and any additional dirty water areas, a temporary stormwater management plan should be implemented. This will include construction of temporary ditches and runoff containment areas, such that all runoff emanating from the topsoil/material stockpile areas together with any additional dirty water areas are conveyed and contained within the site area. Construction activities should be undertaken during the dry season to limit the possibility of normal to heavy infrequent rainfall events.	4	2	2	2	16	-	L	Ensure the site stormwater management plan is in place prior to the construction activities. The temporary stormwater controls must be maintained such that no blockages are present in the channels and containment ditches so as to ensure effective functioning.	Construction	Health, Safety, Environmental and Community Manager (HSEC).	Included in operational cost

Hydrocarbon Fuel Spillage	Pit Area, and related infrastructure , WRD	During the construction phase, a high volume of traffic by vehicles will occur due to the transport of equipment/material to site. Potential Spillages of hydrocarbons unto the site area is therefore envisaged. If no mitigation measures are present, hydrocarbon spillages can easily be washed downstream by heavy rains, and end up in the downstream drainages/watercours e.	6	2	2	3	30	-	M	All vehicles must be serviced timeously to ensure the potential for leakages of hydrocarbons are minimized.	4	2	2	2	16	-	L	Develop a detailed schedule of vehicles being used during the constructio n phase and their service history. Only vehicles which have been effectively services should be allowed onsite.	Constructio n	Health, Safety, Environment al and Community Manager (HSEC).	Included in operational cost
Reduction of Catchment Yield	Pit Area, and related infrastructure , WRD	Reduction of catchment yield as a result of the footprint areas of the associated infrastructure as the footprint areas will no longer form part of the natural downstream catchment thereby potentially resulting in a decrease of runoff downstream	2	4	2	2	16	-	L	The loss of catchment area as a result of the associated infrastructure cannot be mitigated. The only way to mitigate the above mentioned impacts is to not proceed with the mining option. Therefore, the impact rating for pre and post mitigation measures will remain unchanged. It should also be noted that the footprint area less than 1% of the total quaternary catchment area of B20A and will therefore result in a negligible loss in runoff.	2	4	2	2	16	-	L	No action plan is required.	Constructio n	N/A	N/A
Flooding of proposed infrastructures	Pit Area, and related infrastructure , WRD	Floodlines will be required on all major watercourses within close proximity to the proposed infrastructures. Based on GN 704 requirements, the mine infrastructure in question should fall outside of the 1:100 year floodline or the 100 m away, whichever is greater.	1 0	4	2	4	64	-	H	The floodline modelling was undertaken for two river sections. All infrastructures falling within the 1:100 year floodline for the two rivers need to be repositioned	4	4	2	2	20	-	L	All infrastructur e is to be placed outside of the 1:100 year floodline or 100 m buffer, whichever is greater.	Constructio n	Health, Safety, Environment al and Community Manager (HSEC).	Included in operational cost

		This is undertaken so as to minimise damage to infrastructure during periods of extreme flooding.																			

Table 8-2 Summary of Impact Assessment (Operational Phase)

POTENTIAL ENVIRONMENTAL IMPACT	APPLICABLE AREA	ACTIVITY	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION							RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION							ACTION PLAN	PHASE	PERSON	ANNUAL MANAGEMENT COST
			M	D	S	P	TOTAL	STATUS	SP		M	D	S	P	TOTAL	STATUS	SP				
OPERATIONAL PHASE																					
HYDROLOGY																					
Pollution of downstream watercourse	Pit Area, and related infrastructure, WRD	During the operational phase of the mine, a stormwater management plan which adheres to GN 704 requirements in terms of separation of clean and dirty water is required so as to ensure no mixing of clean and dirty water occurs. Lack of proper stormwater controls will result in dirty water contaminating the downstream clean water environment.	6	4	2	4	48	-	M	A conceptual stormwater water management plan was developed. The stormwater management plan details the proposed placement of clean and dirty water channels together with their respective conceptual sizing. All clean and dirty water controls were sized based on the 1:50 year storm event as per GN 704 requirements. Dust suppression is also required in the WRD and Open Pit Areas throughout the operational phase of the mine.	4	4	2	2	20	-	L	Ensure that the conceptual stormwater management plan is implemented which includes the stormwater maintenance plan. The maintenance plan is required to ensure that all stormwater controls function efficiently. Dust suppression is required twice a week, with water sourced from the Open Pit sump. The estimated dust suppression volume is 11000 m^3/month.	Operational	Health, Safety, Environmental and Community Manager (HSEC).	Included in operational cost

