RIETVLEI COLLIERY

Surface Water Study

Final

07-2014

We put Science into Practice

Report prepared for

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Project Number		AEC0199
Report Number		AEC0199/04/07-2014

. Executive Summary

Aqua Earth Consulting (AEC) was appointed by WSP on behalf of Butsanani Joint Venture (Anglo Operations Limited), to carry a surface water study as part of an environmental impact assessment (EIA) for the proposed Greenfields Open Cast Coal Mining Operation at Rietvlei. The site is located northeast of Mhluzi (formerly Middelburg) in the Mpumalanga Province, and will be call “proposed Rietvlei Mine” in the report.

Aqua Earth has completed the surface water study and the following conclusions are reached:

- The site straddles mainly three surface three surfaces run off catchments.
- Available information for this project included a limited number of surface water samples and publicly available topography, regional flow and rainfall data;
- Local storm water runoff model has been set up for the site, from a regional rainfall-runoff model;
- 1:100, flood line has also been calculated for the main three surface water drainage line;
- The main catchment of impact is considered to be catchment B32B;
- The 1:100, flood line is likely going to intersect the pit on the southern side.
- Managing dirty and clean water will be important for each considered run off catchment and the water management plan has been developed taking this into consideration;
- Water storage facilities proposed in this document are based on calculated volumes, and no designs are included for the individual facilities;
- Water balance was developed with the available information (regional meteorological data, flow simulation from groundwater and surface water numerical model) for 20 years of operation;
- The water balance developed during this investigation is considered a preliminary water balance and should be refined once more specific site information (storage facilities) and water use (for operating and processing) monitoring data will be available;
- Focus areas for data collection have been identified and actions recommended;
- A water management and monitoring plan has been developed and it would be important to populate and update this on a regular basis.
- Generally, impacts on surface water are manageable and with a strict application of the proposed mitigation measures, impact significances would be reduced to between very low and medium low.

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1 Introduction

Originally appointed by Mindset Mining Consultants (Pty) on behalf of Butsanani Joint Venture (Anglo Operations Limited), to carry out a surface water impact assessment as part of an environmental impact assessment (EIA) for the proposed Greenfields Open Cast Coal Mining Operation at Rietvlei ; Aqua Earth Consulting (AEC) was then subsequently appointed by WSP to update the studie. The site is located northeast of Mhluzi (formerly Middelburg) in the Mpumalanga Province, and will be call “proposed Rietvlei Mine” in the report.

The present report follows the comment made by WSP on the original surface water study conducted by Aqua Earth.

1.1 Scope of the works

The present baseline assessment did not include any field investigation except the site visit. It aims to use the available environmental specialists’ studies on the proposed mining site at Rietvlei Colliery, together with publicly available information to develop a comprehensive environmental impact assessment (EIA) that would include:

- Summary on background information,
- A detailed description of the surface water features;
- Determination of storm water runoff from the proposed site;
- Determination of flood line;
- Projects Impacts and cumulative Impacts on surface water assessments;
- Proposition of surface water management infrastructures;
- Development of Initial Water Balance; and
- Development of Initial surface water management plan.

This report outlines the results of the environmental assessment of the various mining targets at Rietvlei colliery and provides recommendations for the protection of the surface water resources that may be impacted once the mining activities starts.

1.2 Specific tasks

Subsequent to the above objectives, the following tasks have been conducted in the baseline surface water assessment:

- Desktop studies including review of existing monitoring data, maps and reports;

- Surface water modelling including regional surface water model, local storm water runoff model, and flood peaks calculation;
- Impacts risk asessment;
- Compilation of the monitoring and management plan; and
- Final Reporting.

1.3 Sources of information

The following existing specialist studies on the project area were used to gain background information and an understanding of the present surface water baseline conditions:

- Faunal, Floral, Wetland and Aquatic Assessment as part of the EIA process for the the proposed Rietvlei colliery, Milddelburg. Sections (A,B,C,D,E) by Scientific Aquatic Services, 2011;
- Rietvlei colliery Geotechnical investigation, Leo Consulting 2012;
- Feasibility Report, Section 5 Mining on the Rietvlei colliery Asset; by Mindset Mining Consulting (PTY) LTD, April 2013;
- Soil, land capability and land use assessment of the proposed Rietvlei Opencast Mine footprint, situated on the remaining portion of the farm Rietvlei 397 JS, near Middelburg, Mpumalanga Province. By Rehab Green, November 2012.
- Groundwater Baseline Assessment: Rietvlei. (Aqua Earth C, July 2012);

