SURFACE WATER ASSESSMENTS FOR THE MATAI MINING (PTY) LTD MINING RIGHT APPLICATION FOR VANADIUM, TITANIUM AND IRON ORE MINE

PROJECT LOCATION: VARIOUS FARMS WITHIN THE MAGISTERIAL DISTRICT OF MANKWE, NORTH WEST PROVINCE, SOUTH AFRICA

Prepared by CM Eclectic Pty Ltd

On behalf of Kimopax (Pty) Ltd

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Report Information

Report Name	Surface Water Assessments for The Matai Mining (Pty) Ltd Mining Right Application for Vanadium, Titanium and Iron Ore Mine
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Executive Summary

Background

Matai Mining (Pty) Ltd (Matai Mining) holds the Prospecting Right that was granted in terms of the Mineral and Petroleum Resources Development Act 28 of 2002 as amended by Act 49 of 2008 ("MPRDA"). Matai Mining herewith apply for a Mining right for Vanadium, Titanium and Iron Ore in terms of the Section 23 (a), (b) and (c) read together with regulation 11(1) (g) of the MPRDA (ACT 28 of 2002). The mining right is on farm Wildebeestkuil 7 JQ, and certain portions of these farms Magazynskraal 3 JQ, Haakdoorn 6 JQ, Syferkuil 9 JQ and Middelkuil 8 JQ in the Northwest Province within the Mankwe Magisterial District.

CM Eclectic Pty Ltd (CM Eclectic) an independent consultancy was appointed by Kimopax Pty Ltd (Kimopax) to prepare a hydrology assessment for Matai Project including water balance, flood-line mapping and a stormwater management plan (SWMP) for the proposed Matai Project

Province) and 10 km South of Northam. The Matai project will involve open pit mining of Vanadium, Titanium and Iron Ore. The proposed project will be constructed on land previously used for agriculture, with a proposed mining right area of approximately 9837Ha. The ore will be mined using excavators, bulldozers, trucks, bowl scraper and shovel. A tripper conveyor is proposed for the stacking method. The proposed mining method commences with a box cut. A rollover mining technique will be practised, in such a case the topsoil and overburden from the initial cut of the opencast mine are stockpiled at the position of the final cut.

The infrastructure footprint will include the open cast mining, the processing plant, pollution control dams, workshops, material stockpiles, storage, excavations, access roads, diesel and wash bays.

Baseline

This surface water study was undertaken by a suitably qualified and experienced Hydrologist registered with the South Africa Council for Natural Scientific Professions (SACNASP) as a Professional Natural Scientist (Pr.Sci.Nat.) in the field of Water Resources Science.

Considering the Water Resources of South Africa Manual WR2012 (WRC, 2012), the project area falls within the Limpopo Water management area (WMA) 1. Most of the project site falls within quaternary catchment A24E, lesser extent of the project site is located within the quaternary catchment A24D. The tributaries of the Brakspruit within the catchment A24E which drain through the MRA area east of the infrastructure footprint are the Sefahlane and the Lesobeng which flow north from the Pilanesberg to a confluence, approximately 0.5 km south of the project area. On the west of the site within quaternary catchment A24D, is the Bofue river draining northwards. The mean annual precipitation determined for the site from the WRC2012 database is 579.8 mm which is within close ranges to the 592 and 600 mm for the A24E and A24D respectively.

Kimopax's Hydrogeologist conducted a site visit on the 13th of December 2018 as part of the Hydrocensus study and collected water quality samples from the water resources within the project area. Out of the five selected water quality sample sites, only one was sampled as most of them were dry at time for site visit. The water quality results were benchmarked against the SANS 241 (2015), Drinking Water – Edition 2 and the Department of Water Affairs and Forestry, 1996. South African Water Quality Guidelines (second edition), Volume 5: Agricultural Water Use: Livestock watering. From the water quality results, exceedances of the SANS 241 drinking water standards were determined, and these were for the parameters aluminium, iron and turbidity. High turbidity can be attributed to the rains that were reportedly received on the day of the sampling as the water was observed to be very muddy, this was also expected. The elevated iron and aluminium can be attributed to the general geology, however there were no other samples taken to validate this.

Water Balance

A site wide water balance has been prepared to understand the flows within the mine's operation water circuit for the wet and dry season as well as annual averages. The water balance is water negative for all 3 scenarios and required make up water. The external / make up water demand of the processing plant is as follows:

- wet season 12 411 m3/month
- dry season 28 479 m3/month
- average 20 551 m3/month

Stormwater Management Plan (SWMP)

The SWMP was undertaken to provide conceptual inputs into the design requirements and placement of storm water management structures and recommendations based on the infrastructure plan. The following measures were recommended:

- Clean stormwater will be diverted around dirty catchments and allowed to flow towards the watercourses on either side of the site depending on the topography. This will be accomplished through the construction of upstream clean water diversion berms/channels to prevent clean water from entering the dirty areas and ensure that it drains away from the site through the channels upstream of dirty areas;
- Moderately clean areas that otherwise cannot easily be conveyed to the clean water system between the planned road and the infrastructure will be collected with the dirty water system for reuse;
- A series of dirty water berm and channel systems will be required to capture and convey runoff emanating from the dirty water areas (plant, mining area and ROM). The dirty water trenches will convey the runoff to the PCD via a silt trap;
- Open channels are preferred for ease of maintenance and can easily be constructed to accommodate design capacity, whilst maintaining suitable drainage gradients;
- Stormwater collecting in the PCD will be pumped to the Process Water Dam (PWD) during and after rainfall events to supply the plant's water requirements; and

- Considering the general topography, a PCD location is proposed at the downstream most (southern corner of the mining department
- The PCD is sized to accommodate runoff generated from a 1:50 year design rainfall (24 hour) event and the highest monthly rainfall (January) less the corresponding monthly evaporation (January) taking place over the surface area of the dam of 22500 m3 excluding the 0.8 m freeboard allowance

Floodlines

GN704 regulation 4 stipulates restrictions on mine related infrastructure or operations relative to the 1:100 year flood-line and the 1:50 year flood-line or a horizontal distance of 100 metres from any watercourse. the floodlines were therefore determined and it was determined that the mine surface infrastructure is located outside the flood-lines, however the proposed mine road crosses the flood-lines. The modelling shows that 1: 100 year and1:50 year flood-lines exceed 100 m horizontal distance from the watercourse in all locations. This can be attributed to the flat retain where the flood plain is wide. Where the road cross the flood-lines and watercourse, these can be designed such that they do not impact upon conveyance within the floodplain. This can be achieved by ensuring that, the water surface elevations at the cross sections nearby the highest being 1029.8 m amsl (cross sections 1358.518, 1315.725 and 1256.561) in the vicinity are considered. Considering the flood lines, it has been concluded that the flood risk to the surface infrastructure has been adequately assessed on the Lesobeng and Sefahlane, therefore; given that the infrastructure complex is shown to be located outside of the conservative estimate of flood-lines and the 100 m buffer, no further flood modelling work is considered necessary.

Impact Assessments

Informed by the baseline hydrology, flood modelling extents and design specifications for the storm water management measures and water balance model results, potential impacts and mitigation measures have been identified and presented in the report. The main impacts are summarised below:

- Sedimentation of watercourses due to exposing and loosening of soil as a result of vegetation clearing for the construction of infrastructure and pollution of watercourses due to hydrocarbon spillages;
- Altered drainage paths and loss of catchment yield due to the removal of vegetation and construction of diversion berms;
- Pollution of surrounding watercourses as a result of activities during the operational phase;
- Reduction in water quantity reporting to the river and on the catchment yield, however, will be less significant given the spatial scale, as storm water management measures will contain, catchment area for runoff for the catchments A24E and A24D by 0.19% and 0.04% respectively;
- Potential decant threatening surface water quality when decant takes place post closure; and

- Ongoing rehabilitation of mined out areas resulting in a positive improvement to onsite surface water drainage and an improvement in catchment yield.

The implementation of mitigation measures is essential for the continuation of the mining project to manage potential impacts.
If the proposed mitigation measures, design principles are implemented, the project may go ahead.

Recommendations

Several limitations were identified and from these recommendations have been presented.

- Continue baseline monitoring to create a more extensive baseline before mining can commence;
- An update of the ware balance when more information and monitoring data becomes available;
- It is recommended that the capacity of the PCD is reviewed during detailed design of the stormwater measures by a daily timestep water balance model to ensure compliance with GN 704 and BPG A4 (DWAF, 2007), considering the predicted inflows to and outflows from each containment facilities taken from the site wide water balance; and
- It is recommended that the hydraulic gradients and channel sizes are checked during the detailed design of channels. The requirement for, and specification for lining of the channels and dams should also be confirmed during detailed design of these features.

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Acronym / Abbreviation	**Definition**
DDF	Depth Duration-Frequency
DWS	Department of Water and Sanitation
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
GIS	Geographic Information system
GN 704	Government Notice 704
HEC-RAS	Hydrologic Engineering Centres – River Analysis System
IDF	Intensity Depth Frequency
LOM	Life of Mine
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
MRA	Mining Right Area
NFEPA	National Freshwater Ecosystem Priority Areas
PrSciNat	Professional Natural Scientist
PCD	Pollution Control Dam
RoM	Run of Mine
SABS	South Africa Bureau of Standards
SACNASP	South African Council for Natural Scientific Professions
SANRAL	South African National Road Agency
SANAS	South African National Accreditation System
SANS	
SAWS	South African Weather Service
SCS	Soil Conservation System
SAWS	South Africa Weather Services
Tc	Time of Concentration
UPD	Utilities Programme for Drainage
WQG	Water Quality Guideline
WMA	Water Management Area
WR2005	Water Resources of South Africa 2005 Study
WULA	Water Use License Application
WR2012	Water Resources of South Africa 2012 Study

Table of Acronyms and Abbreviations

Table of Units

mg/l	Milligram per litre
m^3/s	Cubic meters per second

m^3	Cubic metres
Mcm	Million cubic metres
m	meters
Ha	Hectares
m^2	Square metres
L/day	Litres per day
Km	Kilometres
Km2	Square kilometres
mm	millimetres
m amsl	Metres above mean sea level

1 Introduction

1.1 Background

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This surface water study was undertaken by a suitably qualified and experienced Hydrologist registered with the South Africa Council for Natural Scientific Professions (SACNASP) as a Professional Natural Scientist (Pr.Sci.Nat.) in the field of Water Resources Science, the CV is appended to the report (Appendix A).

1.2 Project Description

The Matai project is located approximately 80km North East of Rustenburg (North West Province) and 10 km South of Northam. The Matai project will involve open pit mining of Vanadium, Titanium and Iron Ore. The proposed project will be constructed on land previously used for agriculture, with a proposed mining right area of approximately 9837Ha.

The ore will be mined using excavators, bulldozers, trucks, bowl scraper and shovel. A tripper conveyor is proposed for the stacking method. The proposed mining method commences with a box cut. A rollover mining technique will be practised, in such a case the topsoil and overburden from the initial cut of the opencast mine are stockpiled at the position of the final cut.

The infrastructure footprint will include the open cast mining, the processing plant, pollution control dams, workshops, material stockpiles, storage, excavations, access roads, diesel and wash bays.

1.3 Legislation

1.3.1 National Water Act

National Water Act (Act No. 36 of 1998), Government Notice 704 (Government Gazette 20119 of June 1999) (hereafter referred to as GN 704), was established to provide regulations for the use of water for mining and related activities aimed at the protection of water resources. Regulations 4, 5, 6, 7 and 10 of the GN704 are applicable in this study and are summarised below:

- Regulation 4 which defines the restrictions for the locality of mine working and infrastructure 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;

- Regulation 5 which restricts the use of 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;
- Regulation 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 of flows of a 1:50 year recurrence event. 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.
- Regulation 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.

1.3.2 Best Practice Guidelines

In addition to the GN 704 regulations, the Department of Water and Sanitation (DWS) Best Practice Guidelines (BPG) for the mining industry have been consulted namely:

- BPG G1: Storm Water Management;
- BPG A4: Pollution Control Dams; and
- BPG G3: Water Monitoring Systems.

The measures provided in the SWMP have been developed in accordance with the principles of BPG G1: Storm water management, with the objective of keeping clean and dirty water separate, as defined by the following:

- Collect all storm water that is of poor quality in a dirty water trench and contain it within the storage facilities (dam) for reuse within the reclamation operations;
- Ensure that all storm water structures that are designed to keep dirty and clean water separate can accommodate a defined precipitation event. (The magnitude of the precipitation event used in this assessment is the 1:50 year, 24 hour event);
- Route all clean storm water directly to natural watercourses without increasing the risk of a negative impact on safety and infrastructure, e.g. loss of life or damage to property due to an increase in the peak runoff flow;
- Ensure that the maximum volume of clean water runoff is diverted directly to watercourses;

- The SWMP must be sustainable over the life cycle of the mine and over different hydrological cycles and must incorporate principles of risk management; and
- The statutory requirements of various regulatory agencies and the interests of stakeholders must be considered and incorporated.

1.4 Methodology and Scope Work

This study included the following

- Catchment description – Section 2 presents a review and analysis of various sources of rainfall and evaporation data. The section also presents the baseline hydrology of the site and surroundings including topography, watercourse network and catchment delineation. The catchment attributes namely Mean Annual Runoff (MAR), Mean Annual Precipitation (MAP) and Mean Annual Evaporation (MAE) were obtained from the Water Research Commission (WRC) Reports K5/1491 (WRC, 2012). In addition, the extreme event rainfall depths/ design rainfall events were determined from the South African Weather Services (SAWS) rainfall information database using data from 6 nearest stations. A 24 hour design rainfall depths model was run on a Design Rainfall Estimation (DRE) in South Africa software (Smithers and Schulze, 2003) for the 1: 50 and 1: 100 year return periods;
- Water quality - A site assessment was conducted to collect water quality samples within the nearby river selected up - and downstream samples along the surface water resources for the water quality parameters of concern including (TDS, SS, SO4, pH, EC etc.) and full metal analysis. The baseline quality will be determined by benchmarking against standards of the South African National Accreditation Systems' (SANAS) accredited laboratory against the South African National Standard (SANS) 241: 2015 Drinking Water and Department of Water Affairs water use specific guidelines (the most stringent of the standards to be used for each of the variables analysed). The SANS 2011 standards limit for chronic health were utilised as the upper class for the maximum allowable limits (Class II) and the stricter aesthetic value limits were used as the stricter limits (Class I).
- Floodlines - Section 3 presents estimates of the flood hydrology (peak flows) of the catchments of the nearby streams (Lesobeng and Sefahlane), the and hydraulic flood modelling undertaken for the watercourses of interest including methodology, software, results and the flood-lines associated with the 1:50 year, 1:100 year events;
- Conceptual Storm Water Management - Section 5 presents the recommended storm water drainage measures to manage flood risks to the operation and minimise risks of polluting any water resources, including clean and dirty water catchment delineation, estimation of peak flows, channel routing and sizing, and sizing of pollution control dams;
- Impact Assessment – Section 6 presents a qualitative assessment of the impacts of the project on the baseline surface water environment, a range of mitigation measures to minimise impacts, and recommendation on monitoring; and
- Conclusions – Section 7 presents a summary of the main conclusions and recommendations of this report

Most of the sections in this report have been compiled following review of available reports and received information from other consultants namely the following reports undertaken for Matai:

- Scoping Report (Kimopax, 2018)
- Mine Works Programme (Kimopax, 2018)
- Matai Concept Study (Ukwazi Mining Studies (Pty) Ltd, 2018)

2 Baseline Hydrology

2.1 Catchment Characterisation

2.1.1 Introduction

South Africa is divided into 9 water management areas (WMAs) in line with the National Water Resource Strategy 2 (NWRS 2) boundary readjustments proposition from the previous 19 WMAs; which have been published in the Government gazette number 40279 of 19/09/16 (Notice no 1056, DWS, 2016), managed by their own water boards. Each of the WMAs is made up of quaternary catchments which relate to the drainage regions of South Africa. This section presents a review of catchment information from various sources

2.1.2 Regional Hydrology

The Water Resources of South Africa Manual WR2012 (WRC, 2012) shows that the project area falls within the Limpopo Water management area (WMA) 1. Most of the project site falls within quaternary catchment A24E, lesser extent of the project site is located within the quaternary catchment A24D both of which are upstream of Bierspruit Dam. The catchments are within the catchment of the Crocodile River which ultimately feeds into the Limpopo.

The quaternary catchment climatic and runoff parameters such as mean annual; runoff (MAR), mean annual precipitation (MAP) an mean annual evaporation (MAE), have been extracted from the WR2012 study are indicated in Table 2-1 (WRC, 2012)

Table 2-1: MAR, MAP and MAE of the A24E and A24D Quaternary

Quaternary Catchment	Total Area (km²)	MAR (* 10^6 m³)	MAP (mm)	MAE (mm)	Rainfall Zone	Evaporation Zone	MRA in Catchment %/ km²
A24D	1328	19.72	600	1850	A2N	3A	1% (13.8 km2)
A24E	688	10.39	592	1800	A2N	3A	12% (85.2km2)

*million cubic meters (mcm).

2.1.3 Local Hydrology

Both quaternary catchments are bound to the south by the Pilanesberg, which comprises an area of elevated topography and hills. The watercourses in the area are all non-perennial with the headwaters emanating from the Pilanesberg. The watercourses have a relatively flat grade except for the watercourses originating at the catchment divide in the Pilanesberg mountain range, which are extremely steep through the mountainous area before flattening at the foot of the range.

The tributaries of the Brakspruit within the catchment A24E which drain through the MRA area east of the infrastructure footprint include:

- The Sefatlhane (also known as the Moruleng in upstream reaches) flows north from the Pilanesberg to a confluence with the Lesobeng.
- The Lesobeng (also known as the Lesele in upstream reaches) flows north from the Pilanesberg to a confluence with the Sefathlane, approximately 0.5 km south of the project area;

On the west of the site within quaternary catchment A24D, is the Bofule river draining northwards. The potential runoff from the study area drains, either to the west into the Bofule (only the pit footprint) or to the east into the Lesobeng - Sefahlane river system.