Reduction of Catchment Yield	Pit Area, and related infrastructure, WRD	In the operational phase the reduction of catchment yield will occur due to the construction of the associated infrastructure and the implementation of the stormwater management plan.	2	4	2	2	16	-	L	The loss of catchment area as a result of the associated infrastructure cannot be mitigated. The only way to mitigate the above mentioned impacts is to not proceed with the mining option. Therefore, the impact rating for pre and post mitigation measures will remain unchanged. It should also be noted that the footprint area less than 1% of the total quaternary catchment area of B20A and will therefore result in a negligible loss in runoff.	2	4	2	2	16	-	L	No action plan is required.	Operational	N/A	N/A
Flooding of proposed infrastructures	Pit Area, and related infrastructure, WRD	During the operational phase of a mine expansion or change in the mining footprint area may result in additional areas falling within the delineated floodline area or 100 m river buffer.	10	4	2	4	64	-	H	The current floodlines should be used and updated if required depending on additional project infrastructure placement and/or expansion in the project footprint area.	4	4	2	2	20	-	L	All new infrastructures or footprint area expansions are to be placed outside of the 1:100 year floodline or 100 m buffer, whichever is greater.	Operational	Health, Safety, Environmental and Community Manager (HSEC).	Included in operational cost

Table 8-3 Summary of Impact Assessment (Decommissioning and Closure Phase)

POTENTIAL ENVIRONMENTAL IMPACT	APPLICABLE AREA	ACTIVITY	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION							RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION							ACTION PLAN	PHASE	PERSON	ANNUAL MANAGEMENT COST
			M	D	S	P	TOTAL	STATUS	SP		M	D	S	P	TOTAL	STATUS	SP				
DECOMMISIONING AND CLOSURE PHASE																					
HYDROLOGY																					
Siltation of water resources	Pit Area, and related infrastructure, WRD	Activities during this phase include dismantling and removal of major equipment and infrastructure, rehabilitation of disturbed areas including stockpile dumps and pits, backfilling of the open pits using overburden and waste. The major impacts to consider in the decommissioning and closure phase will be siltation of surface water resources as a result of soil erosion influenced by removal of infrastructures.	6	4	2	4	48	-	M	Ensure that the surface profile is rehabilitated to promote natural runoff drainage and avoid ponding of water within the rehabilitated area. Surface inspection should be continuously undertaken to allow runoff to drain onto the downstream drainage/rivers. All rehabilitated areas must be established with vegetation.	4	4	2	2	20	-	L	Ensure a proper surface water rehabilitation plan is developed.	Decommissioning and Closure	Health, Safety, Environmental and Community Manager (HSEC).	Included in operational cost

9 Conclusions and Recommendations

The summary of conclusions are listed below:

- Summary of the primary impacts relating to the proposed project relate to flooding of infrastructure and the pollution of downstream watercourse as a result of mixing of clean and dirty water.
- All project infrastructures should be placed outside of the delineated 1:100 year floodline.
- A detailed stormwater management plan which provides placement of proposed clean water channels, together with conceptual sizing of clean and dirty water channels was undertaken.
- Water used for dust suppression is to be obtained from the Open Pit sump. The estimated dust suppression volume is 11000 m^3/month.
- The clean water channels are based on a trapezoidal unlined channel with maximum depths of 1 m, side slopes of 1:3 (1 vertical to 3 horizontal) and bottom width of 4 m.
- The dirty water channels are based on a rectangular lined channel, with a maximum depth of 1 m and width of 2 m.
- The stormwater management plan should be followed so as to ensure clean and dirty water separation, thereby mitigating the impact of pollution of the downstream environment.
- The waterbalance which was developed is based on a maximum estimated groundwater ingress into the open pit of 280 m^3/day.