In addition of these specialists' reports on specific to the proposed mining site, publically available information has been used and these include:

- "1/250 000 Geological Series: 2528 Pretoria published in 1978 by the Government Printer;
- An Exploration of the 1:500 000 general hydrogeology map by H.C. Barnard – October 2000;
- SA Explorer for climatic data;
- DWA rain gauging stations;
- Schulze, R.E. 2006. Soils: A grohydrological Information Needs Information Sources and Decision Support; In: Schulze, R.E. (Ed). 2006. South African Atlas of Climatology and Agrohydrology. Water Research Commission, Pretoria, RSA, WRC Report 1489/1/06, Section 4.1.;

- South African National Biodiversity Institute (SANBI), 2009. Updating National Land Cover.
- Water Resources of South Africa 2005 (WR2005) (WRC Report No.: K5/1491)
- Shuttle Radar Topography Mission (SRTM); 90

1.4 Legal aspects

Section 26 of the National Water Act, 1998 (Act 36 of 1998) regulates any activity that may have an impact on a water resource and the conservation and protection of this water resource. Legislative requirements relevant to surface water as administrated by the Department of Water Affairs (DWA) are:

- National Water Act, 1998 (Act 36 of 1998) (NWA, 1998).
- Government Notice (GN) 704, dated June 1999, in terms of the NWA (1998);
- General authorisations in terms of the NWA: GN 398 and 399, dated March 2004
- DWA Best Practice Guidelines, dated 2007;
- General authorisations in terms of the NWA GN 1199, dated December 2009, in terms of the NWA, 1998;
- Government Notice Regulation (GNR) 77, dated June 1999, in terms of the NWA.

The following overarching legislation was taken into account in the present surface water assessment:

- National Environmental Management Act, 1998 (Act 107 of 1998) (NEMA).
- NWA, 1998 (Act 36 of 1998) ;
- National Environmental Management: Waste Act, 2008 (Act 59 of 2008) (NEM: WA);
- Mineral and Petroleum Resources Development Act (No 28 of 2002) (MPRDA).

1.5 Details of specialists

The following surface water study has been conducted under by an experienced water specialists' team, and is managed by a fully qualified Professional Engineer that have been involved in leading several Water Research Commission (WRC) projects. The consultant details are giving as follow:

The following surface water study project has been conducted by experienced water specialists' team, and is managed by a fully qualified professional water scientist, who has been involved in leading relevant projects. The consultant details are giving as follow:

Table 1 : Specialist details

PROJECT TITLE: Surface water impact assessment-.			
Specialist:	AQUA EARTH CONSULTING		
Nature of specialist study compiled:	Surface Water Study		
Contact person:	AHOKPOSSI D P		
Postal address:	PO.BOX :1747 North Riding		
Postal code:	2162	**Cell:**	0735721424
Telephone:	0117913490	**Fax:**	0115076612
E-mail:	pacome@aquaearth.co.za		
Qualifications & relevant experience:	Bsc Civil Engineering - Msc Geohydrology (10 years)		
Professional affiliation(s) (if any)	SACNASP		

1.1 Declaration of Independence

Aqua Earth was appointed to conduct a specialist surface water study as part of EIA and act as the independent specialist in this application. Aqua Earth will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant. Aqua Earth has the expertise in conducting the specialist report relevant to this application and will not engage in conflicting interests in the undertaking of this study

Signed: ________________________________

Name:__________________________________

Position:_________________________________

2 General Physical description of the receiving environment

2.1 Location

The study area lies approximately 50km northeast of the town of Emalahleni and 22km northeast of Mhluzi (formerly Middelburg) in the Mpumalanga Province (

Figure 1). It is linked to Mhluzi by the R555 provincial roadway. The prospecting area lies within a farming area and is bordered by private properties on all sides.