Both the Bofule and Sefahlane river systems eventually end in the into the Bierspruit River after they converge at the outflow from the quaternary catchment A24E approximately 19km northeast and downstream off the Matai project boundary. The Bierspruit then flows onwards to a confluence with the Crocodile River approximately 45km north of the project area.

The hydrological setting of the project site is indicated in Figure 2-1.

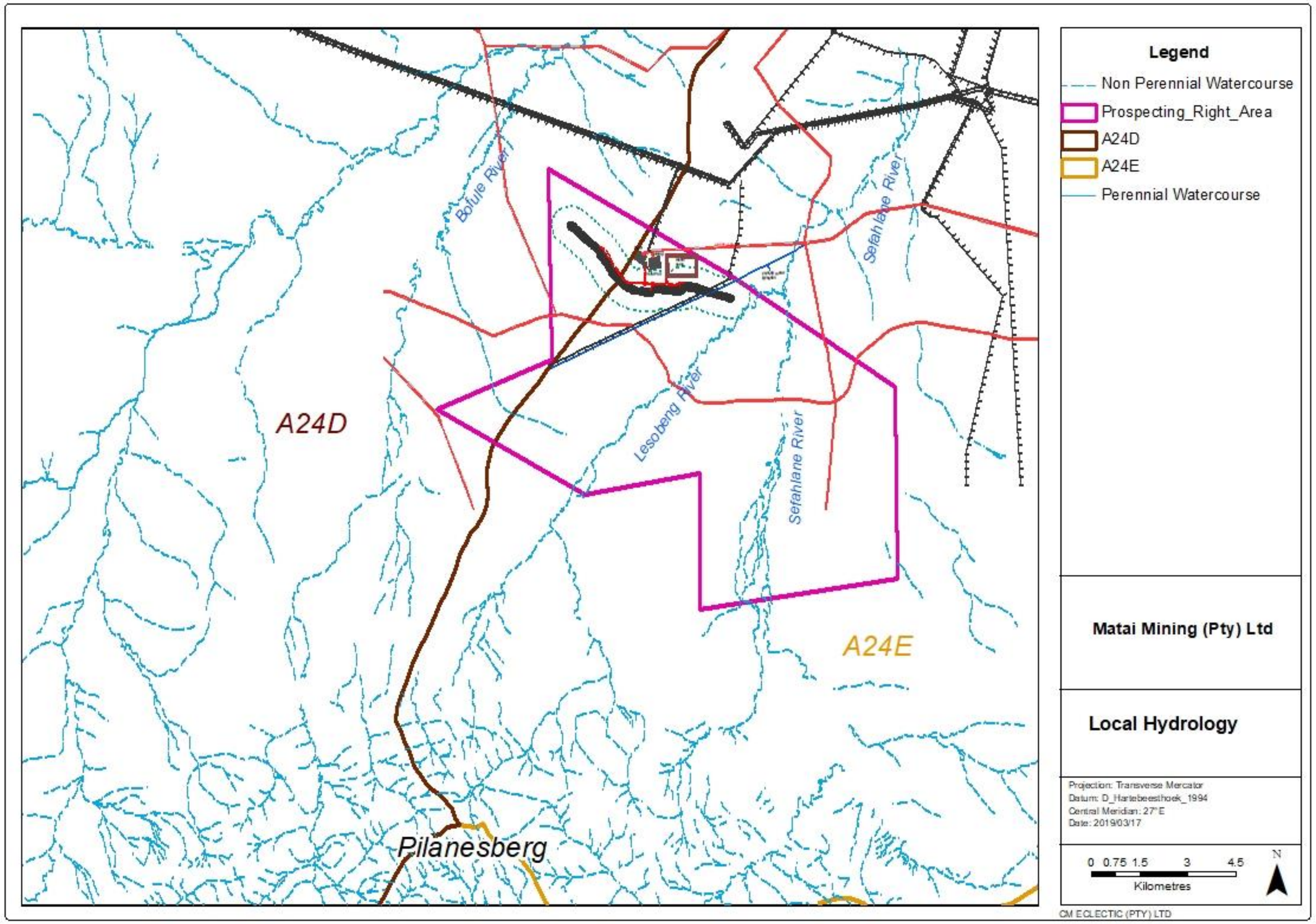

Figure 2-1: Hydrological Setting

2.1.4 Stream Flows

There are no DWA stream flow gauges within the vicinity of the proposed project site. It was also not possible to have stream velocity measurements during the site visit as the perennial rivers had no flow.

2.1.5 Topography

To the south of the Matai project site is a regionally significant area of elevated topography, formed by the Pilanesberg where the peaks reach an elevation of 1687 m with the discharge into the crocodile river system, north of the site being at approximately 900 m.

The topography of the infrastructure site is characterised by elevations of approximately between 1063 and 1138 m amsl with general slope of less than 1%.

The watercourses which flow through the Matai MRA footprint originate from the Pilanesberg, which is an area of elevated topography, situated 5km south of the project infrastructure. The upper reaches of the watercourses are much steeper than the lower sections.

2.1.6 Vegetation

The proposed mining site is currently used for agricultural purposes characterized by farming and mining activities, generally the land use is open veld. In the Pilanesberg national park, in the upper catchment, the area features relatively dense vegetation and thickets, whereas the lower catchments of the Sefahlane and Lesobeng including the site feature a less dense bushveld and thornveld with agriculture and grazing.

The vegetation in the area consists mainly of grasslands and scattered thorn bushes with areas of dense thorn bushes comprising of less grasslands and the opposite occurring as well.

2.1.7 Soil

Most of the mining right area is covered in red-yellow, freely drained red soils. Considering the Soil Conservation System (SCS) soil classification types for South Africa map, the site is classified as hydrological soil type C/D with very small area of class B/C confined mostly to the water courses flood plains. these two classes according to Schulze (SCS-SA shapefiles) have the following typical texture classes

- B/C – with typical sandy loam and sandy clay soil texture with moderately low to moderately high runoff potential and sandy loams
- C/D - with a typical textural class of clay with moderately high to high runoff potential

The further classification of the soils is not part of this report however, the SCS classes assist in estimation of runoff factors of the project site.

2.2 Climatic Characterisation

2.2.1 Rainfall

No records of rainfall recorded at the site are available and as such rainfall data from the following source was reviewed to characterise rainfall patterns at the site:

- Water Resources of South Africa 2012 Study (WR2012).

The WR2012 GIS maps show that the MAP at the site is likely to be in the region of 500 - 600mm and within the influence of the elevated topography of the Pilanesberg which increases total rainfall. Monthly average rainfall data obtained from the WR2012 database nearest rainfall stations as presented in Table 2-2.

Table 2-2: WR2012 Database Rainfall Stations

Station	Start	End	MAP	Distance - direction from site
0548280_W	1969	2007	613.1	15.4 - S
0587477_W	1968	2003	562.5	16.1- NE
0548 483_W	1915	1952	563.7	18.1 - E

Rainfall data for the project area is based on the average of these three nearest rain gauge stations. Monthly average rainfall for the site is based on records from the rain gauges which run from the periods stated in Table 2-2 and are presented in Table 2-3.

Table 2-3: Monthly Average Rainfall

Station name	SAULSPOORT	NORTHAM (POL)	DRIELAAGTE	Site Average
SAWS Code	**0548280_W**	**0587477_W**	**0548483_W**	
Distance from site	15.4 - S	16.1- NE	18.1 - E	
January	113.9	110.4	86.4	103.6
February	89.8	84.8	89.8	88.1
March	82.5	82.2	86.0	83.6
April	36.8	32.8	32.2	34.0
May	14.3	7.5	15.2	12.3
June	3.0	1.7	6.4	3.7
July	1.0	1.4	3.9	2.1
August	5.0	2.1	8.2	5.1
September	12.1	14.9	13.3	13.4
October	54.6	48.8	41.4	48.3
November	78.3	79.6	82.1	80.0
December	121.9	96.2	98.7	105.6
Total	613.1	562.5	563.7	579.8

The MAP determined for the site from the WRC2012 database is 579.8 mm which is within close ranges to the 592 and 600 mm for the A24E and A24D respectively.

An analysis of the rainfall information from the three stations indicates the wettest and driest year that have a large variation ranges as presented in Table 2-4 below.

Table 2-4: Summary of Wettest and Driest Year Maps for Nearest Weather Stations

Station	Wettest year MAP	Driest year MAP
0548280_W	1096.3	241.6
0587477_W	927.1	251.5
0548 483_W	875.4	293.1

2.2.2 Evaporation

Evaporation data is based on records from DWA operated station reference A2E021 (Zwartklip @ Rustenb. Plat.Mine; -24.94227; 27.15802), which is located approximately 10km north east of the proposed project site with Symons Pan (S-Pan) evaporation record length of length of 15 years from 1970 until 1986. S-Pan evaporation was converted to open water evaporation using evaporation coefficients from WR1990[1.] The evaporation records show a mean annual evaporation (MAE) of 1329mm, which will be adopted for the site.

Table 2-5 presents the average monthly rainfall and evaporation adopted for the site.

Table 2-5: Average Monthly Evaporation Adopted for The Site

Month	A-Pan Evaporation (mm)	S-Pan Evaporation (mm)	Conversion Factors	Lake Evaporation (mm)
January	170.5	197.9	0.84	143.2
February	127.6	147.4	0.88	112.3
March	134.5	150.9	0.88	118.4
April	98.3	119.3	0.88	86.5
May	83.8	98.5	0.87	72.9
June	67.7	82.2	0.85	57.5
July	68.6	92.8	0.83	56.9
August	99.8	139.7	0.81	80.8
September	138.4	182.0	0.81	112.1
October	179.0	210.2	0.81	145.0
November	178.7	201.5	0.82	147.7
December	185.5	203.2	0.83	154.0
Total	**1533.8**	**1825.6**	**N/A**	**1287.3**

[1] Surface Water Resources of South Africa 1990 - Volume 1 Appendices. WRC Report 298/1.1/94

2.2.3 Storm Depth-Duration-Frequency (DDF)

Design storm estimates for various return periods and storm durations were sourced from the Design Rainfall Estimation Software for South Africa, developed by the University of Natal in 2002 as part of a WRC project K5/1060 (Smithers and Schulze, 2002). This method uses a Regional L-Moment Algorithm in conjunction with a Scale Invariance (RLMA&SI) approach to provide site specific estimates of depth duration- frequency (DDF) rainfall, based on surrounding observed records. This method of DDF rainfall estimation is considered more robust than previous single site methods. The software extracts the storm depth-duration-frequency (DDF) data for the six closest rainfall stations, as presented in Table 2-6

Table 2-6: Summary of Weather Stations Used for Generating Rainfall DDF for The Road

Station Name	SAWS Number	Distance (km)	Record Length (years)	Mean Annual Precipitation (mm)	Altitude (m amsl)
SAULSPOORT	0548280_W	15.4	38	611	1095
NORTHAM (POL)	0587477_W	16.1	31	587	1007
DRIELAAGTE	0548483_W	18.1	39	572	1050
JERSEY FARM	0587475_W	19.5	28	565	998
MIDDELKOP	0587139_W	21.9	49	650	1113
VLAKNEK	0587350_W	23.4	38	636	1050

The adopted storm rainfall depth based on the gridded rainfall depths for the above six stations for the 5 minute duration up to the 7 day storm duration for various recurrence intervals are shown below in Table 2-6.

Table 2-7: Storm Depth-Duration-Frequency (DDF) Rainfall For Project Site

Duration	Rainfall Depth (mm)						
	1:2 years	1:5 years	1:10 years	1:20 years	1:50 years	1:100 years	1:200 years
5 minutes	9.8	13.5	16.1	18.6	21.9	24.5	27.1
10 minutes	14.6	20.1	23.9	27.6	32.5	36.4	40.2
15 minutes	18.4	25.3	30.1	34.8	41	45.8	50.7
30 minutes	23.3	32.1	38.1	44.1	52	58	64.2
45 minutes	26.7	36.8	43.8	50.6	59.7	66.6	73.7
1 hour	29.5	40.6	48.3	55.8	65.8	73.5	81.3
1.5 hours	33.8	46.7	55.4	64	75.5	84.4	93.4
2 hours	37.3	51.5	61.1	70.6	83.3	93.1	103
4 hours	44.0	60.7	72.1	83.3	98.2	109.7	121.4
6 hours	48.4	66.8	79.3	91.7	108.1	120.8	133.6
8 hours	51.9	71.5	84.9	98.1	115.8	129.3	143.1
10 hours	54.7	75.4	89.6	103.5	122.1	136.3	150.8
12 hours	57.1	78.7	93.5	108.1	127.5	142.4	157.5
16 hours	61.1	84.3	100.1	115.7	136.5	152.4	168.6
20 hours	64.5	88.9	105.6	122	143.9	160.7	177.8
24 hours	67.3	92.8	110.2	127.4	150.2	167.8	185.7
2 days	68.9	95.1	112.9	130.5	153.9	171.9	190.2
3 days	77.9	107.4	127.5	147.4	173.8	194.2	214.8
4 days	84.8	116.9	138.9	160.5	189.3	211.4	233.9
5 days	90.6	124.9	148.4	171.4	202.2	225.9	249.9
6 days	95.6	131.9	156.6	181	213.5	238.4	263.8
7 days	100.1	138	163.9	189.4	223.4	249.6	276.2

3 Water Quality Assessment

3.1 Introduction

Kimopax's Hydrogeologist conducted a site visit on the 13th of December 2018 as part of the Hydrocensus study and collected water quality samples from the water resources within the project area. Table 3-1 indicates the surface water sampling point locations in relation to the project area; also shown in Figure 3-1.

The water samples were sent to aQualande Laboratories (Pty) Ltd, a South African National Accreditation System (SANAS) accredited laboratory in Pretoria to be analysed for physical and chemical water quality parameters.

Out of the five selected water quality sample sites, only one was sampled as most of them were dry at time for site visit.

The water quality guidelines that are used were determined from the land use and current water use. The following guidelines and standards were used for interpretation as and when applicable:

- SANS 241 (2015), Drinking Water – Edition 2.
- Department of Water Affairs and Forestry, 1996. South African Water Quality Guidelines (second edition), Volume 5: Agricultural Water Use: Livestock watering.

The drinking water guidelines were used as they are the most comprehensive set of standards and provide for a worst-case scenario where the water is unintentionally used for consumption by humans. Both the DWS and the SABS standards for drinking water were referred to in this report. SANS 241 specifies the quality of acceptable drinking water, defined in terms of microbiological, physical, aesthetic and chemical determinants. Water that complies with SANS 241 is deemed to present an acceptable water quality for consumption (this implies an average consumption of 2 litres of water per day for 70 years by a person that weighs 60 kg).

Table 3-1:Sampling Locations

Site ID	Description	Latitude	Longitude	Photograph
SW01	Situated at the downstream most point of the site on the Sefahlane stream after the confluence of the Lesobeng and the Sefahlane A sample was collected	25° 0'37.88"S	27°10'10.73"E	
SW02	On the Sefahlane just upstream of the confluence with Lesobeng No water	25° 1'30.40"S	27° 9'56.40"E	

SW03	On the Lesobeng just upstream of the confluence with Sefahlane Dry	25° 1'26.48"S	27° 9'52.08"E	
SW04	Located on the Sefahlane upstream of the project infrastructure area No flowing water, not sampled	25° 3'18.74"S	27° 9'52.95"	

SW05	Located on the Lesobeng upstream of the project infrastructure area Dry	25° 2'56.50"S	27° 8'3.84"E	

3.2 Results

The water quality results from SW01 are presented in Table 3-2 and discussed below

Table 3-2: Water Quality Results

Site Location Date	Symbol	Units	SANS 241:2015 Drinking Water Standards				South African Water Quality Guidelines - (SAWQG), 1996- Target Water Quality	SW01
			Operational	Aesthetic	Acute Health	Chronic Health	Agriculture: Livestock Watering	13-12-2018
Electical Conductivity	EC	mS/m	-	170	-	-	-	25.9
Alkalinity	CacO3	mg/l	-	-	-	-	-	95.7
Aluminium	Al	mg/l	0.3	-	-	-	5	4.244
Boron	B	mg/l	-	-	-	2.4	5	0.02
Calcium	Ca	mg/l	-	-	-	-	1000	18.48
Chloride	Cl	mg/l	-	≤ 300	-	-	1500	8
Copper	Cu	mg/l	-	-	-	2		0.008
Cadmium	Cd	mg/l	-	-	-	0.003	0.01	<0,001
Flouride	F	mg/L	-	-	-	≤ 1.5	2	5
Ammonium	NH_3	mg/L	-	1.5	-	-	-	0.2
Iron	Fe	mg/l	-	0.3	-	2	10	2.883
Lead	Pb	mg/l	-	-	-	0.01	0.1	0.007
Magnesium	Mg	mg/l	-	-	-	-	500	6.07
Manganese	Mn	mg/l	-	0.1	-	0.4	10	0.087
Mercury	Hg	mg/l	-	-	-	0.006	1	<0,002
Nitrate	NO3	mg/l	-	-	≤ 11	-	100	1
pH	pH	-	5-9.7	-	-	-	-	7.64
Potassium	K	mg/l	-	-	-	-	-	4.78
Sodium	Na	mg/l	-	200	-	-	2000	32.46
Sulfate	SO4	mg/l	-	250	≤ 500	-	1 000	13
Suspended Solids	SS	mg/l	-	-	-	-	-	100
Chromium	Cr	mg/l	-	-	-	0.05	1	<0,005
Total Dissolved Solids		mg/l	-	1200	-	-	-	174
Zinc	Zn	mg/l	-	5	-	-	20	0.014
Chromium 6+	Cr	mg/l	-	-	-	-	-	<0,010
Ammonium	NH_4	mg/l	-	-	-	-	-	0.3
Total hardness	$CaCO_3$	mg/l	-	-	-	-	-	58
Total Cyanide	CN	mg/l	-	-	-	-	-	<0,07
Silica	SiO_2	mg/l	-	-	-	-	-	16.4
Nitrite	NO_2	mg/l	-	-	0.9	-	-	0.2

Site Location Date	Symbol	Units	SANS 241:2015 Drinking Water Standards				South African Water Quality Guidelines - (SAWQG), 1996- Target Water Quality	SW01
			Operational	Aesthetic	Acute Health	Chronic Health	Agriculture: Livestock Watering	13-12-2018
Orthophosphate	PO_4	mg/l	-	-	-	-	-	<0,1
Chemical Oxygen Demand	O_2	mg/l	-	-	-	-	-	12
Turbidity	Turb	NTU	1	5	-	-	-	318

From the water quality results, exceedances of the SANS 241 drinking water standards were determined, and these were for the parameters aluminium, iron and turbidity. High turbidity can be attributed to the rains that were reportedly received on the day of the sampling as the water was observed to be very muddy, this was also expected. The elevated iron and aluminium can be attributed to the general geology, however there were no other samples taken to validate this.