The following is recommended

- The waterbalance should be updated during the operational phase once more data becomes available as the areas of the clean and dirty water infrastructure footprints may change.

Prepared by

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Hydrologist

10 References

Introduction to Flood Hydrology, J HAARHOFF and AM CASSA, 2009.

SANRAL, “Drainage Manual-Sixth Edition”, The South African National Roads Agency Limited, Pretoria, 2013.

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Appendices

Appendix A: HEC-RAS Results

Floodline Catchment 1

HE-RAS Output - Catchment 1					
Cross Section	**Profile**	**Peak Flow (m^3/s)**	**Water Stage Elevation (m)**	**Velocity (m/s)**	**Froude Number**
5876	50 Year	41.88	1598.39	0.99	0.57
5876	100 Year	56.58	1598.46	1.07	0.58
5714	50 Year	41.88	1596.54	1.07	0.57
5714	100 Year	56.58	1596.6	1.21	0.58
5521	50 Year	41.88	1595.33	0.79	0.36
5521	100 Year	56.58	1595.43	0.88	0.37
5226	50 Year	41.88	1594.13	0.8	0.36
5226	100 Year	56.58	1594.22	0.9	0.38
5022	50 Year	41.88	1592.16	1.6	0.99
5022	100 Year	56.58	1592.23	1.74	0.98
4852	50 Year	41.88	1590.53	0.68	0.29
4852	100 Year	56.58	1590.62	0.77	0.31
4708	50 Year	41.88	1590.14	0.64	0.31
4708	100 Year	56.58	1590.22	0.72	0.31
4484	50 Year	41.88	1589.31	0.75	0.37
4484	100 Year	56.58	1589.39	0.82	0.39
4242	50 Year	41.88	1588.19	0.63	0.36
4242	100 Year	56.58	1588.25	0.71	0.37
4042	50 Year	41.88	1586.05	1.51	0.97
4042	100 Year	56.58	1586.1	1.65	0.98
3855	50 Year	41.88	1585.42	0.48	0.2
3855	100 Year	56.58	1585.51	0.53	0.21
3642	50 Year	41.88	1585.15	0.51	0.21
3642	100 Year	56.58	1585.24	0.57	0.22
3436	50 Year	41.88	1584.84	0.47	0.23
3436	100 Year	56.58	1584.94	0.52	0.23
3143	50 Year	41.88	1584.35	0.57	0.24
3143	100 Year	56.58	1584.45	0.63	0.24
2881	50 Year	41.88	1583.85	0.63	0.27

2881	100 Year	56.58	1583.95	0.71	0.28
2706	50 Year	41.88	1582.89	1.41	0.78
2706	100 Year	56.58	1582.95	1.57	0.83
2441	50 Year	41.88	1580.42	0.95	0.42
2441	100 Year	56.58	1580.53	1.03	0.42
2294	50 Year	41.88	1580	0.6	0.25
2294	100 Year	56.58	1580.12	0.67	0.26
2047	50 Year	41.88	1578.68	1.73	0.98
2047	100 Year	56.58	1578.75	1.86	0.98
1796	50 Year	41.88	1575.54	0.83	0.37
1796	100 Year	56.58	1575.65	0.92	0.38
1491	50 Year	41.88	1574.4	0.74	0.33
1491	100 Year	56.58	1574.49	0.83	0.34
1206	50 Year	41.88	1571.97	1.53	1
1206	100 Year	56.58	1572.03	1.67	1.01
956	50 Year	41.88	1569.83	0.64	0.29
956	100 Year	56.58	1569.91	0.72	0.3
717	50 Year	41.88	1568.15	1.6	0.98
717	100 Year	56.58	1568.22	1.71	0.97
514	50 Year	41.88	1565.68	0.68	0.28
514	100 Year	56.58	1565.78	0.77	0.29
372	50 Year	41.88	1565.37	0.64	0.26
372	100 Year	56.58	1565.47	0.73	0.28
240	50 Year	41.88	1564.84	1	0.54
240	100 Year	56.58	1564.91	1.09	0.55