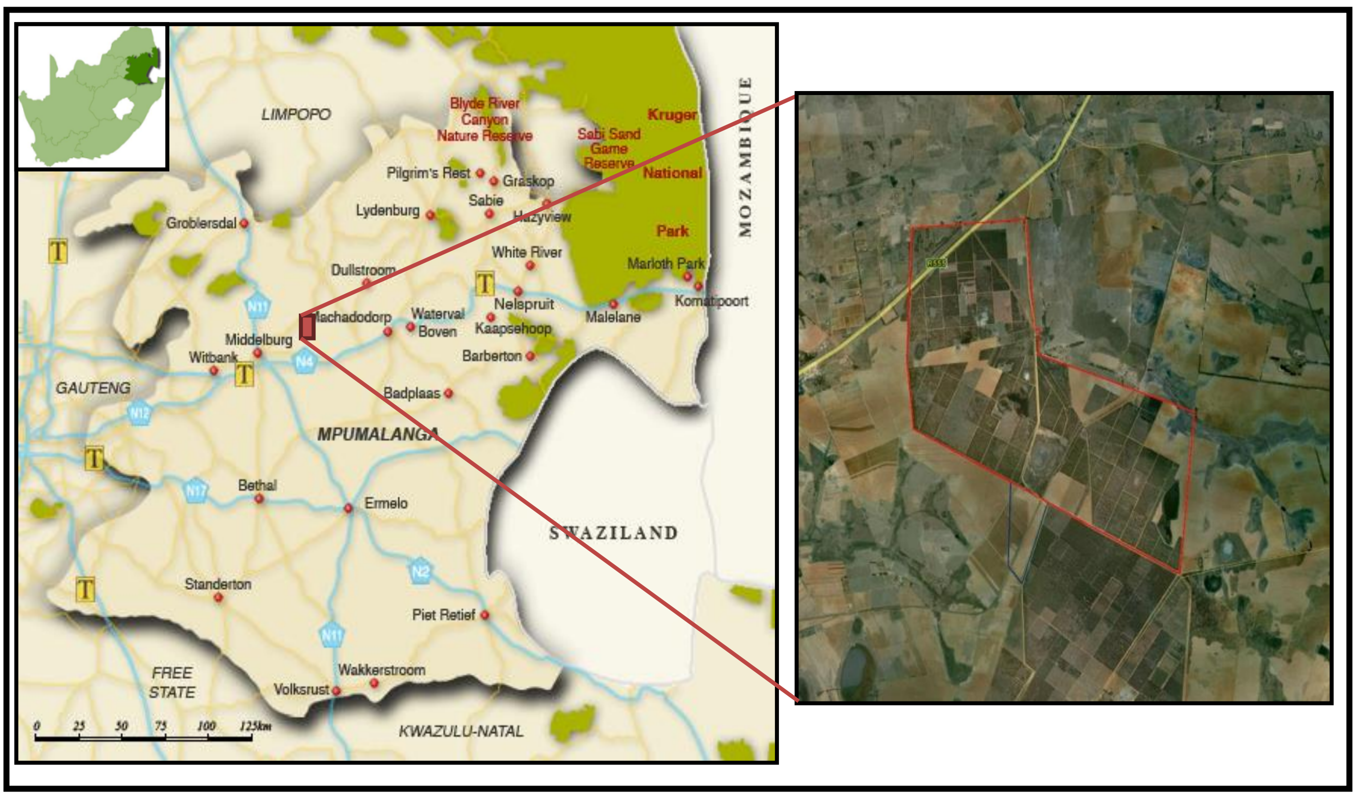


Figure 1: Locality of Rietvlei Colliery

2.2 Mining infrastructures

The positions of the surface infrastructure as reported in section 5 of the Rietvlei mining feasibility report are shown together with local runoff catchments and drainage in Figure 2. This map will be used in the establishment of surface water management plans related to each surface infrastructure.

The mining sequence (layout) and the associated mining schedule as designed by Mindset are presented respectively in and Figure 4.