3.3 Limitations and Further Work

Sampling was done during a wet period (December 2018) and serves as a baseline description of the quality of surface water on site. With the current shift in the wet season being experienced in South Africa this should have been the peak of the wet season, however the streams were rather dry for a wet season. Monitoring site visit are recommended before the mine actually commences so as to gather a good water quality baseline. This is important for the protection of the resources as well as due diligence for the Matai Project if a good baseline is available. These are once-off samples and do not necessarily indicate average quality at the site.

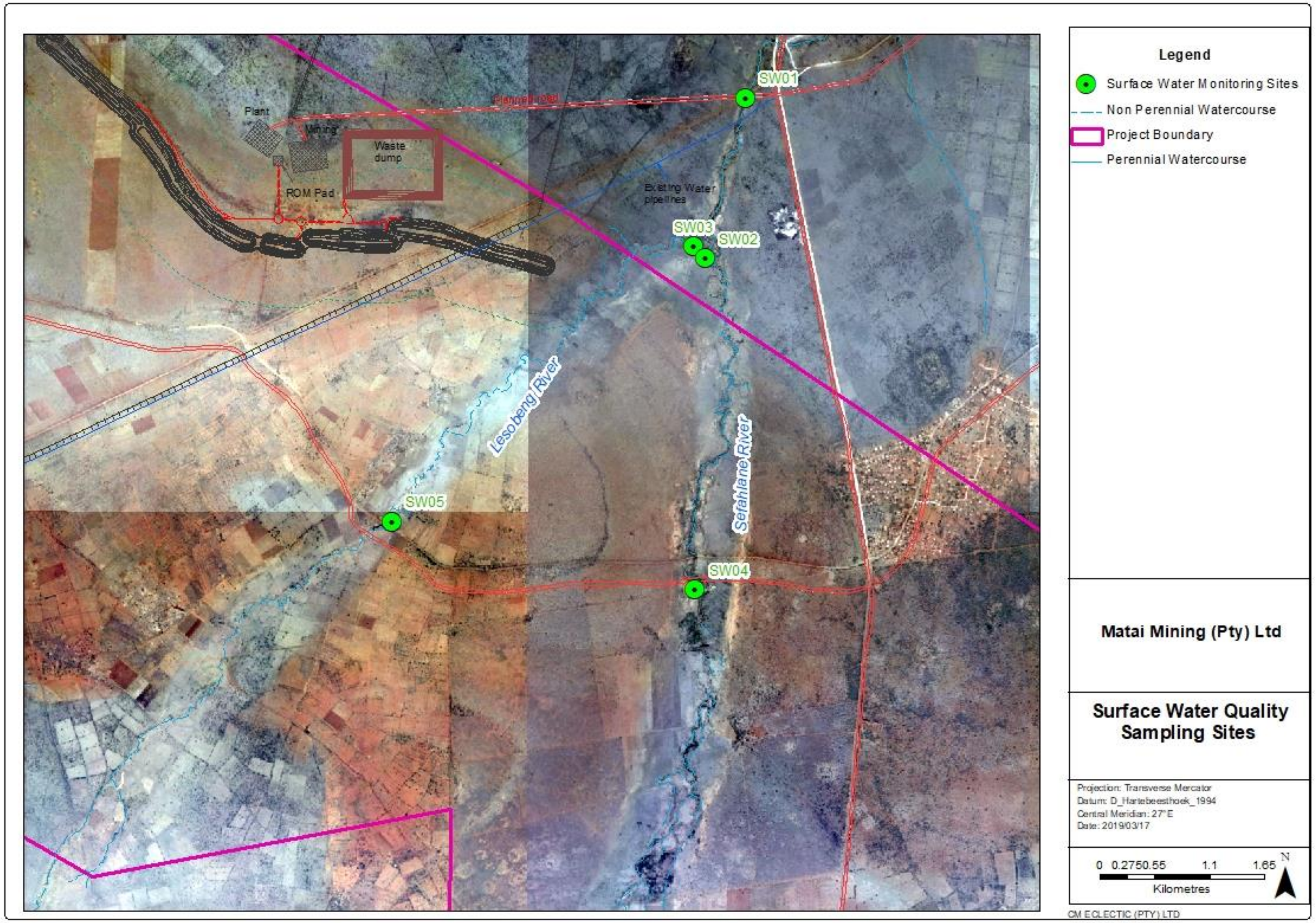

Figure 3-1: Surface Water Quality Sample Locations

4 Steady State Water Balance

4.1 Introduction

A site wide water balance has been prepared to understand the flows within the mine's operation water circuit for the wet and dry season as well as annual averages throughout the the life of mine. This section details the water balance for the Matai project which is done in accordance with the Best Practice Guideline G2 – Water and Salt Balances (DWA, 2010).

The modelled water balance circuit includes water inflows, losses and transfers for the following aspects of the operation:

- Open Pit;
- Mining area;
- Process Plant (crushing and screening plant);
- Stockpiles (WRD) and ROM pads, and;
- Various Support Services (offices, laboratory, stores and yards, change house, workshops and load out stations)

The water balance will be used by the mine in support of the Water Use Licence (WUL) application as well as a water management tool to achieve goals of water management such as:

- Understanding the water circuit at the mine;
- Estimating the water volumes required during deficits and excess volumes produced during surplus, and;
- Assessing the site for areas where water conservation may be implemented.

The water balance was developed in static / steady state water balance – the dry season inflows, transfers and losses which are not influenced by rainfall and are modelled as a set of steady flows.

4.2 Methodology

A spreadsheet based (Microsoft Excel) static model was used to represent the flows within the water circuit using information taken from various studies.

Water sources (inflows) were taken as:

- Groundwater and stormwater ingress into the open pit workings.
- Potable water from water supply boreholes or from Municipal supply infrastructure through Magalies Water
- Stormwater collected from the plant, mining and RoM pad and conveyed to the PCD.
- Direct rainfall into the various dams

Water losses were taken as:

- Evaporation from the pollution control dam (PCD) and pit sumps.
- Potable water consumption and sewage plant losses.
- Interstitial lock up in the waste dump.
- Losses in the plant processing and scrubbing circuits
- Dust suppression – roads and at the plant.

Stormwater, groundwater and process water will be collected within a series of storage facilities including:

- Plant PCD.
- Pit sumps.

Water within these facilities will be returned for re-use at the plant or reused directly for roads dust suppression.

4.3 Water Reuse Hierarchy

The water usage within the mine operation will be prioritised to reusing dirty water from the open pit sump then the PCD for non-potable uses before make-up water from clean water sources such as the municipality or groundwater sources via boreholes is required. The PCD will store dirty water that has been collected from around the mining property during storm events as well as treated sewage effluent.

4.4 Assumptions and Input Parameters

Several assumptions have considered in the water balance, since the Matai Mining Project is under planning, there has been no measurements undertaken and some of the parameters required for the modelling were unavailable. Average values from the literature were used for many of the parameters, and in some cases, conservative estimates and 'worst-case' values were used in the model. These estimations and assumptions should be modified as and when the correct information becomes available at any stage and the resulting water balance would be automatically updated.

The water balance is based on the following assumptions

- 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 (June to August); ii) average values during the three wettest months of the year (December to February); and iii) annual average values;
- Rainfall related inflows and evaporation related losses for the wet and dry conditions were estimated for each month based on the average rainfall and lake evaporation for weather stations in the vicinity of the mine as there is currently no site data available;
- Groundwater pit ingress figures were estimated based on a percentage recharge (20%) of the average rainfall for each mining method as determined by Lukas E and Vermeulen D of

the Institute of Groundwater Studies (IGS) (369m^3/day) were assumed since the groundwater study has not provided the groundwater inflows;

- Treated sewage water from the offices and workshops is stored in the PCD for reuse in the plant process;
- All footprint areas used in the water balance calculation are based on the provided mine infrastructure plan and were kept constant;
- The water used at the offices, workshops, change rooms and all associated buildings will be sourced from the municipality or from boreholes drilled on site. An allocation of 90 L/day per person for the employees and contractors has been assumed;
- As per Client email communication, it is assumed that total water that will be required for the processing plant will be about 5 000 m^3/day during the operational phase in addition to the 90L/day allocated to employees. However, it was assumed that some of the plant water is recovered for recycling in the plant approximately 70% for the scrubbing and processing and the dust suppression component if all lost;
- Dust suppression requirement was determined from the assumption that 3 mm of water will be used daily for the total area of the haul roads as well as the conveyor discharge and transfer points;
- The water from the PCD will also be used for the haul road and on-surface dust suppression.
- Runoff coefficients were estimated based on observations during the site visit and are fixed i.e. not influenced by antecedent climatic conditions.
- Evaporation from the dams will only occur if there is water in the dam.
- This water balance model is run for only steady state average wet dry season conditions and no consideration is given to storage of water at any aspect of the infrastructure modelled i.e. flow in = flow out.

The input parameters are presented in Table 4-1.

Table 4-1: Water Balance Input Parameters

Component	Description	Quantity	Units	Notations
Meteorological Parameters	Wet Month Average Rainfall	0.099	m/mon	Section 2.2 of this report
	Dry Month Average Rainfall	0.00363	m/mon	
	Wet Month Average Lake Evaporation	0.13649	m/mon	
	Dry Month Average Lake Evaporation	0.06511	m/mon	
Areas	Total pit area	1 163 940	m^2	Site location infrastructure drawing
	Open pit area	116 394	m^2	Assumed 10% of the total Pit area is open for mining at anytime
	Open pit sump	5 820	m^2	Assumed 5% of open pit is sump
	ROM pad	10 027	m^2	Site location infrastructure drawing
	Plant area	75 060	m^2	Site location infrastructure drawing
	Mining Area	105 080	m^2	Site location infrastructure drawing

Component	Description	Quantity	Units	Notations
	PCD	8 500	m²	Estimated Sizing (Stormwater Section) of this Report
	Waste Dump	700 000	m²	Site location infrastructure drawing
	Normal Roads	48 000	m²	Ukwazi 2019 (6km stretch with 4m wide lanes)
	Primary haul roads	62 000	m²	Measured L form infrastructure drawings Width =15.5m (Ukwazi 2019)
	Pit Roads / ramps	77 500	m²	Measured from Infrastructure Drawing
	Total property (Total lease area)	98 366 652	m²	Kimopax, 2017 - Scoping Report
Ratios and coefficients	Pit Runoff	0.5		Assumed from Hodgson F.D.I. and Krantz R.M. (1998)
	Mining	0.52		Assumed same as in SWMP (Section 5.5)
	RoM	0.40		
	Plant	0.52		
	Waste Dump	0.52		Assumed same as in SWMP (Section 5.6)
Volumes	Ground Water Ingress / seepage	369.26	m³/month	Lukas E & Vermeulen D, 2005-
Plant Water Uses	Plant Dust Suppression	2 500.00	m³/day	Client email 21 February 2019
	Scrubbing	1 500.00	m³/day	
	Fines Processing	1 000.00	m³/day	
	Pit water uses	5 022.00	m³/month	Assume 3mm water for total area for dust suppression 1x times per day for pit haul roads x 5days per week
	Municipal /Borehole Portable water	464	m³/month	Assumed 172 people each using 90L/day (mine personnel, mining contractor management, processing plant management)
	Portable water losses to soakaway and WTP	394.74	m³/month	Assumed 0.85 of water supplied
	Water consumption	46	m³/month	Assumed 0.1 of water supplied
	System losses	23.22	m³/month	Assumed system losses (0.05)
	WWTP Losses	59.211		Assumed 15%
	Dust suppression demand (on normal roads)	1152	m³/month	Assume 3mm water for total area for dust suppression 8 times per month
	Dust suppression demand (on haul roads)	1488	m³/month	Assume 3mm water for total area for dust suppression 8 times per month
	Dust suppression Wet Season	0.3	-	Multiply dry season by 0.3 because conditions are wet

4.5 Results

The summary of the average wet period, average dry period and the average yearly period water balance are shown in Table 4-2 through to Table 4-4 and in Figure 4-1 through to Figure 4-3 respectively and the results are summarized as follows:

- The external / make up water demand of the processing plant is as follows
  - wet season 12 411 m³/month
  - dry season 28 479 m³/month
  - average 20 551 m³/month

Table 4-2: Water Balance Summary, Average Wet Season

Facility Name	Water In		Water Out		Balance
	Water Stream	Quantity (m3/mon)	Water Stream	Quantity (m3/mon)	Quantity (m3/mon)
Offices, Workshops & Changerooms	Municipal/Borehole Water	464	Consumption	46	
			Losses	23	
			Sewage Treatment Plant	395	
		464		**464**	**0**
WWTP (sewage treatment plant)	Sewage Treatment Plant	395	Sludge Water Loss	59	
			Reclaimed Water to PCD	336	
		395		**395**	**0**
Pollution Control Dam (PCD)	Reclaimed Water to PCD	336	Evaporation	1 257	
	Rainfall	819	Dust Suppression on haul roads	2 640	
	Runoff (Plant, RoM Stockpile and Mining)	7 693	Processing Plant Demand	19 789	
	Pit Water Pumped to PCD	14 839			
		23 687		**23 686**	**0**
Processing Plant	Processing Plant Demand-PCD	19 789	Processing Losses	9 200	
	Make-up Water	12 411	Scrubbing Losses	13 800	
	Water Reuse	67 467	Dust Suppression (plant area)	76 667	
		99 667		**99 667**	**0**
Open Pit	Rainfall and Runoff	5 835	Pit Water Pumped to PCD	14 839	
	Groundwater Ingress	11 324	Dust suppression within pit	1 507	
			Losses/ Evaporation	813	
		17 159		**17 159**	**0**
Waste Dump (WD)	Rainfall on WD	67 480	Evaporation	6 748	
			Interstitial Storage	60 732	
		67 480		**67 480**	**0**
Total Water Circulation		**208 852**		**208 851**	**1**

Table 4-3: Water Balance Summary, Average Dry Season

Facility Name	Water In		Water Out		Balance
	Water Stream	Quantity (m3/mon)	Water Stream	Quantity (m3/mon)	Quantity (m3/mon)
Offices, Workshops & Changerooms	Municipal/Borehole Water	464	Consumption	46	
			Losses	23	
			Sewage Treatment Plant	395	
		464		**464**	**0**
WWTP (sewage treatment plant)	Sewage Treatment Plant	395	Sludge Water Loss	59	
			Reclaimed Water to PCD	336	
		395		**395**	**0**
Pollution Control Dam (PCD)	Reclaimed Water to PCD	336	Evaporation	553	
	Rainfall	31	Dust Suppression on haul roads	2 640	
	Runoff (Plant, RoM Stockpile and Mining)	290	Processing Plant Demand	3 721	
	Pit Water Pumped to PCD	6 258			
		6 915		**6 914**	**1**
Processing Plant	Processing Plant Demand-PCD	3 721	Processing	9 200	
	Make-up Water	28 479	Scrubbing	13 800	
	Water Reuse	67 467	Dust Suppression (plant area)	76 667	
		99 667		**99 667**	**0**
Open Pit	Rainfall and Runoff	220	Pit Water Pumped to PCD	6 258	
	Groundwater Ingress	11 324	Dust suppression within pit	5 022	
			Losses/ Evaporation	264	
		11 544		**11 544**	**0**
Waste Dump	Rainfall on WD	2 543	Evaporation	254	
			Interstitial Storage	2 289	
		2 543		**2 543**	**0**
Total Water Circulation		**121 528**		**121 527**	**1**

Table 4-4: Water Balance Summary, Annual Average

Facility Name	Water In		Water Out		Balance
	Water Stream	Quantity (m^3/mon)	Water Stream	Quantity (m3/mon)	Quantity (m3/mon)
Offices, Workshops & Changerooms	Municipal/Borehole Water	464	Consumption	46	
			Losses	23	
			Sewage Treatment Plant	395	
		464		**464**	**0**
WWTP (sewage treatment plant)	Sewage Treatment Plant	395	Sludge Water Loss	59	
			Reclaimed Water to PCD	336	
		395		**395**	**0**
Pollution Control Dam (PCD)	Reclaimed Water to PCD	336	Evaporation	911	
	Rainfall	411	Dust Suppression on haul roads	2 640	
	Runoff (Plant, RoM Stockpile and Mining)	3 857	Processing Plant Demand	11 431	
	Pit Water Pumped to PCD	10 378			
		14 982		**14 982**	**0**
Processing Plant	Processing Plant Demand-PCD	11 431	Processing	9 138	
	Make-up Water	20 551	Scrubbing	13 706	
	Water Reuse	67 008	Dust Suppression (plant area)	76 146	
		98 990		**98 990**	**0**
Open Pit	Rainfall and Runoff	2 924	Pit Water Pumped to PCD	10 378	
	Groundwater Ingress	11 247	Dust suppression within pit	3 264	
			Losses/ Evaporation	529	
		14 171		**14 171**	**0**
Waste Dump (WD)	Rainfall on WD	33 822	Evaporation	3 382	
			Interstitial Storage	30 440	
		33 822		**33 822**	**0**
Total Water Circulation		**162 824**		**162 824**	**0**