Floodline Catchment 2

HEC-RAS Output - Catchment 2					
Cross Section	**Profile**	**Peak Flow (m^3/s)**	**Water Stage Elevation (m)**	**Velocity (m/s)**	**Froude Number**
3825	50 Year	23.87	1596.09	1.12	0.75
3825	100 Year	32.25	1596.13	1.26	0.78
3668	50 Year	23.87	1594.84	0.63	0.34
3668	100 Year	32.25	1594.91	0.69	0.35
3546	50 Year	23.87	1594.32	0.66	0.36
3546	100 Year	32.25	1594.39	0.72	0.37
3435	50 Year	23.87	1593.46	1.01	0.62
3435	100 Year	32.25	1593.51	1.11	0.64
3271	50 Year	23.87	1590.81	1.07	0.68
3271	100 Year	32.25	1590.87	1.16	0.69
3119	50 Year	23.87	1589.54	0.67	0.37
3119	100 Year	32.25	1589.59	0.75	0.39
3003	50 Year	23.87	1588.68	0.87	0.54
3003	100 Year	32.25	1588.73	0.97	0.56
2923	50 Year	23.87	1587.94	0.76	0.46
2923	100 Year	32.25	1587.99	0.84	0.47
2799	50 Year	23.87	1586.12	1.1	0.88
2799	100 Year	32.25	1586.15	1.2	0.9
2678	50 Year	23.87	1585.18	0.36	0.28
2678	100 Year	32.25	1585.23	0.43	0.29
2559	50 Year	23.87	1584.6	0.73	0.43
2559	100 Year	32.25	1584.65	0.81	0.44
2403	50 Year	23.87	1583.63	0.59	0.38
2403	100 Year	32.25	1583.69	0.64	0.39
2286	50 Year	23.87	1582.8	0.72	0.47
2286	100 Year	32.25	1582.85	0.8	0.48
2207	50 Year	23.87	1581.46	1.41	0.98
2207	100 Year	32.25	1581.51	1.52	0.97
2087	50 Year	23.87	1580.34	0.5	0.25

2087	100 Year	32.25	1580.42	0.56	0.26
1993	50 Year	23.87	1580.16	0.47	0.23
1993	100 Year	32.25	1580.24	0.52	0.24
1913	50 Year	23.87	1580.02	0.49	0.23
1913	100 Year	32.25	1580.1	0.54	0.24
1806	50 Year	23.87	1579.82	0.52	0.25
1806	100 Year	32.25	1579.9	0.57	0.25
1646	50 Year	23.87	1579.5	0.52	0.25
1646	100 Year	32.25	1579.59	0.57	0.25
1525	50 Year	23.87	1579.2	0.65	0.31
1525	100 Year	32.25	1579.29	0.71	0.32
1433	50 Year	23.87	1578.92	0.62	0.31
1433	100 Year	32.25	1578.99	0.69	0.32
1280	50 Year	23.87	1578.44	0.59	0.3
1280	100 Year	32.25	1578.52	0.66	0.31
1167	50 Year	23.87	1577.98	0.76	0.41
1167	100 Year	32.25	1578.05	0.84	0.42
1054	50 Year	23.87	1576.55	1.46	1
1054	100 Year	32.25	1576.59	1.59	1.01
957	50 Year	23.87	1575.39	0.71	0.4
957	100 Year	32.25	1575.45	0.78	0.41
837	50 Year	23.87	1575.07	0.39	0.21
837	100 Year	32.25	1575.13	0.44	0.22
774	50 Year	23.87	1574.97	0.41	0.22
774	100 Year	32.25	1575.04	0.45	0.22
663	50 Year	23.87	1574.79	0.45	0.22
663	100 Year	32.25	1574.86	0.5	0.22
527	50 Year	23.87	1574.46	0.63	0.33
527	100 Year	32.25	1574.54	0.69	0.34
415	50 Year	23.87	1574.15	0.44	0.25
415	100 Year	32.25	1574.22	0.48	0.26

283	50 Year	23.87	1573.81	0.45	0.27
283	100 Year	32.25	1573.88	0.5	0.28
169	50 Year	23.87	1573.25	0.76	0.5
169	100 Year	32.25	1573.3	0.83	0.51