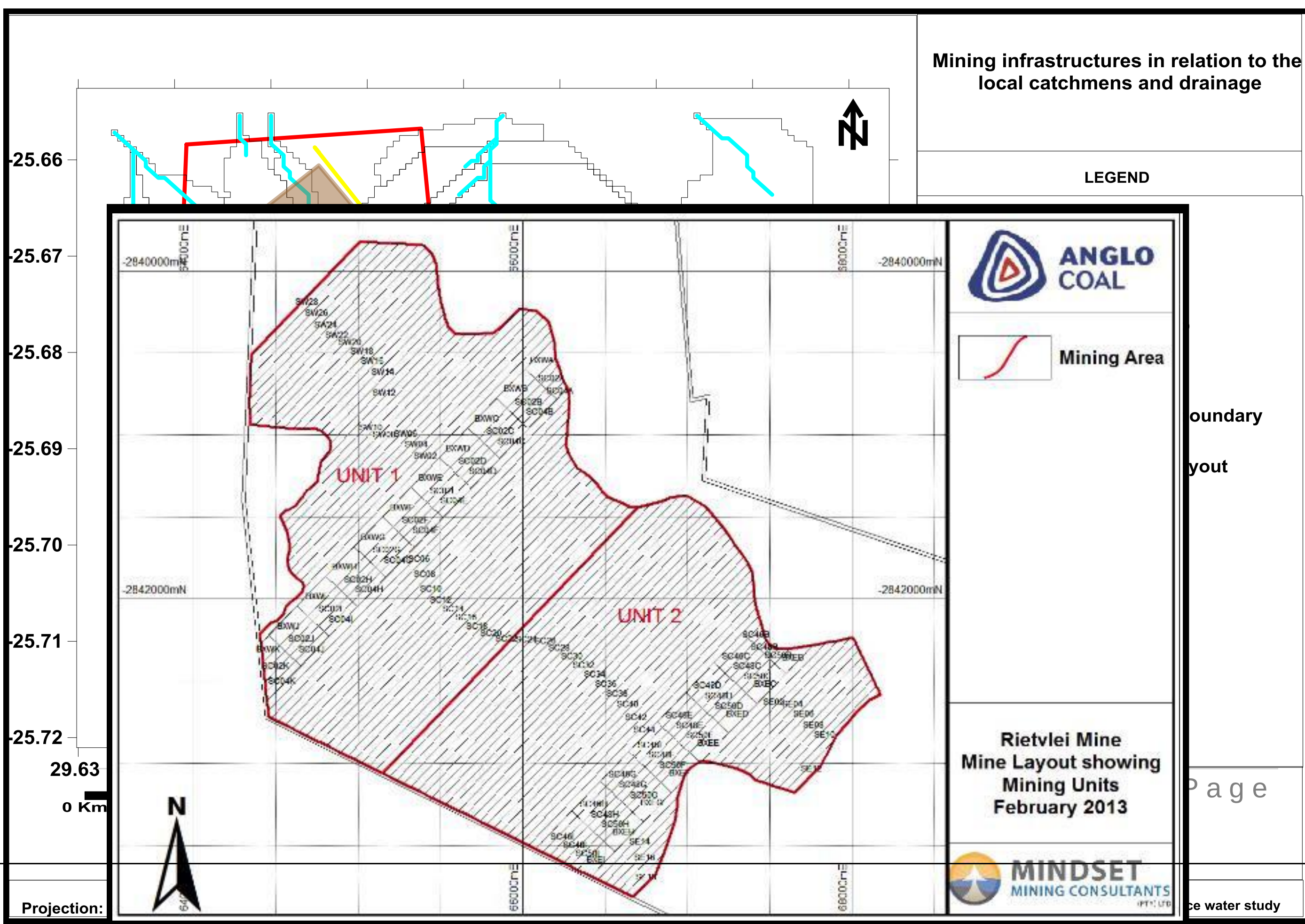
Figure 2: Surface infrastructure and local drainage

Figure 3 : Mining Layout (from section 5 of the Rietvlei mining feasibility)

Figure 4 : Mining schedule (from section 5 of the Rietvlei mining feasibility)

2.3 Climate

Based on data provided by SA explorer, the climate is typical of the Highveld, with warm summers and cold winters. The area experiences an average of 8.3 hours of sunshine a day. The mean annual temperature is approximately 23oC (Figure 6). The area falls into the summer



rainfall region with most rain occurring between October and March (Figure 7). The mean average annual rainfall for Optimum Mine (in close proximity of Rietvlei Colliery) is approximately 680 -700 mm. The mean monthly evaporation for a Class “A” pan is shown in Figure 5.