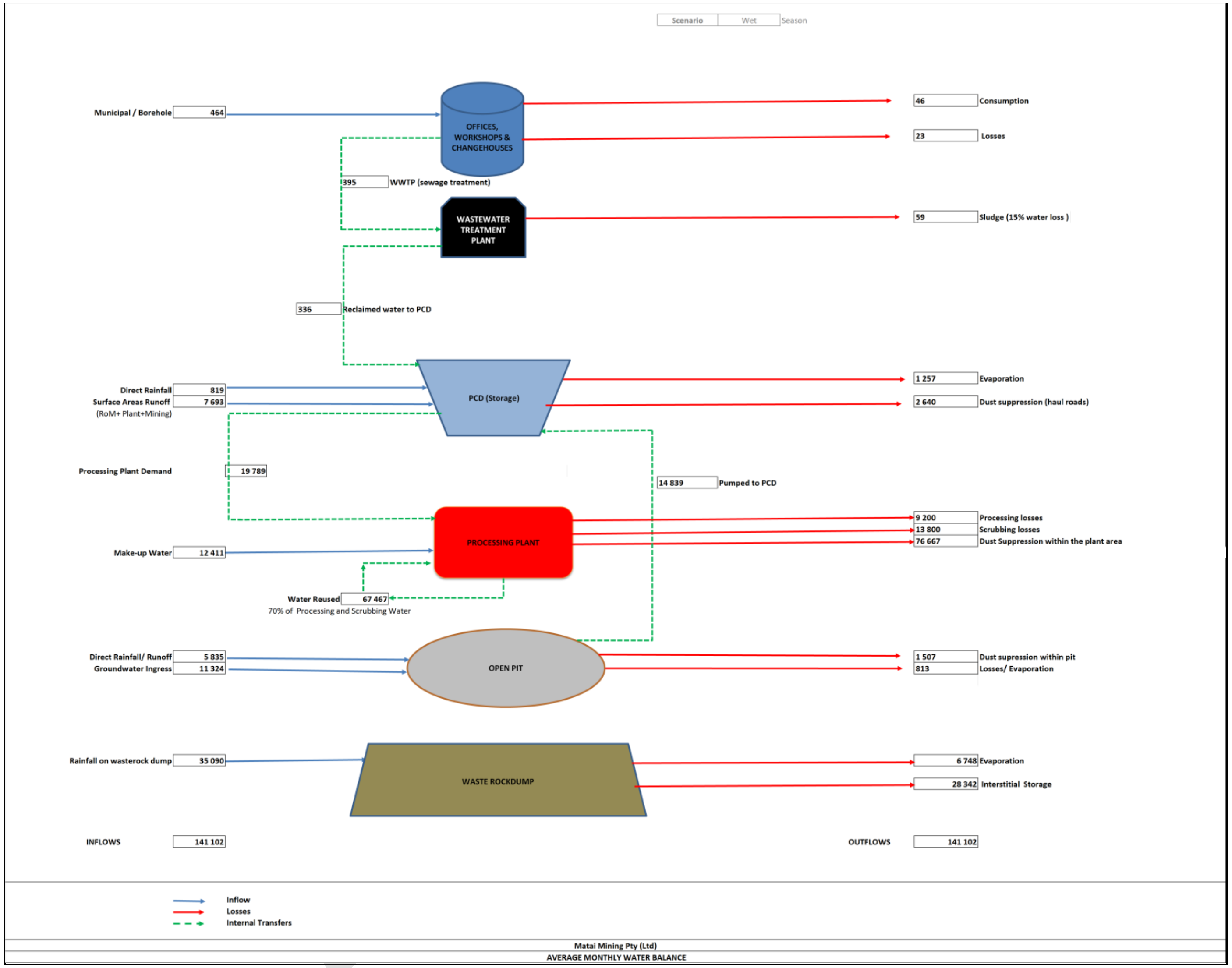

Figure 4-1: Average Wet Season Water Balance

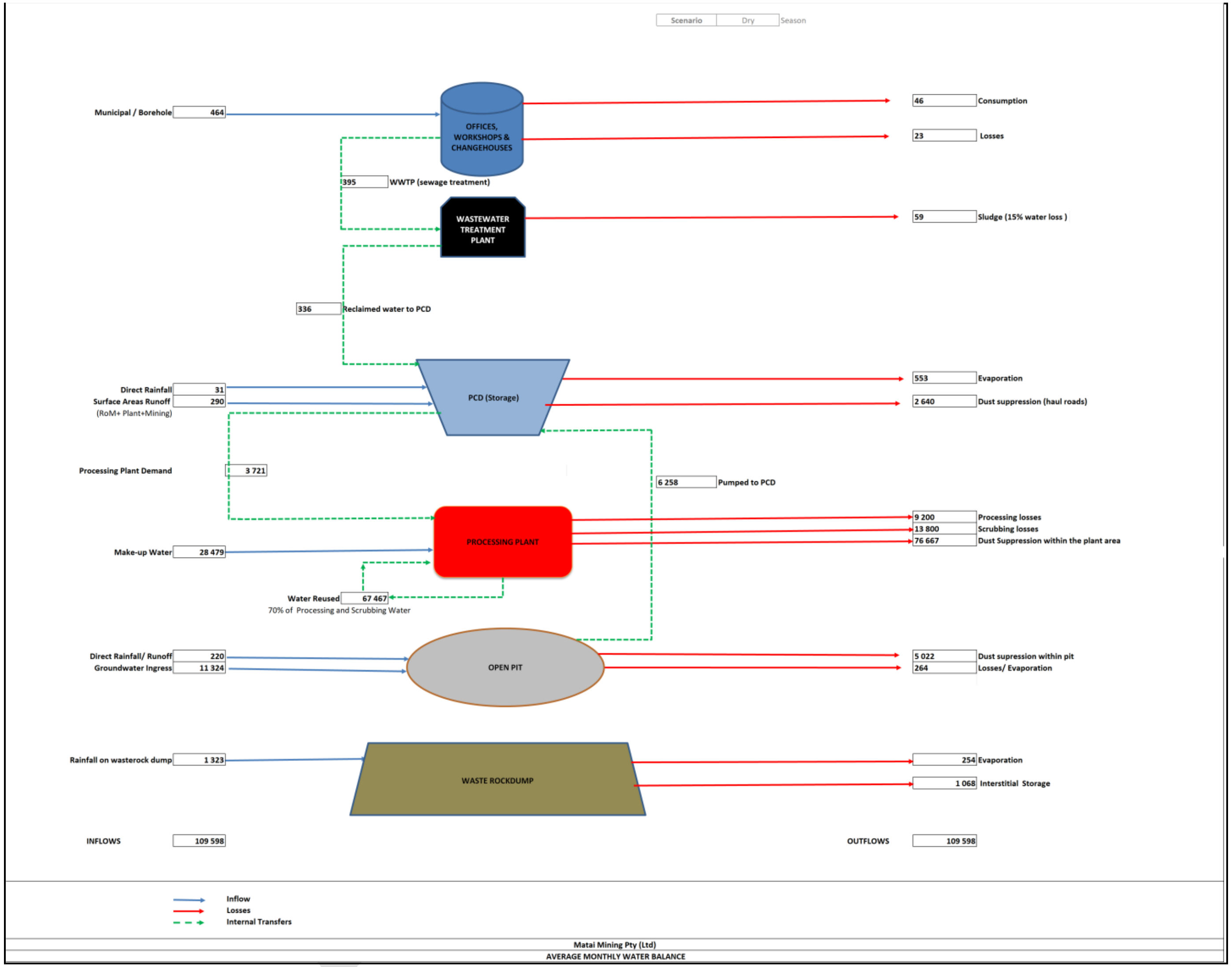

Figure 4-2: Average Dry Season Water Balance

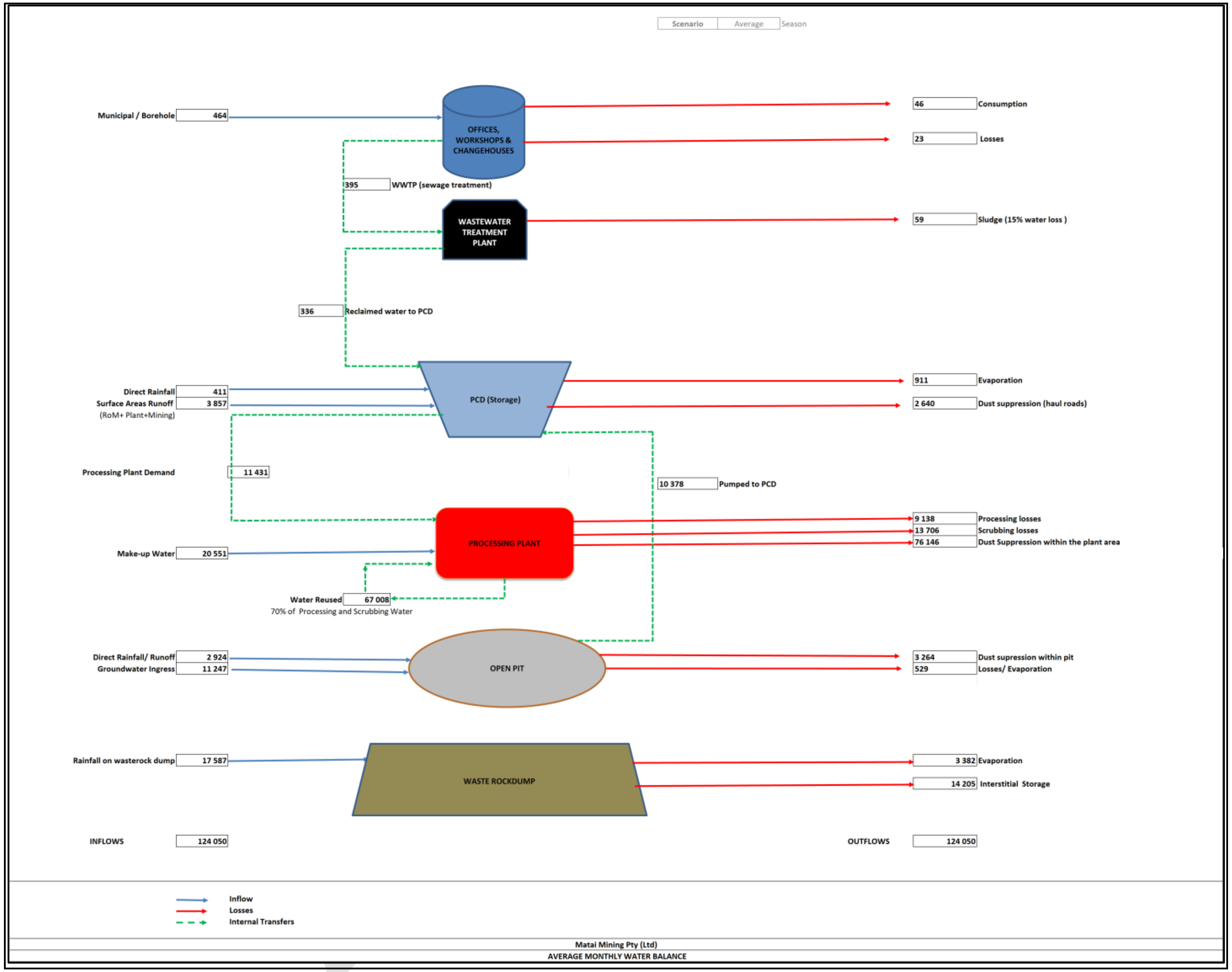

Figure 4-3: Average Annual Water Balance

4.6 Limitations and Further Work

Considering that the project is in planning phase, a limited amount of information was available at the time of development of this water balance, therefore, assumptions have been made in developing the model. It is recommended that the model should undergo periodic updates as more information becomes available during mine operation. The limitations of the model are listed below:

- Generation of runoff will vary substantially season to season and year to year and it is recommended that runoff volume measurements are collected and used to calibrate the water balance model particularity in the water storage structures such as PCDs and RoM pads;
- The model is based on conservative values, assuming the maximum areas for runoff. It will be necessary to update with operational mine water balance when mining commences;
- The dust suppression water demand should be recorded and used to calibrate the model; and
- In addition to runoff and groundwater inflow, monitoring of the other key water transfers should be undertaken on monthly basis and used to calibrate the water balance model

The water balance is based on average steady state and does not consider storage volumes or spillage, which can be determined through a dynamic daily time step water balance during the detailed design stages to endeavour to understand how the water balance behaves in variable climatic conditions and extreme events.

For the water balance modelling presented above, the processing plant is treated as a black box, where only net inflows and losses are considered, as it is assumed that the net inflow for the plant will be met by water from all or any of the water supply sources.

No consideration is given to the impact of water quality treatment facilities. Any changes to the processing plant water circuit which may include water treatment facilities may require a revision of the above findings and recommendations.

5 Conceptual Stormwater Management Plan

5.1 Introduction

The SWMP will provide conceptual inputs into the design requirements and placement of storm water management structures and recommendations based on the infrastructure plan.
Mining operations have the potential to have a negative impact on the natural water quality of an area in the following ways:

- Bulk earthworks which will strip vegetation and expose topsoil and sub-soils. Storm water flow will contribute to erosion thereby increasing levels of suspended solids within local watercourses and water features;
- Earthworks and mineral processing operations may expose elements naturally occurring within soils and geology to storm water, mobilising them into local watercourses and water features;

- Storage and use of process specific chemicals and vehicular related pollutants which, if not properly managed, may be washed by storm water into local watercourses and water features; and
- Discharge of polluted or improperly treated storm water, process water and sewage water into local watercourses or water features may occur.

A negative impact on the baseline water quality by mining operations will likely affect local aquatic ecosystems, and/or the local community who use the water for livestock watering. Furthermore, storm water may pose a risk of flooding to a proposed development, if not managed correctly.

The aim of the stormwater management plan (SWMP) is to fulfil the requirements of the National Water Act (Act 36 of 1998) and more particularly, GN704 (as discussed in Section 1), which deals with the separation of clean and dirty water. This conceptual stormwater management plan will form a necessary part of the IWULA, submitted to the Department of Water and Sanitation (DWS).

The following definitions from GN 704 are appropriate to the classification of catchments and design of stormwater management measures at the Matai project:
GN704 was published to provide regulations on the use of water for mining and related activities aimed at the protection of water resources. There are important definitions in the regulation, which require understanding, and these are discussed below.

- Clean water system includes any dam, other forms of impoundment, canal, works, pipeline and any other structure or facility constructed for the retention or conveyance of unpolluted (clean) water;
- Dam: includes any settling dam, slurry dam, evaporation dam, catchment or barrier dam and any other form of impoundment used for the storage of unpolluted water or water containing waste (i.e. dirty water);
- Dirty area: means any area at a mine or activity which causes, has caused or is likely to cause pollution of a water resource;
- Dirty water system: this includes any dirty water diversion bunds, channels, pipelines, dirty water dams or other forms of impoundment, and any other structure or facility constructed for the retention or conveyance of water containing waste (i.e. dirty water); and
- Activity: means any mining related process on the mine including the operation of washing plants, mineral processing facilities, mineral refineries and extraction plants; the operation and the use of mineral loading and off-loading zones, transport facilities and mineral storage yards, whether situated at the mine or not; in which any substance is stockpiled, stored, accumulated, dumped, disposed of or transported.

5.2 SWMP Catchments Classification

A mine infrastructure layout has been proposed, and consequently the SWMP has been based on this proposed layout. The proposed infrastructure pertinent to this SWMP has been classified as dirty or clean areas as indicated in Table 5-1.

Table 5-1: Clean and dirty area classification

Area Classification	Mine Areas	Stormwater Treatment Technique
Clean	• Area upstream of the Mine infrastructure (upstream of pit and upstream of the • Area between the plants and pit	• Divert around dirty areas and discharge to natural environment system
Moderately Clean	• Haul roads • Administration buildings • The area between the plant, RoM and Mining area, that can't be routed to clean catchment system	• Dust control • Contain water that cannot be routed to clean catchment due to infrastructure set up
Dirty	• Run of Mine (RoM) stockpile • Plant area • Mining infrastructure area • Pit • Waste Dump	• Convey dirty water and contain in a pollution control dam (PCD) and reuse • Perimeter berms for waste dumps and allow water to evaporate

5.3 Proposed Stormwater Management Measures

Informed by the baseline hydrology of the site and surroundings (presented in Section 2), a review of the proposed surface infrastructure has been undertaken, and a series of design principles for stormwater management have been developed to ensure compliance with the requirements of GN 704 and the guidelines of the BPG G1

The main objective of SWMP measures is to ensure that surface water risks within the project sub-catchment are minimised. The primary risk is the contamination of the surface water environment (including storm water drainage) from the mobilisation of ore and sandy material, as well as dirty water into the clean catchment.

The proposed conceptual stormwater management plan is presented on Figure 5-1, the key features include:

- Clean stormwater will be diverted around dirty catchments and allowed to flow towards the watercourses on either side of the site depending on the topography. This will be accomplished through the construction of upstream clean water diversion berms/channels to prevent clean water from entering the dirty areas and ensure that it drains away from the site through the channels upstream of dirty areas;

- Moderately clean areas that otherwise cannot easily be conveyed to the clean water system between the planned road and the infrastructure will be collected with the dirty water system for reuse;
- A series of dirty water berm and channel systems (example in Figure 5-2) will be required to capture and convey runoff emanating from the dirty water areas (plant, mining area and RoM). The dirty water trenches will convey the runoff to the PCD via a silt trap;
- Open channels are preferred for ease of maintenance and can easily be constructed to accommodate design capacity, whilst maintaining suitable drainage gradients;
- Stormwater collecting in the PCD will be pumped to the Process Water Dam (PWD) during and after rainfall events to supply the plant's water requirements; and
- Considering the general topography, a PCD location is proposed at the downstream most (southern corner of the mining department)

The detailed storm water management measures per infrastructure are presented in Table 5-2 and in Figure 5-1.

Table 5-2: Recommended SWMP Operational Management Measures per Infrastructure

SWMP Aspect Infrastructure	Operation Management Recommendation
RoM stockpile area	Contaminated storm water runoff from this area will be routed at a macro scale through perimeter trenches through a silt trap to the PCD.
Haul roads	No formal diversions are recommended, rather normal roadside drainage with collectors should be constructed. Where necessary onsite culverts should be designed to pass clean and dirty water diversion channels.
Plant area	Clean water catchment upstream of the plant is diverted away in a clean water channel and berm system Dirty stormwater from the rest of the plant will be intercepted at a macro scale by a perimeter drainage channel and conveyed to the site PCD after passing through a silt trap. The plant catchment will have some parts which are hard standing, some covered by gravel / erodible material and undisturbed soils and vegetation.
Mining department	Areas for vehicular workshops and fuels storage will be hard standing areas and bunded off from the rest of mining area. Any stormwater and cleaning water will be collected in a microscale channel and passed through an oil separator before being discharged into the dirty water channel to the PCD. Dirty stormwater from the rest of the mining area will be intercepted at a macro scale by a perimeter drainage channel and conveyed to the Plant PCD. The admin buildings and change houses can be treated as clean areas and the clean water collected into clean water drains for discharge into the clean water system or the PCD depending on actual layout within the site (detailed SWMP and micro level SWMP is not part of the scope of this study)

SWMP Aspect Infrastructure	Operation Management Recommendation
Waste Dump	As the waste disposal method will be a dry method, there will be no need to collect supernatant water, however, the seepage from the dump is collected in an external perimeter trench towards. The contaminated storm water runoff from this area will be collected at the toe trenches. It will be contained through a perimeter berm and allowed to evaporate, the sizing of the perimeter berm is discussed in Section 5.6 Clean water from clean upstream catchments will be diverted around the sides of the WD to stop it becoming contaminated with the same perimeter berm.
Pits	Clean stormwater will be prevented from ingress into the pit area through upstream diversion berms, this will be in addition to the perimeter berms that are normally part of pit designs. The upstream catchments to be diverted are quite small and hence nominal 1m berms will be adequate to divert clean water with an outside earth channel towards the river. Storm Water captured in the pits should be pumped to the PCD to allow for safe mining when the in-pit dust suppression measures have been met.

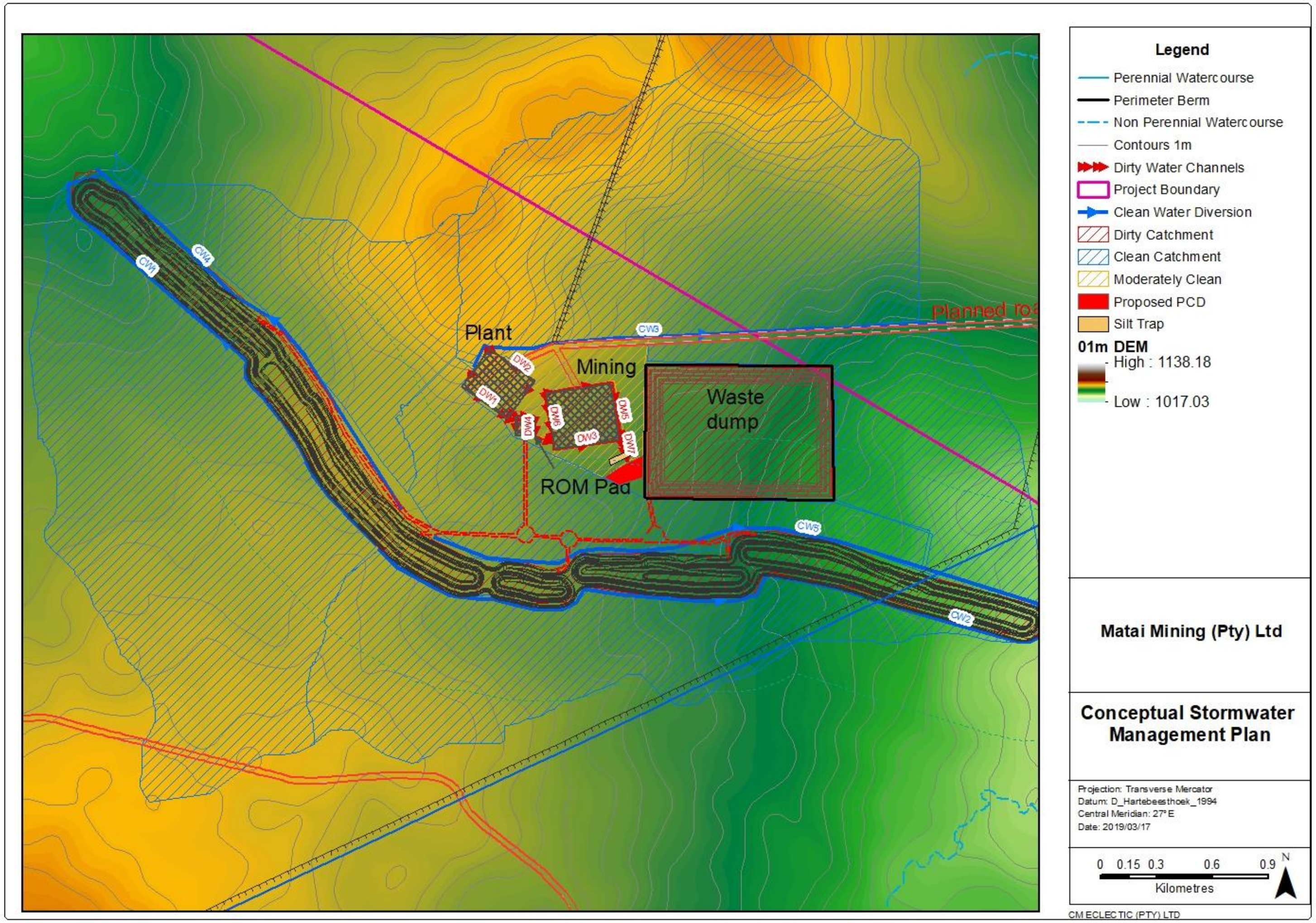

Figure 5-1: Conceptual Stormwater Management Plan

In order to meet the design principles detailed above, conceptual design details for the proposed stormwater management measures are presented below, along with the specific hydraulic design standards, methodologies, assumptions and input parameters for each measure proposed.
It should be noted that the design and sizing of the PCD and channels do not form part of this conceptual SWMP. This sections below describe the standards in place for the designs and the conceptual sizing of PCD and channels.

5.4 Drainage Channels and Berms

GN704 requires that the clean water systems are designed, constructed, maintained and operated so that they are not likely to spill into a clean water environment more than once in 50 years. Therefore, proposed clean water channels should be sized to accommodate the 1:50 year peak flows.
The clean and dirty stormwater catchments and route of drainage channels are presented in Figure 5-1. The estimated design flows and recommended channel sizes are presented below.

5.4.1 Design Methodology

A spreadsheet calculation using the Rational Method (as presented in the SANRAL Drainage Manual) was used to estimate design flows for the proposed channels.

The Rational Method equation is:

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

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 coefficients for each catchment were estimated using Tables 3.7 and 3.8 of the SANRAL Drainage Manual and the time of concentration was estimated for both overland flow and channel flow using equations 3.11 and 3.13 of the SANRAL Drainage Manual.

The worst case rainfall event for each catchment (i.e. duration = time of concentration) was taken from the Storm DDF estimates presented in Table 2-7.

Following estimation of the design flows for each diversion channel, the channels have been sized using the Manning's Equation to ensure that the flow capacity of the channel is sufficient to convey the 1:50 year flow.

The Mannings equation is:

$$Q = A\frac{1}{n}R^{2/3}S^{1/2}$$

Where:

A = Area of Channel

R = Hydraulic Radius (area / wetted perimeter);
S = Longitudinal Slope of Channel; and
n = Mannings Roughness Coefficient

5.4.2 Peak Flow Estimates

The rainfall intensities and peak flow estimates for each of the stormwater diversion channels are presented in Table 5-3.

Table 5-3: Design Flow Estimates

Catchment	Area (km^2)	Runoff Coefficient	Time of Concentration (hours)	Rainfall Intensity (mm/hr)	Flow (m^3/s)
Dirty Catchments					
Mining	0.105	0.524	0.356	138.56	2.12
RoM	0.010	0.405	0.174	192.43	0.22
Plant	0.075	0.520	0.279	157.13	1.70
Waste Dump	0.700	0.432	0.751	79.56	6.68
Moderately Clean	0.272	0.257	0.945	68.81	1.34
Clean Catchments					
CW1	3.266	0.256	2.147	40.39	9.37
CW2	1.864	0.256	2.375	38.44	5.09
CW3	3.097	0.256	1.855	44.17	9.72
CW4	1.216	0.256	1.935	42.77	3.69
CW5	2.388	0.256	2.181	40.10	6.80

5.4.3 Recommended Channel Sizing

In order to accommodate the design flows, the recommended channel sizes are presented in Table 5-4 and Figure 5-2 presents a typical cross-section through the channel.
The following assumptions were made during the design of the flow diversion channels:

- The channels are sized to take the maximum flow calculated for the downstream end of the contributing catchment and the channel sizing will be uniform along their entire length.
- The longitudinal gradients are based on 1m contours generated from Remote Sensing Satellite Image Data and provided by Geoscientific Mineral Resources (Pty) Limited.
- Some cut and fill maybe required along the length of the channels to achieve the required gradient to ensure that water flows freely within the channels.
- Open channels are preferred for ease of maintenance and can easily be constructed to accommodate design capacity, whilst maintaining suitable drainage gradients
- Clean water will be kept out of the dirty water channels by constructing a linear bund with the material excavated from the channel (as shown on Figure 5-2).

- The dirty water channels should be lined with a low permeability liner to prevent dirty water from infiltrating through the base of the channels which otherwise might impact upon the quality of the underlying groundwater.

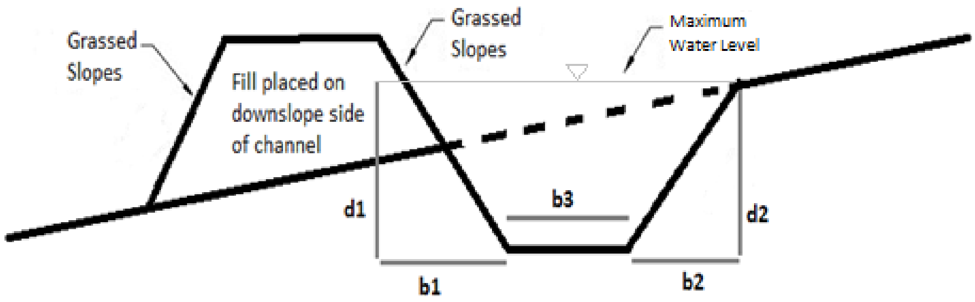

Figure 5-2: Stormwater Diversion Channel Sizing

Table 5-4: Stormwater Diversion Channel Sizing

Catchment	Catchment Flow	Drainage Channel	**Design Flow		Channel Dimensions					S	n	A	P	R	V	*Design Flow (Q)
					b1	d1	b2	d2	b3							
	m^3/s		%	m^3/s	m	m	m	m	m	m/m		m^2	m	m	m/s	m^3/s
Plant	1.70	DW1	50%	0.85	0.4	0.4	0.4	0.4	1.0	0.010	0.025	0.6	2.1	0.3	1.6	0.91
	1.70	DW2	50%	0.85	0.4	0.4	0.4	0.4	1.0	0.010	0.025	0.6	2.1	0.3	1.6	0.91
100% plant+ 50% ROM+ 50% Moderately Clean+ 50% Mining	3.54	DW3	100%	3.54	1.2	0.8	1.2	0.8	1.5	0.005	0.025	2.2	4.4	0.5	1.8	3.80
ROM	0.22	DW4	50%	0.11	0.3	0.3	0.3	0.3	1.0	0.005	0.025	0.4	1.8	0.2	1.0	0.39
50%Mining+ 50% Moderately Clean	1.73	DW5	100%	1.73	1.1	0.7	1.1	0.7	1.0	0.005	0.025	1.4	3.5	0.4	1.5	2.22
Mining	2.12	DW6	25%	0.53	0.6	0.4	0.6	0.4	1.0	0.005	0.025	0.6	2.4	0.3	1.2	0.74
All (Mining RoM, Plant and Moderately Clean	5.38	DW7	100%	5.38	1.8	1.2	1.8	1.2	1.0	0.005	0.025	3.4	5.3	0.6	2.1	6.98
Clean Catchments	9.37	CW1	100%	9.37	2.4	1.2	2.4	1.2	1.3	0.005	0.025	4.4	6.6	0.7	2.1	9.40
	5.09	CW2	100%	5.09	1.5	1.0	1.5	1.0	1.2	0.005	0.025	2.7	4.8	0.6	1.9	5.19
	9.72	CW3	100%	9.72	2.1	1.4	2.1	1.4	1.0	0.005	0.025	4.3	6.0	0.7	2.3	9.83
	3.69	CW4	100%	3.69	1.5	1.0	1.5	1.0	1.0	0.005	0.025	2.5	4.6	0.5	1.9	4.70
	6.80	CW5	100%	6.80	2.6	1.3	2.0	1.0	1.0	0.005	0.025	3.8	6.1	0.6	2.1	7.93

**The flow which the recommended channel sizing can accommodate, and this should be greater than or equal to the calculated design flows based on catchment characteristics*

*** Calculated design flows*

5.5 Pollution Control Dam (PCD)

A single PCD is proposed in a PCD location is proposed at the downstream most (southern corner of the mining department) as presented on Figure 5-1.

5.5.1 Hydraulic Design Standards

- GN704 requires that dirty water containment facilities are designed, constructed, maintained and operated so that they are not likely to spill into a clean water environment more than once in 50 years. GN704 also requires that as a minimum, the 1:50 year design volume and a 0.8 m freeboard allowance should always be available.
- The PCD is sized to accommodate runoff generated from a 1:50 year design rainfall (24 hour) event and the highest monthly rainfall (January) less the corresponding monthly evaporation (January) taking place over the surface area of the dam.

5.5.2 Design Methodology

The catchments are presented on Figure 5-1, the average monthly rainfall depths are presented in Table 2-3, and the design rainfall depths are presented in Table 2-7. Runoff coefficients for the different catchment areas were estimated using Tables 3.7 and 3.8 of the SANRAL Drainage Manual. Different runoff coefficients were used to estimate runoff generated during different intensity storm events, or during a typical wet month.

The design parameters used for conceptual sizing the silt trap and PCD are presented in Table 5-5 below.

Table 5-5: PCD - Design Input Parameters

Catchment	Area (km2)		1:50 year 24 hour Event		Average Wet Month		
	Total	Hardstanding	Runoff Coef.	Rainfall (mm)	*Runoff Coef.	Rainfall (mm)	Evaporation (mm)
Mining	0.105	0.032	0.52	150.2	0.21	103.6	170.5
RoM	0.010		0.40	150.2	0.16	103.6	170.5
Plant	0.075	0.023	0.52	150.2	0.21	103.6	170.5

*Assuming that the influence of initial saturation is higher and adjustment factor for C1 is 0.4

5.5.3 Recommendations

The recommended capacity requirements for the PCD is presented in Table 5-6. The PCD should be run close to empty to allow for it to hold runoff from the dirty areas in the event of a 1:50 year storm event.

Table 5-6: Silt Trap and PCD Capacity

Facility	1:50yr Storm Runoff (m^3)	Wet Month Runoff (m^3)	Wet Month Evaporation (m^3)	Design Capacity (m^3)	PCD Footprint (m^2)
PCD	16018	7932	1449	22500	8500

The PCD will be lined to prevent seepage of dirty water, which otherwise might pollute local surface and ground water resources. The PCD will have an engineered spillway to convey design exceedance events through the PCD to the environment without causing erosion of the dam walls, which may compromise the structural integrity of the PCD.

5.6 Sizing of Waste Dump (WD) Stormwater Retention Berm

Runoff from the WD will collect at the toe of the WD, and unless managed could in an extreme rainfall event migrate off site and reach a surface water receptor. This is considered likely due to the topography, it is recommended that stormwater retention berms are constructed around the perimeter of the WD to collect dirty stormwater from the WRDs and satisfy the requirements of GN 704.

Based on the Concept study (Ukwazi Mining Studies (Pty) Ltd, 2018), the WD was designed with a lift height of 10m, a 35-degree face angle and a step-back of 10m between benches.

Runoff from the upper slopes of the WD will collect on the benches and infiltrate through into the permeable WD. Runoff from the lowest portion of the side slope will be collected by the perimeter stormwater retention berm (Figure 5-3) which will be created parallel to the toe of the WD.
Indicative sizing of the stormwater retention berms is as follows:

- Maximum width of WD side slope (between benches) = 20m.
- Offset of perimeter stormwater retention berm from toe of WRD = 10m.
- 1:50 year 24 hour rainfall depth = 150mm.
- Runoff coefficient = 0.52.
- Runoff volume form longest side (1km) = 1652 m^3
- Maximum water depth = 0.16m
- Recommended nominal Berm height = 0.5 m

Considering the high evaporation and a conservative estimate of infiltration, it is anticipated that the water contained behind the retention berms will evaporate rather in a short space of time and within a few days considering:

- The lowest basic infiltration rate for clay soils (FAO,1988) of 1 mm/hr (24mm/day).
- Mean annual evaporation (1533.8 mm) gives a daily evaporation of 4.2 mm/d.
- Max water depth in TSF paddocks = 160mm.

- Time to empty (160mm / 28mm/d) = 6 days.

Given the arid climate and the fact that the WDs rarely generate much runoff, the stormwater berms are not considered to be dams in the context of GN704, and as such, the application of 0.8m freeboard is not considered appropriate. The benches should either be sloped inwards towards the toe of previous section of the WRD above the bench or small berms constructed on the edges to contain stormwater from each side slope for evaporation or seepage.

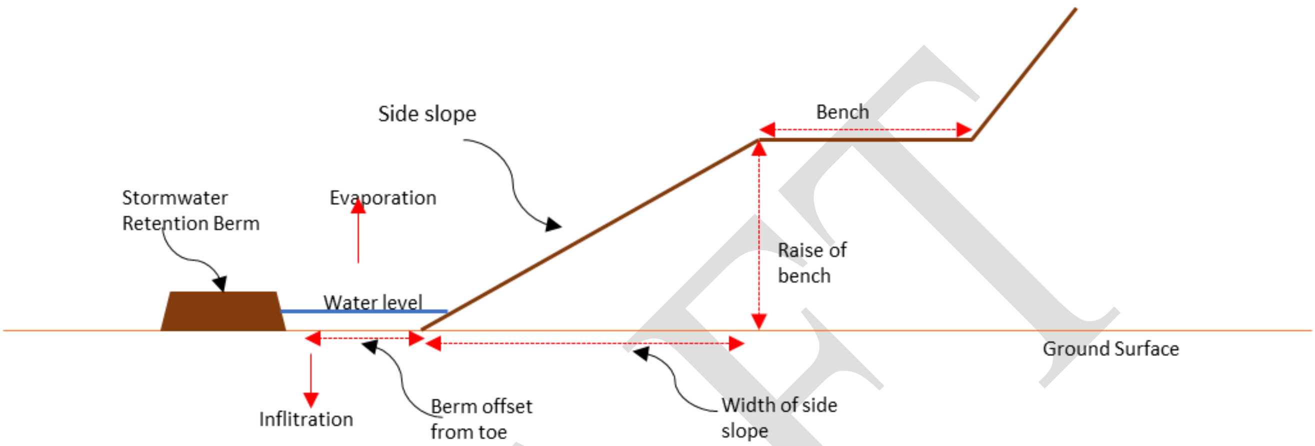

Figure 5-3: Illustration Stormwater Management Measures Conceptual Design Recommendations

5.7 Impacts on Mean Annual Runoff

The mean annual runoff (MAR) of the quaternary catchments is described in Section 2.1.2. it is proposed that stormwater from an area of approximately 1.76km^2 is contained in dirty water areas for reuse by the operation. The impact of the diversion of the MAR for the affected quaternary catchments was estimated and presented in Table 5-7

Table 5-7: Impacts on Mean Annual Runoff

Catchment Name	Area (km^2)	TOTAL MAR (mcm)	m^3/km	Contained Area (km^2)	MAR Reduction (mcm)	MAR Reduction (%)
A24E	688	19.72	28662.79	1.29	0.0369	0.19%
A24D	1328	10.39	7823.80	0.47	0.0036	0.04%

The data presented in suggests that the proposed SWMP measures have a negligible impact upon the MAR of the quaternary catchment.

5.8 Limitations and Further Work

This study is based on a single event 1:50 year 24 hour rainfall event, which is adequate for conceptual sizing and placement of stormwater management measures. It is recommended that the capacity of the PCD is reviewed during detailed design of the stormwater measures by a daily timestep water balance model to ensure compliance with GN 704 and BPG A4 (DWAF, 2007), considering the predicted inflows to and outflows from each containment facilities taken from the site wide water balance. A critical component in sizing of PCDs in accordance with GN 704 is the rate at which water will be pumped from the PCD for re-use at the plan and this will be checked using a daily timestep water balance model.

It is recommended that the hydraulic gradients and channel sizes are checked during the detailed design of channels. The requirement for, and specification for lining of the channels and dams should also be confirmed during detailed design of these features.

The clean water diversions are to be sized to cater for the 1:50 year flood event with dimensions finalised during the detailed design phase of the project.

6 Flood lines

6.1 Flood Hydrology

6.1.1 Introduction

Three sub-catchments of the Lesobeng and Sefahlane River catchment systems were delineated to cover the watercourses within the project site boundary and were utilised to determine the flood peaks for the 1: 50 and 1: 100 year extreme events for the purposes of defining the flood risks.

The following catchments were delineated based on 5m contours sourced for the national database and the 1m elevation contour lines data provided by Kimopax (obtained from Remote Sensing Satellite Image Data and provided by Geoscientific Mineral Resources (Pty) Limited) as shown in Figure 6-1.

6.1.2 Methodology

Flood peaks for the three sub-catchments selected for flood modelling were estimated by the Standard Design Flood (SDF) considering the catchment areas are relatively large for the other methods such as the Rational methods (limited to 15km^2); The SDF method was used as detailed in the SANRAL, 2013 using the Utility Programs for Drainage (UPD) software, 2007

The Standard Design Flood (SDF) method was developed specifically to address the uncertainty in flood prediction under South African conditions (Alexander, 2002). The runoff coefficient (C) is replaced by a calibrated value based on the subdivision of the country into 26 regions or Water Management Areas (WMAs). The design methodology looks at the probability of a peak flood event occurring at any one of a series of similarly sized catchments in a wider region, while other methods focus on point probabilities (SANRAL, 2013).

The SDF method requires catchment area and slope in addition to the specification of the site as lying within SDF Basin number 1.

6.1.3 Model Inputs

Catchment characteristics (Table 6-1) were evaluated and used to estimate the flood peaks for the following catchments:

Table 6-1: Catchment Characteristics

Parameter	Lesobeng	Sefahlane	Sefahlane (Lower)= Total Catchment
Catchment area - km2	110	210	344.5
Mean annual precipitation - mm	579.8	579.8	579.8
Length of longest stream - km	23	30.65	33.65
Height difference along 10-85 slope -m	178	160	173
Average slope along the 10-85 - m/m	0.008	0.005	0.005
Distance to catchment centroid - km	10	13	14.5
Veld type	8	8	8
Kovacs K-Region	4.8	4.8	4.8
Height difference along equal area slope (m)	572	235	241
SDF Basin	1	1	1

6.1.4 Peak Flow Estimates

The resulting peak flows from the three catchments are presented in Table 6-2.

Table 6-2: modelling results and Peak Flow estimates (1:50 and 1:100 years) (m^3/s)

Catchment Name	Lesobeng		Sefahlane		Sefahlane (lower)- Total catchment	
Average slope	0.010		0.007		0.007	
Time of concentration (h)	4.32		6.26		6.77	
Runoff Coefficient (C)	0.28		0.43		0.36	
Catchment area - km^2	110		210		344.5	
Return period and peaks m^3/s	1:50	1:100	1:50	1:100	1:50	1:100
Standard Design Method (SDF)	276.72	350.44	276.72	350.44	570.56	722.56

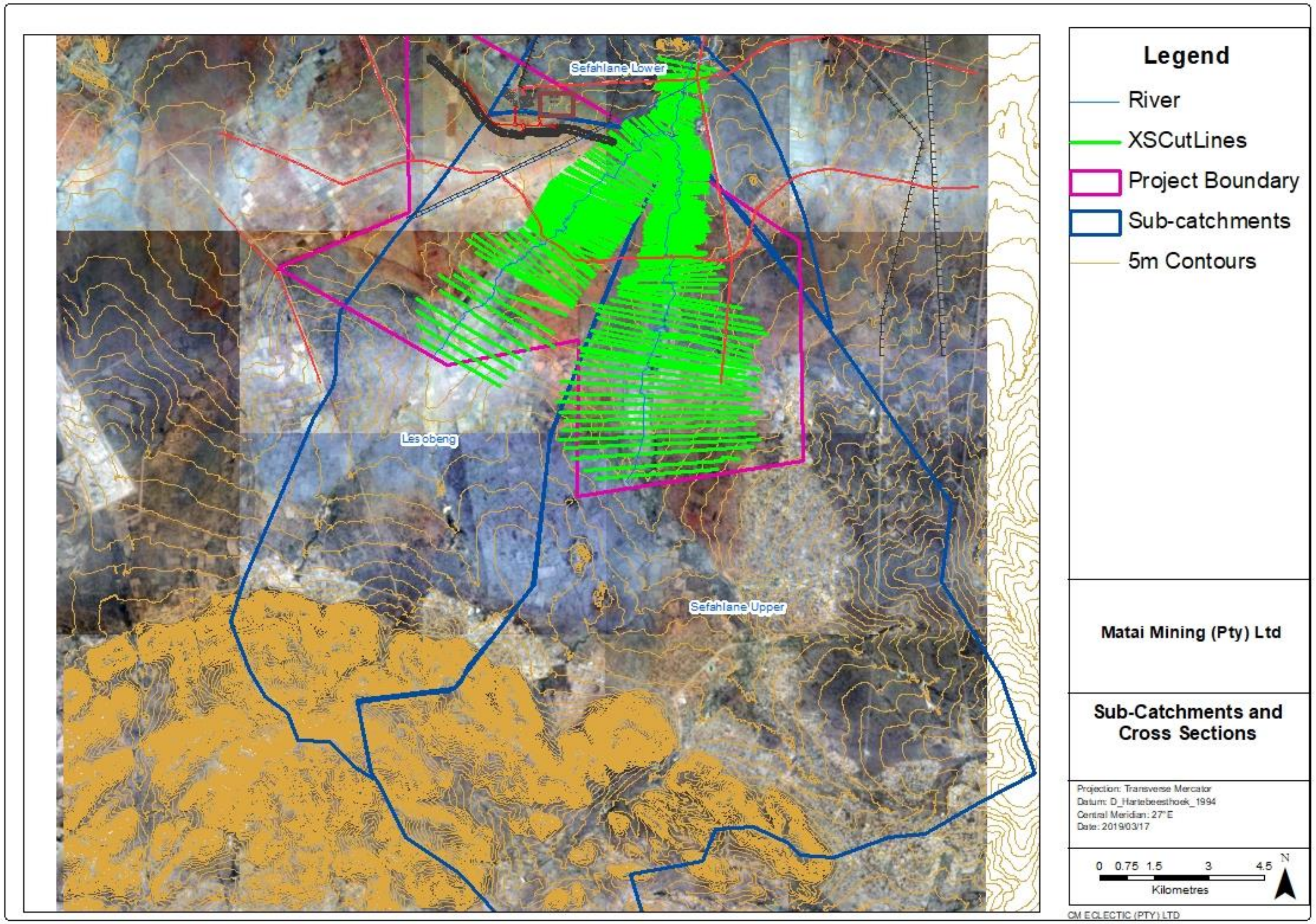

Figure 6-1: Sub-Catchments and Cross Sections

6.2 Flood Hydraulics

GN704 regulation 4 (presented in Section 1.3) stipulates restrictions on mine related infrastructure or operations relative to the 1:100 year flood-line and the 1:50 year flood-line or a horizontal distance of 100 metres from any watercourse. The following section details the approach and the methods used in the development of a hydraulic model for the purposes of defining the 1:50 year and 1:100 year flood extents for a section of the Lesobeng and Sefahlane River.

6.2.1 Choice of Software

HEC-RAS 5.0 was used for the purpose of modelling the flood elevation profile for the 1: 50 and 1: 100 year flood event. HEC-RAS is a hydraulic programme designed 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.

In this study the pre-processing and GIS operations were undertaken in HEC-GeoRAS, an extension of HEC-RAS in the ArcGIS environment and ArcMap 10.2 respectively. HEC-GeoRAS was used to extract the cross-sections and river profiles from a Digital Elevation Model (DEM) for export into HEC-RAS for modelling. It is further used in post processing to import HEC-RAS results back into ArcMap, to perform flood inundation mapping.

6.2.2 Topographic Profile Data

The 1m contours generated from Remote Sensing Satellite Image Data and provided by Geoscientific Mineral Resources (Pty) Limited (7 March 2019) were used to create a digital elevation model (DEM). The methods of obtaining this data, pre-processing as well as accuracy of elevation data was not assessed, and it was assumed to be adequate for the flood lines modelling. Although the small roads through the project site are not evident on the elevation, the river profiles are more pronounced than it would be on 5m contours for national database. This was considered adequate and fit for purpose for the environmental purposes for which the floodlines are required.

The DEM model forms the foundation for the HEC-RAS model and was used to extract elevation data for the river profile together with the river cross-sections. The DEM was also used to determine placement positions for the cross-sections along the river profile, such that the watercourse can be accurately modelled.

Figure 6-1 presents the cross-section locations and the 3 catchments considered for the flood modelling.

6.2.3 Roughness Coefficients

Manning's roughness factor (n) is used to describe the channel and adjacent floodplains resistance to flow. Based on observations of the channel and floodplain characteristics from aerial topography and the elevation data, a Manning's n coefficient of 0.05 was assigned to both the channel and floodplain areas.

6.2.4 Inflows and boundary conditions

The estimated peak flows used in the hydraulic model are described in Section 6.1.4. A summary of the modelling flow input data is presented in Table 6-3.

Table 6-3: HECRAS Model flow parameters

River-Reach	**Peak Flows (m3/s)**	
	1: 50yr	**1:100yr**
Lesobeng Upper	276.72	350.44
Sefahlane Upper	381.6	483.25
Sefahlane Lower (overall catchment)	570.56	722.56

6.2.5 Model Development Methodology

Development of the hydraulic model included the following steps:

- Creation of a DEM from the contour data;
- Digitising the stream centre lines and flow paths using HEC-GeoRAS;
- Generating cross-sections approximately regular intervals apart through the watercourses using HEC-GeoRAS;
- Importing geometric data into HEC-RAS and inspection thereof;
- Entering the Manning's values, peak flows, and upstream and downstream slope boundary conditions in HEC-RAS;
- Performing steady, mixed-flow regime hydraulic modelling within HEC-RAS to generate flood levels at modelled cross-sections followed by inspection of inundations; and
- Importing flood levels and projecting levels onto the DEM using HEC-GeoRAS to determine the flood inundation areas.

6.2.6 Key Assumptions in the Hydraulic Model

In-line with the development of the flood-lines the following assumptions were made:

- The topographic data provided was of a sufficient accuracy and coverage to enable hydraulic modelling at a suitable level of detail;
- There would be no significant attenuation or storage of floodwater within the farm dams in the vicinity of the project;
- Hydraulic structures such as culverts on the small roads passing through the site were not modelled as part of this study;
- The Manning's 'n' values used is considered suitable for use in the both the 1:50 year and 1:100 year events modelled, as well as in representing both the channel and floodplain;
- No abstractions from the river section or discharges into the river section were considered during the modelling;
- Steady state hydraulic modelling was undertaken, which assumes the flow is continuous at the peak rate; and
- A mixed flow regime which is tailored to both subcritical and supercritical flows was selected for running of the steady state model.

6.2.7 Results

The Figure 6-2 presents the 1:50 and 1:100 year floodlines and the 100m buffer for the Lesobeng and the Sefahlane rivers. The results are suitable for planning of mining infrastructure and flood protection design and the greater of the two should be considered according to GN704.

The mine surface infrastructure is located outside the floodlines, however the proposed mine road crosses the flood-lines. The modelling shows that 1: 100 year and1:50 year flood-lines exceed 100 m horizontal distance from the watercourse in all locations. This can be attributed to the flat retain where the flood plain is wide.

Where the road crosses the floodlines and watercourse, these can be designed such that they do not impact upon conveyance within the floodplain. This can be achieved by ensuring that, the water surface elevations at the cross sections nearby the highest being 1029.8 m amsl (cross sections 1358.518, 1315.725 and 1256.561) in the vicinity are considered.

6.2.8 Limitations and further work

Steady state flood modelling was undertaken which is a conservative approach as it ignores the effect of storage within the system and therefore produces higher flood levels than would be expected to occur. In addition to pure conveyance, in-channel and floodplain flood storage exhibit a large influence in flood levels and floodplain extents within the low gradient watercourses such as the study catchment. As such, the steady state modelling will result in worst case (conservative) estimates of flooding, and resultant flood levels and floodplain extents would decrease if unsteady state modelling were undertaken using an inflow hydrograph as opposed to continuous peak flow.

The flood risk to the surface infrastructure has been adequately assessed on the Les obeng and Sefahlane, therefore; given that the infrastructure complex is shown to be located outside of the conservative estimate of flood-lines and the 100 m buffer, no further flood modelling work is considered necessary.

It is recommended that detailed design of the road and any other future structures located within the flood-lines are designed to withstand the flow velocities

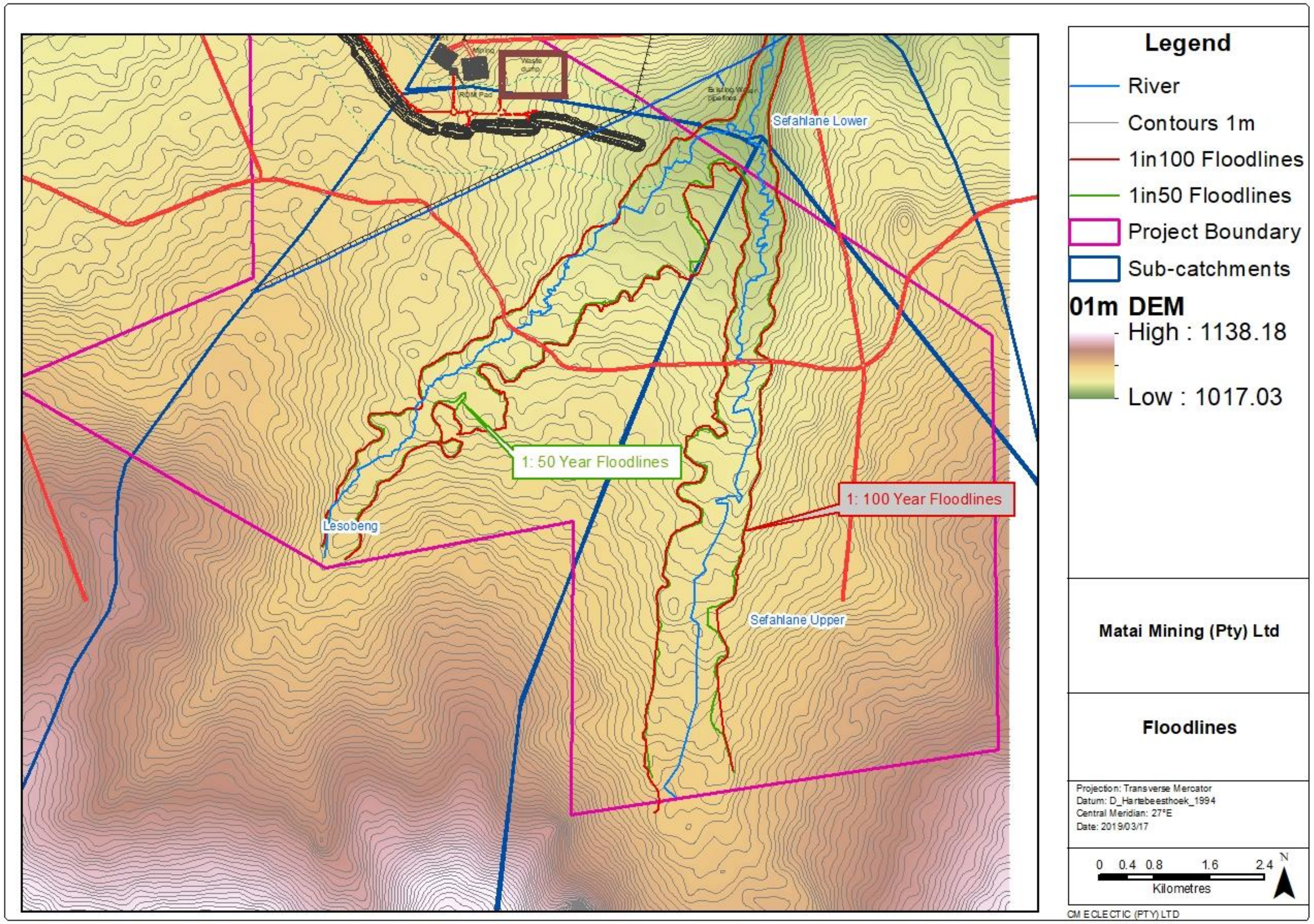

Figure 6-2: Floodlines Delineations

7 Surface Water Impact Assessments

7.1 Introduction

Informed by the baseline hydrology, flood modelling extents and design specifications for the storm water management measures and water balance model results, the potential impacts of the proposed activities which may impact the surface water receptors as well as sensitivity of the surface water resources are discussed in this section.

7.2 Receptors Sensitivity

This study determined surface water receptors as the rivers Lesobeng and Sefathlane which are considered as sensitive areas. The surface water quality form these rivers is relatively pristine, with only iron, aluminium and turbidity exceeding the SANS 241:2015 drinking water standards and not the South African Water Quality Guidelines -(SAWQG), 1996- Target Water Quality for Agriculture: Livestock Watering. This makes them sensitive and the pristine nature should be preserved so that the livestock can continue drinking from it.
Furthermore, the 1:50, 1:100 year flood-lines and the 100m horizontal buffer were delineated for the Lesobeng and Sefahlane Rivers and this is considered as a very sensitive area and no infrastructure with potential to impact water resources should be placed within these flood-lines.

7.3 Impacts description

Identification of impacts of the anticipated major activities on the surface water resources have been identified for the three main stages of the project namely the construction, operation and closure phases as presented in Table 7-1.

Table 7-1: Summary of Identified Potential Impacts

Project Activities	Interaction	Impact description
Construction		
Initial earthworks associated with site clearing, stripping and stockpiling of soil resources, preparations and construction of new surface infrastructure.	Water quality	Deterioration of water quality as a result of the following • Clearing the surface and site preparations, for the mine infrastructure will result in exposure of soil surfaces to erosion factors. When a large area of vegetation is cleared and topsoil disturbed, exposing a large area of loose material, susceptible to erosion. During rainfall events, runoff from the exposed site will transport the eroded soil material in to the nearby watercourses. • Uncontrolled spills of contaminants such as fuel and oils, and subsequent washing away of these into the surface water resources.
	Water quantity	• A reduction of runoff water quantity to the surface water resources system. When the initial storm water management measures are constructed on site, the

		catchment area for runoff is reduced for catchments A24E and A24D by 0.19% and 0.04% respectively (as stated in Table 5-7). • The water balance is water negative for all (wet, dry and average) climatic conditions, therefore make up water is required (Section4). This could alter downstream flow regime resulting in reduced flows and water availability to communities and impact on biodiversity values.
Operation		
Open pit mining, stockpiling, processing and operation of surface infrastructure (diversion channels, pollution control dams, stockpiles, workshops & offices, crushing and screening plant, waste dump)	Water quality	Deterioration of water quality as a result of the following: • Contaminated stormwater runoff from operational areas containing potential pollutants such as oils, solvents, paints, fuels and waste materials and discharge of dirty water into the catchment when extreme events do occur. • Some of the structures may overtop such as the PCD.
	Water quantity	• Informed by the water balance, there may be need for makeup water, however these will not impact surface water resources as they are non-perennial, and this water is source from other sources such as Magalies water line or boreholes not investigated in this report
Closure		
Cessation of the mining and the removal and demolition of surface infrastructure and rehabilitation	Water quality	• Decant from the pits (backfilled or not) resulting in water quality deterioration. • Removal and handling of hazardous waste offsite and waste storage facilities, damage to waste handling facilities resulting water quality deterioration
Removal of surface infrastructure and rehabilitation	Water quantity	• With adequate rehabilitation and closure some of the catchment is returned to a self-sustaining system and therefore the contributing runoff catchment. Return of natural drainage patterns as a result of freely draining topography

7.4 Impact Rating

The proposed mining project design includes various mitigation by design measures presented in the stormwater management plan, water balance and flood lines. If these design standards were not considered, the potential impacts on the environment would be much higher, although the mine would almost certainly not be allowed to proceed without compliance with current best practice and relevant industry guidelines.

The potential unmitigated impacts (unrealistic worst-case scenario), and residual impacts of the project after considering the design mitigation measures proposed within this report are qualitatively assessed in this section and presented in Table 7-2 proceeding the impact assessment methodology outlined in Appendix A

Table 7-2: Summary of Impact Assessment

Impact	Pre-mitigation:						Recommended mitigation	Post-mitigation:					
	Duration	Extent	Intensity	Consequence	Probability	Significance		Duration	Extent	Intensity	Consequence	Probability	Significance
Construction													
Sedimentation of watercourses due to exposing and loosening of soil as a result of vegetation clearing for the construction of infrastructure and pollution of watercourses due to hydrocarbon and chemical spillages	The impact will last for the construction phase Short term (<5yrs)	The impacts will be localised to the Sub-catchments of the Lesobeng and Sefahlane rivers Local	The catchment will be moderately altered, and receptors may adapt Moderate - negative	Low	Without appropriate mitigation, this may occur Highly Likely	Moderate	- Use wet suppression, chemical stabilization and wind speed reduction methods that should be used to control open dust sources at the construction sites - Vegetation should only be removed where absolutely necessary; - Hydrocarbons should be stored on hardpark bunded facilities to ensure that all spillages are contained; and - Clean and dirty surface water trenches/channels should be constructed to divert runoff separately to appropriate storage facilities	With mitigation the impacts will only occur in very extreme events Transient (Very short duration)	The impacts will be confined to the site should they occur Site-specific	The infrastructure areas cover only 0.19% and 0.04% of quaternary catchments A24E and A24D respectively Low - negative	Very Low	Impact may occur Likely	Low - negative

CM Eclectic

Impact	Pre-mitigation:						Recommended mitigation	Post-mitigation:					
	Duration	Extent	Intensity	Consequence	Probability	Significance		Duration	Extent	Intensity	Consequence	Probability	Significance
Altered drainage paths and loss of catchment yield due to the removal of vegetation and construction of diversion berms.	The impact will last for the construction phase Short term (<5yrs)	The infrastructure areas cover only 0.19% and 0.04% of quaternary catchments A24E and A24D respectively Site Specific	The infrastructure areas cover only 0.19% and 0.04% of quaternary catchments A24E and A24D respectively Low - negative	Very Low	Loss of some catchment runoff water will occur Almost Certain/ Don't know	Minor - negative	Reuse dirty water as much as possible onsite instead of obtaining water from the catchment, or to treat dirty water to acceptable standards and then to discharge to the catchment.	The impact will last for the construction phase Short term (<5yrs)	The infrastructure areas cover only 0.19% and 0.04% of quaternary catchments A24E and A24D respectively Site Specific	Water will be reused and a small part of catchments will be contained Low - negative	Very Low	The impact will occur as long as the mine exists Almost Certain/ Don't know	Minor - negative
Operational Phase													
Pollution of surrounding watercourses as a result of activities during the operational phase (spills, overflows and contaminated runoff)	Impacts could be long term for the lifetime of the project. Long term (>10yrs)	Impacts could stretch far downstream into the quaternary catchment rivers and beyond. Regional/District	Without mitigation, the project could have a severe impact on the quality of surface water resources during mining and post closure. High - negative	High	Without mitigation there could be a high probability of impacting the quality of surface water resources. Highly Likely	Minor - negative	This will prevent contamination of surrounding water resources due to storm water runoff; -Waste storage facilities should be on a hard parked, roofed and bunded facility. -Storm water management measures such as diversion berms, trenches and PCDs should be monitored and maintained fairly regularly. - prevent and contain hydrocarbon spillages that may wash off into nearby watercourses.	Impacts could be long term for the lifetime of the project Long term (>10yrs)	Any impacts would be localised within the holding facilities. Local	Considering the mitigation measures discussed within this report, the mine will have a low severity of the impact the quality of surface water resources. Low - negative	Low	Probability of impacts are unlikely as mitigation measures covers for extreme events. Unlikely	Negligible - negative

Impact	Pre-mitigation:						Recommended mitigation	Post-mitigation:					
	Duration	Extent	Intensity	Consequence	Probability	Significance		Duration	Extent	Intensity	Consequence	Probability	Significance
Reduced water quantity reporting to catchment from SWMP implementation capturing dirty water	Impacts could be long term for the lifetime of the project. Long term (>10yrs)	The infrastructure areas cover only 0.19% and 0.04% of quaternary catchments A24E and A24D respectively Site Specific	The infrastructure areas cover only 0.19% and 0.04% of quaternary catchments A24E and A24D respectively Negligible	Very Low	Mining project infrastructure will need to be placed on the surface Almost Certain/ Don't know	Minor - negative	There are no mitigation measures for a loss of contained water to the catchment yield as long as the mine is there however, -Reuse dirty water as much as possible onsite instead of obtaining water from the catchment, or to treat dirty water to acceptable standards and then to discharge to the catchment. -Sustainable mine water management needs to be implemented	Impacts could be long term for the lifetime of the project. Long term (>10yrs)	The loss of contained water to the catchment will, however, be minimal, but may affect downstream water users Site Specific	Impacts are localised to only 0.19% and 0.04% of quaternary catchments A24E and A24D respectively Negligible	Very Low	Mining project infrastructure will need to be placed on the surface Highly Likely	Negligible - negative
Decommissioning and closure													
Pollution of surrounding watercourses as a result of activities during the decommissioning phase	Impacts could be long term for the lifetime of the project and a few more years of residual impacts Long term (>10yrs)	Impacts could stretch far downstream into the quaternary catchment rivers and beyond. Regional/District	Without mitigation, the project could have a severe impact on the quality of surface water resources during mining and post closure High - negative	High	Without mitigation there could be a high probability of impacting the quality of surface water resources. Highly Likely	Minor - negative	The perimeter storm water management measures should remain in place and should only be removed once rehabilitation of other activities has been completed. This will capture most of the sediment produced from rehabilitation activities and any spills from removal of hydrocarbon and chemical storage; -Credible contractors should be used for the cessation of the	Impacts could be long term for the lifetime of the project and a few more years of residual impacts Long term (>10yrs)	Impacts will be high locally, diminishing further downstream. Local	Considering the mitigation measures discussed within this report, the mine will have a low severity of the impact the quality of surface water resources. Negligible	Low	Impact may still occur in extreme event and potential residual impacts Likely	Negligible - negative

Impact	Pre-mitigation:						Recommended mitigation	Post-mitigation:					
	Duration	Extent	Intensity	Consequence	Probability	Significance		Duration	Extent	Intensity	Consequence	Probability	Significance
							mining and decommissioning of all infrastructure.						
Rehabilitation of the site post mining will result in a positive impact on surface water quantity when completed.	The restoration of the catchment could last beyond the project closure Permanent	The impacted area is small hence the impact will also be local with potential far reaching impacts Site Specific	The loss of contained water to the catchment will, however, be minimal, but may affect downstream water users Low - positive	Very Low Benefit	With good rehabilitation plans, this may happen Highly Likely	Low - positive	Rehabilitation will result in a positive improvement as surface water drainage patterns will be restored to a state similar to pre-mining which is likely to result in an improvement in catchment yield after land profiling and cover having been restored	The restoration of the catchment could last beyond the project closure Permanent	The impacted area is small hence the impact will also be local with potential far reaching impacts Local	The loss of contained water to the catchment will, however, be minimal, but may affect downstream water users Low - positive	Low Benefit	With good rehabilitation plans, catchment runoff may be restored improving over time Highly Likely	Moderate - positive

7.5 Mitigation Measures

Mitigation by design measures have been discussed in detail in Section 4, 5 and 6. A summary of these measures and additional mitigation measures recommended to further reduce any residual impacts on both surface water drainage quality and quantity is presented below.

Mitigation by design measures:

Flood-Lines: mapping of the flood-lines has demonstrated that the surface infrastructure complex is outside of the flood-lines, whilst the modelled flood-lines. The flood level determined can be used to inform the detailed design of the haul road which crosses the Sefahlane thereby reducing the probability of impacts from the project infrastructure on the baseline flow and quality of the local watercourses during flood events.

Storm Water Management: the project infrastructure was reviewed, and clean and dirty water catchments identified. Measures are proposed to collect and/or treat storm water from dirty areas, thereby reducing the probability of impacts from the project infrastructure on the baseline water quality of the local watercourses.

Water balance: the project's water circuit has been defined and collection and water management strategy defined where the reuse of dirty water will be prioritized, thereby ideally reducing the impacts from the project on the surface water resources through planning for discharge of excess mine water and storing for use in low water supply periods.

In addition to the measures presented and discussed throughout this report, the following management measures should be implemented:

- Infrastructure design: the design of all roads, plant areas, stockpiles, waste dumps, tailings facilities etc. should consider storm water management and erosion control during both the construction and operational phases;
- Good housekeeping practices should be maintained by clean-up of spillages and materials build-ups, as well as ensuring all dislodged material like stockpile and tailings material is kept within the confined storage footprints. In addition, clean-up material and materials safety data sheets for chemical and hazardous substances should be kept on site for immediate clean-up of accidental spillages of pollutants;
- Water management facilities inspection and maintenance should be undertaken throughout the life of mine, to include inspection of drainage structures and liners for any in channel erosion or cracks; de-silting of sumps and PCDs; and any pumps and pipelines should be maintained according to manufacturer's specifications;
- Vehicles or plant equipment servicing should be undertaken within suitably equipped facilities, either within workshops, or within bunded areas, from which any storm water is conveyed to a pollution control dam, preferably after passing through and oil and silt interceptor;

- Pollutant Storage – any substances which may potentially pollute surface water should be stored within a suitably sized bunded area and where practicable covered by a roof to prevent contact with rainfall and/or runoff; and
- Water Conservation and Water Demand Management (WC/WDM) measures to ensure that as much as is possible, water should be collected and reused, minimising the release of any treated storm flows whilst also reducing the abstraction of water from external and potentially clean water sources.

All measures implemented for the mitigation of impacts, should be regularly reviewed as best practice and as compliance with various licences issued on site by authorities including Water Use Licences (WULs).

7.6 Monitoring Program

A monitoring programme is essential as a tool to identify any risks of potential impacts as they arise and to assist in impact management plans by assessing if mitigation measures are operating effectively. Monitoring should be implemented throughout the life of the mine.

7.6.1 Monitoring

Recommendations on surface water monitoring are presented in Table 7-3.

Table 7-3 : Surface Water Monitoring Programme

Monitoring Element	Description	Frequency
Water quality	Ensure that monitoring is implemented to cover all mining activity areas. Sites should be located up and downstream of the site. Analytical suites for water quality analysis recommended are shown in Table 7-4.	Monthly Monitoring needs to carry on after the project has ceased and the results reach a steady state to detect residual impacts.
Flow Volumes	Flow monitoring should be carried out in channels and pipelines and at abstraction and discharge facilities on site	On a monthly basis to update and calibrate the water balance for the mine
Water Levels	Monitoring water levels in dams and channels	Monthly through the dry season and weekly through the wet season or after storm events
Pollutants	Site walkovers to determine the condition of facilities and identify any leaks or overflows, blockages, overflows and system malfunctions for immediate remedial action	Weekly

Monitoring Element	Description	Frequency
Water management structures	Inspection of channels, silt traps, culverts, pipeline, dam walls and dams for signs of erosion, cracking, silting and blockages of inflows, to ensure the performance of the SWMP remains acceptable.	Monthly during wet season and after storm events Monthly in dry season
Meteorological data	Measure rainfall for water balance updates where possible	Daily

The recommended analytical suite for water quality analysis is presented in Table 7-4. Where applicable, the analysis results compared to relevant water quality standards.

Table 7-4: Recommended Water Quality Analytical suite

pH Value @ 20°C	Bicarbonate, HCO_3
Sodium, Na	Sodium Absorption Ratio (SAR)
Conductivity mS/m @ 25°C	Chloride, Cl
Potassium, K	Aluminium, Al
Total Dissolved Solids	Sulphate, SO_4
Free and Saline Ammonia as NH_4	Manganese, Mn
Calcium, Ca	Nitrate, NO_3
Magnesium Hardness as $CaCO_3$	Iron, Fe
Calcium Hardness as $CaCO_3$	Fluoride, F
Total Hardness as $CaCO_3$	Chromium, Cr
Langelier Saturation Index (pH-pHs)	Total Suspended Solids
Total Alkalinity as $CaCO_3$	Phosphorus, P
Dissolved Metals using Inductive Coupled Plasma Scan	

7.6.2 Reporting

Reporting on the above monitoring should be as follows:

- Internal Reporting – Monthly: reporting for flow volumes ,water levels, drainage inspections and pollutant inspections
- External Reporting – Annual: reporting for abstraction volumes, discharge volumes, water quality, spillages / Emissions

Accidental spillages and overflows should be reported as when they occur to the relevant authorities.

7.6.3 Review and Update of Management Plan

It is recommended that operational phase of the SWMP, according to the BPG: G1 should be audited and revised at regular intervals and modifications implemented as conditions and circumstances change, this is normally undertaken on a yearly basis.

Other management measures can be reviewed at least every 3 years as well as following any incidents on site, changes in operations, or if any discharge or emission exceeds relevant standards regularly for the water quality plans.

8 Conclusions and Recommendations

8.1 Conclusions

Baseline

This surface water study was undertaken by a suitably qualified and experienced Hydrologist registered with the South Africa Council for Natural Scientific Professions (SACNASP) as a Professional Natural Scientist (Pr.Sci.Nat.) in the field of Water Resources Science.

Considering the Water Resources of South Africa Manual WR2012 (WRC, 2012), the project area falls within the Limpopo Water management area (WMA) 1. Most of the project site falls within quaternary catchment A24E, lesser extent of the project site is located within the quaternary catchment A24D. The tributaries of the Brakspruit within the catchment A24E which drain through the MRA area east of the infrastructure footprint are the Sefahlane and the Lesobeng which flow north from the Pilanesberg to a confluence, approximately 0.5 km south of the project area. On the west of the site within quaternary catchment A24D, is the Bofue river draining northwards. The mean annual precipitation determined for the site from the WRC2012 database is 579.8 mm which is within close ranges to the 592 and 600 mm for the A24E and A24D respectively.

Kimopax's Hydrogeologist conducted a site visit on the 13th of December 2018 as part of the Hydrocensus study and collected water quality samples from the water resources within the project area. Out of the five selected water quality sample sites, only one was sampled as most of them were dry at time for site visit. The water quality results were benchmarked against the SANS 241 (2015), Drinking Water – Edition 2 and the Department of Water Affairs and Forestry, 1996. South African Water Quality Guidelines (second edition), Volume 5: Agricultural Water Use: Livestock watering. From the water quality results, exceedances of the SANS 241 drinking water standards were determined, and these were for the parameters aluminium, iron and turbidity. High turbidity can be attributed to the rains that were reportedly received on the day of the sampling as the water was observed to be very muddy, this was also expected. The elevated iron and aluminium can be attributed to the general geology, however there were no other samples taken to validate this.

Water Balance

A site wide water balance has been prepared to understand the flows within the mine's operation water circuit for the wet and dry season as well as annual averages. The water balance is water negative for all 3 scenarios and required make up water. The external / make up water demand of the processing plant is as follows:

- wet season 12 411 m3/month
- dry season 28 479 m3/month
- average 20 551 m3/month

Stormwater Management Plan (SWMP)

The SWMP was undertaken to provide conceptual inputs into the design requirements and placement of storm water management structures and recommendations based on the infrastructure plan. The following measures were recommended:

- Clean stormwater will be diverted around dirty catchments and allowed to flow towards the watercourses on either side of the site depending on the topography. This will be accomplished through the construction of upstream clean water diversion berms/channels to prevent clean water from entering the dirty areas and ensure that it drains away from the site through the channels upstream of dirty areas;
- Moderately clean areas that otherwise cannot easily be conveyed to the clean water system between the planned road and the infrastructure will be collected with the dirty water system for reuse;
- A series of dirty water berm and channel systems will be required to capture and convey runoff emanating from the dirty water areas (plant, mining area and ROM). The dirty water trenches will convey the runoff to the PCD via a silt trap;
- Open channels are preferred for ease of maintenance and can easily be constructed to accommodate design capacity, whilst maintaining suitable drainage gradients;
- Stormwater collecting in the PCD will be pumped to the Process Water Dam (PWD) during and after rainfall events to supply the plant's water requirements; and
- Considering the general topography, a PCD location is proposed at the downstream most (southern corner of the mining department
- The PCD is sized to accommodate runoff generated from a 1:50 year design rainfall (24 hour) event and the highest monthly rainfall (January) less the corresponding monthly evaporation (January) taking place over the surface area of the dam of 22500 m3 excluding the 0.8 m freeboard allowance

Floodlines

GN704 regulation 4 stipulates restrictions on mine related infrastructure or operations relative to the 1:100 year flood-line and the 1:50 year flood-line or a horizontal distance of 100 metres from any watercourse. the floodlines were therefore determined and it was determined that the mine surface infrastructure is located outside the flood-lines, however the proposed mine road crosses the flood-lines. The modelling shows that 1: 100 year and1:50 year flood-lines exceed 100 m horizontal distance from the watercourse in all locations. This can be attributed to the flat retain where the flood plain is wide. Where the road crosses the flood-lines and watercourse, these can be designed such that they do not impact upon conveyance within the floodplain. This can be achieved by ensuring that, the water surface elevations at the cross sections nearby the highest being 1029.8 m amsl (cross sections 1358.518, 1315.725 and 1256.561) in the vicinity are considered. Considering the flood lines, it has been concluded that the flood risk to the surface infrastructure has been adequately assessed on the Lesobeng and Sefahlane, therefore; given that the infrastructure complex is shown to be located outside of the conservative estimate of flood-lines and the 100 m buffer, no further flood modelling work is considered necessary.

Impact Assessments

Informed by the baseline hydrology, flood modelling extents and design specifications for the storm water management measures and water balance model results, potential impacts and mitigation measures have been identified and presented in the report. Water quality deterioration from site clearing during construction, potential uncontrolled spills of contaminants such as fuel and oils, and subsequent washing away of these into the surface water resources. Contaminated stormwater runoff from operational areas containing potential pollutants such as oils, solvents, paints, fuels and waste materials and discharge of dirty water into the catchment when extreme events do occur.

In terms of water quantity, potential reduction of runoff water quantity to the surface water resources system was identified. This, however, will be less significant given the spatial scale, as storm water management measures will contain, catchment area for runoff for the catchments A24E and A24D by 0.19% and 0.04% respectively. Furthermore, the water balance is water negative for all (wet, dry and average) climatic conditions, therefore make up water is required. However, these will not impact surface water resources as they are no potential for abstraction because the water resources in the project site are non-perennial, and this water is source from other sources such as Magalies water line or boreholes (not investigated in this report).

The implementation of mitigation measures is essential for the continuation of the mining project to manage potential impacts.

8.2 Recommendations

Several limitations were identified and from these recommendations have been presented.

- Continue baseline monitoring to create a more extensive baseline before mining can commence;
- An update of the ware balance when more information and monitoring data becomes available;
- It is recommended that the capacity of the PCD is reviewed during detailed design of the stormwater measures by a daily timestep water balance model to ensure compliance with

GN 704 and BPG A4 (DWAF, 2007), considering the predicted inflows to and outflows from each containment facilities taken from the site wide water balance; and

- It is recommended that the hydraulic gradients and channel sizes are checked during the detailed design of channels. The requirement for, and specification for lining of the channels and dams should also be confirmed during detailed design of these features.

C Makamure (*Pr Sci Nat*)

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Appendix A: Impact Assessment Methodology

Introduction

The Impact Assessment process is not to provide an incontrovertible rating of the significance of various aspects, but rather to provide a structured, traceable and defendable methodology of rating the relative significance of impacts in a specific context. This gives the project proponent a greater understanding of the impacts of his project and the issues which need to be addressed by mitigation and give the regulators information on which to base their decisions.

Based on international guidelines and South African legislation, the following criteria are taken into account when examining potentially significant impacts:

- Nature of impacts (direct/indirect, positive/ negative);
- Duration (short/medium/long-term, permanent(irreversible) / temporary (reversible), frequent/seldom);
- Extent (geographical area, size of affected population/habitat/species);
- Intensity (minimal, severe, replaceable/irreplaceable);
- Probability (high/medium/low probability); and
- Possibility to mitigate, avoid or offset significant adverse impacts.

Impact Types and Definitions

An impact is any change to a resource or receptor brought about by the presence of a project component or by the execution of a project related activity. The evaluation of baseline data provides crucial information for the process of evaluating and describing how the project could affect the biophysical and socio-economic environment positive and negative impacts are defined below.

- Positive - An impact that is considered to represent an improvement on the baseline or introduces a positive change.
- Negative- An impact that is considered to represent an adverse change from the baseline or introduces a new undesirable factor.

The impact assessment consists of:

- **Impact definition:** The definition statement (description) should include the activity (source of impact), predicted change, receptor as well as whether the impact is direct, indirect or cumulative.
- **Impact evaluation:** Impacts are evaluated according to the methodology provided, often using judgement and values as much as science-based criteria and standards.

The impact assessment methodology requires that each potential impact identified is clearly described including the following:

- Extent (spatial scale) - will the impact affect the national, regional or local environment or only that of the site?
- Duration (temporal scale) - how long will the impact last?
- Magnitude (severity) - will the impact be of high, moderate or low severity?
- Probability (likelihood of occurrence) - how likely is it that the impact may occur?

To determine the environmental significance (importance) of each identified potential impact, a numerical value has been assigned to each of the above criteria (Table 1). The following formula is used to calculate the environmental consequence of each impact:

Consequence = Duration + Extent + Magnitude

Table 1: Consequence Criteria

	Description	Criteria	Score
Duration	Permanent / Unknown	Impact or change will remain permanently.	5
	Long-term	Impact remains for longer than 10 years; Impact will still occur in the closure phase but will not remain permanently.	4
	Medium-term	Impact duration is 5-10 years.	3
	Short-term	Impact duration is < 5 years.	2
	Transient	Very short duration.	1
Extent	National / Unknown	Affects the resources of the country; impact experienced nation-wide.	4
	Regional/District	Affects the resources of the region or district.	3
	Local	Affects the area surrounding the Project and nearby villages.	2
	Site-specific	Localised; confined within the mining licence area.	1
Magnitude	Very High / Unknown	Extreme effect – where natural, cultural or social functions or processes cease in full. Receptors have high sensitivity and very little resilience to impact.	10
	High	Severe effect – where natural, cultural or social functions are fundamentally altered and do not function in full. Minor adaptation by receptors may be possible but there is high sensitivity to the impact.	8
	Moderate	Moderate effect – where natural, cultural or social functions continue, albeit in a noticeably modified way. Some degree of adaptation by receptors is possible.	6
	Low	Minimal effect – affects the environment in such a way that natural, cultural or social functions and processes can readily adapt to the impact.	4
	Negligible	Minimal or negligible effect. Receptors have low sensitivity to the impact.	2

The consequence of an environmental is rated based on the calculated value as per Table 2 below:

Table 2: Consequence Scale

Level	Environmental	Community & Government	Rating
Very High	Severe long term environmental impact which extends to regional or national level. Extensive clean-up required after incidents. Rehabilitation efforts proven to be unsuccessful. Severe breach of Government regulations or non-compliance with likely suspension of operations	Extreme impact on community. High number of concern, complaints or interest from local community. Major increase in the risk of health effects resulting in increased incidence of multiple disabling illnesses among employees and community.	17 - 19
High	Major environmental impact. Impact may extend beyond the lease boundary. Significant clean-up effort required using site and external resources. Ongoing or recurring breach of regulations and standards. Rehabilitation difficult or unlikely to be successful.	Major impact on community. Increasing rate of complaints, repeated complaints from the same area (clustering). Significant increase in the risk of health effects resulting in increase in incidence of disabling illnesses among employees and community.	14 - 16
Moderate	Moderate environmental impact confined within the lease boundary. Medium term (typically within a month) clean-up. Multiple repeat exceedances of regulatory requirement. Rehabilitation and closure of moderate difficulty.	Moderate impact on community. Regular rate of concerns or complaints, repeated complaints from the same area (clustering). Increase in the risk of health effects resulting from acute, short term exposure or progressive chronic condition, infectious disease.	11 - 13
Low	Low environmental impact contained within area impacted by operations. Short term (typically within a week) clean-up. Single repeat exceedance of regulatory requirement related to low impact activity. Single exceedance of regulatory requirement for high impact activity.	Low impact on community. Small numbers of sporadic complaints. Small increase in the risk of health effects resulting in increase in incidence of health effect resulting from acute, short term exposure or progressive chronic condition, infectious disease.	8 - 10
Very Low	No or very low environmental impact confined to a small area within the area impacted by operations. Clean-up undertaken within a few hours. Single exceedance of regulatory requirement (e.g. licence, permit or consent condition; legislation or regulation) related to low impact activity.	No or very low impact on community. Isolated complaints possible. No discernible increase in the likelihood of effects on community health.	4 - 7

Table 3: Likelihood / Probability of Impact Occurring

	Description	Criteria	Score
Probability	**Almost Certain / Don't Know**	The impact is expected to occur; Consequence is likely to be of a high frequency; >90% chance.	**5**
	Highly Likely	The impact will probably occur or has occurred elsewhere before; >50% chance of occurrence during the project.	**4**
	Likely	The impact will occur under certain circumstances; Approximately 30 - 50% chance of occurrence during the project.	**3**
	Unlikely	The impact could occur under certain circumstances that are not likely to occur; Consequence could occur within a one to five year timeframe; <30% chance of occurrence in this period.	**2**

	Rare	Consequence may occur in exceptional circumstances; Consequence has rarely occurred in the industry and is not expected in the life of the project; < 5% chance of occurrence.	**1**

The risk assessment matrix in Figure 1 is used to determine the overall significance of environmental and social impacts, based on the overall consequence and probability of each impact.

The assessment approach considers the impact prior to any potential management controls or mitigation measures, and then assesses the residual impact following the implementation of controls and mitigation strategies. The significance rating is based on the criteria provided in Table 2 and Table 3.

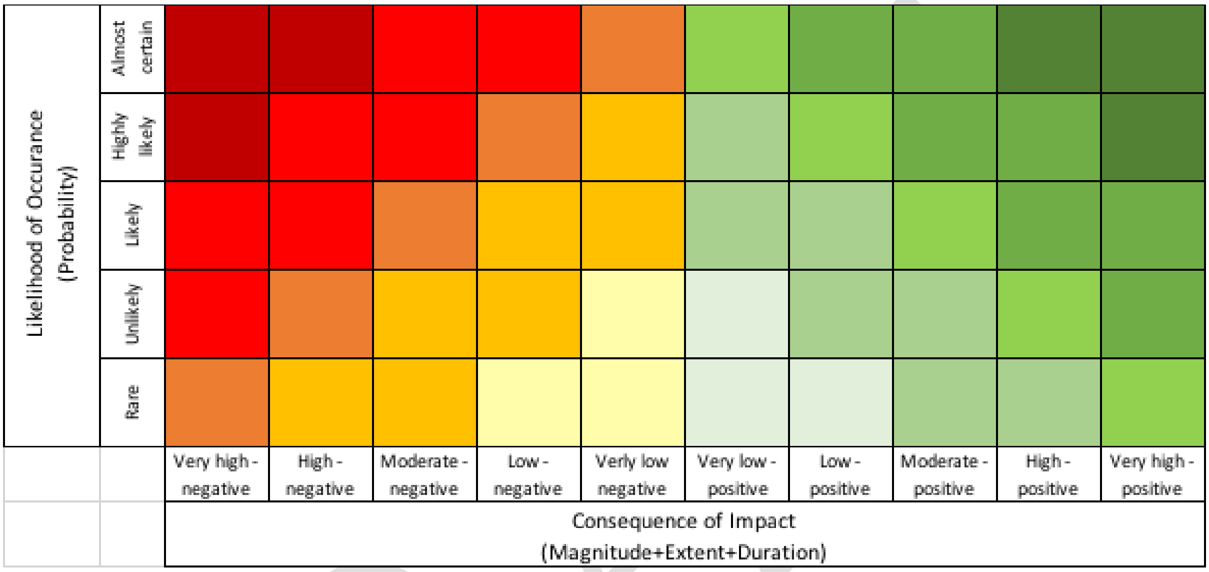

Figure 1: Significance Analysis from the Consequence vs Likelihood Assessment

Table 4: Interpretation of Significance Analysis

Significance of the Residual Impact	Implications for Project	
	Positive Impacts	Negative Impacts
Very low significance	Negligible effects	Negligible effects
Low significance	Some benefits	Acceptable effect
Moderate significance	Appreciable improvements to, or will sustain, existing resources	Effect is serious enough to cause concern. Changes to project design should be considered.
High significance	Very substantial improvement to existing resources	Unacceptable effect. The project should not proceed unless the design is changed so that the significance of this impact is reduced to acceptable levels.
Very high significance	Extremely beneficial and enduring effect.	An automatic fatal flaw. The project should not proceed unless the design is changed so that this impact is eliminated or its significance is reduced to acceptable levels.

Appendix B: Specialist Declaration of Independence