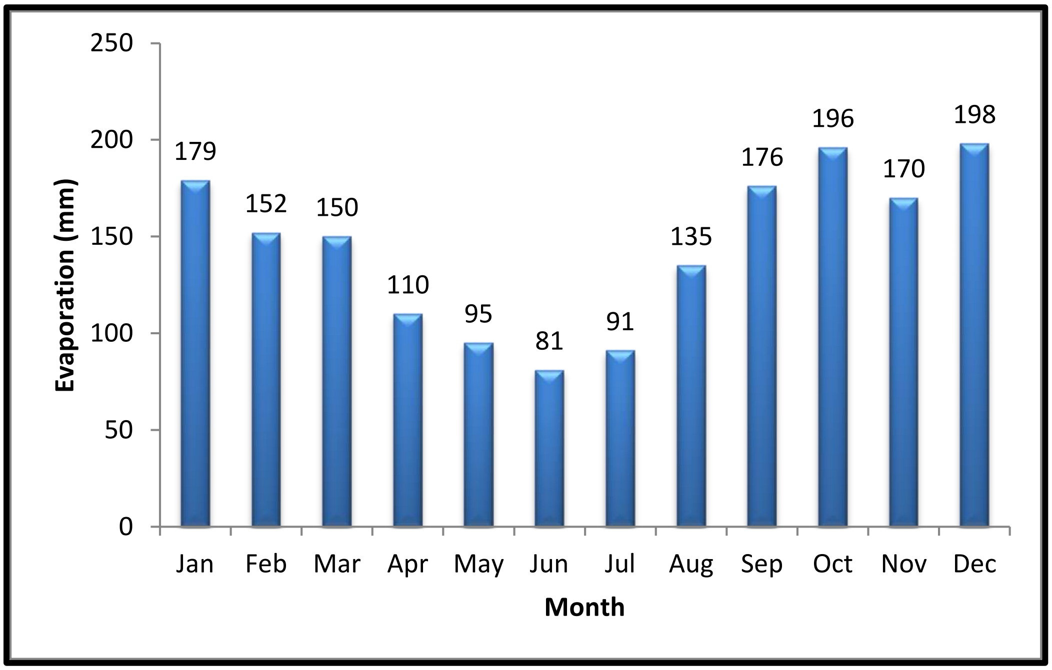


Figure 5: Average evaporation (SA Explorer)

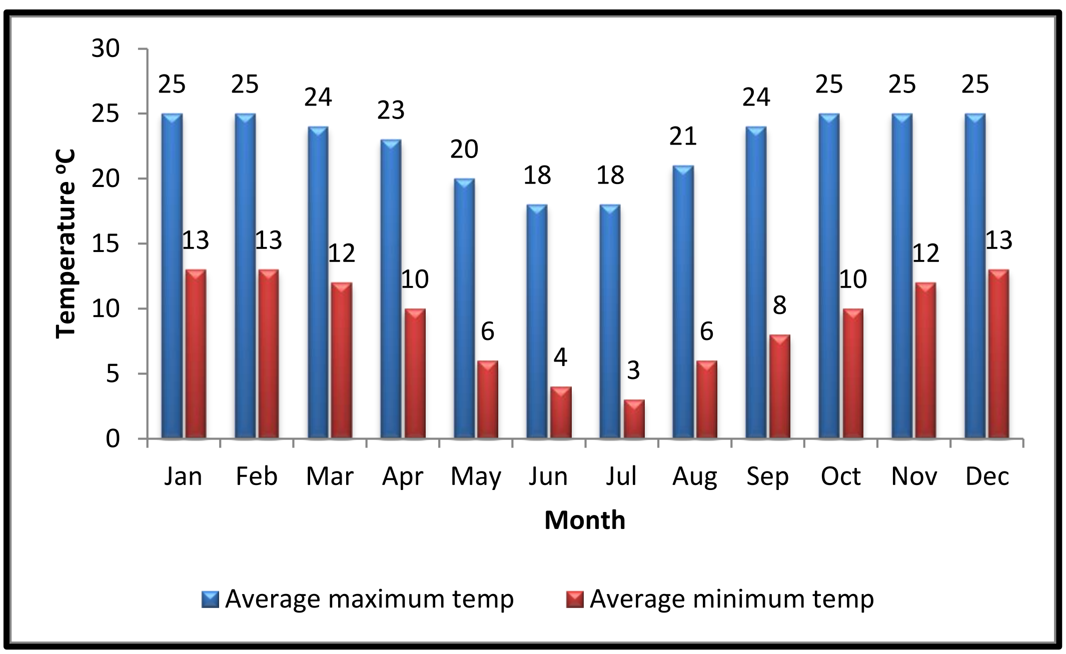


Figure 6: Average monthly temperatures (SA Explorer)

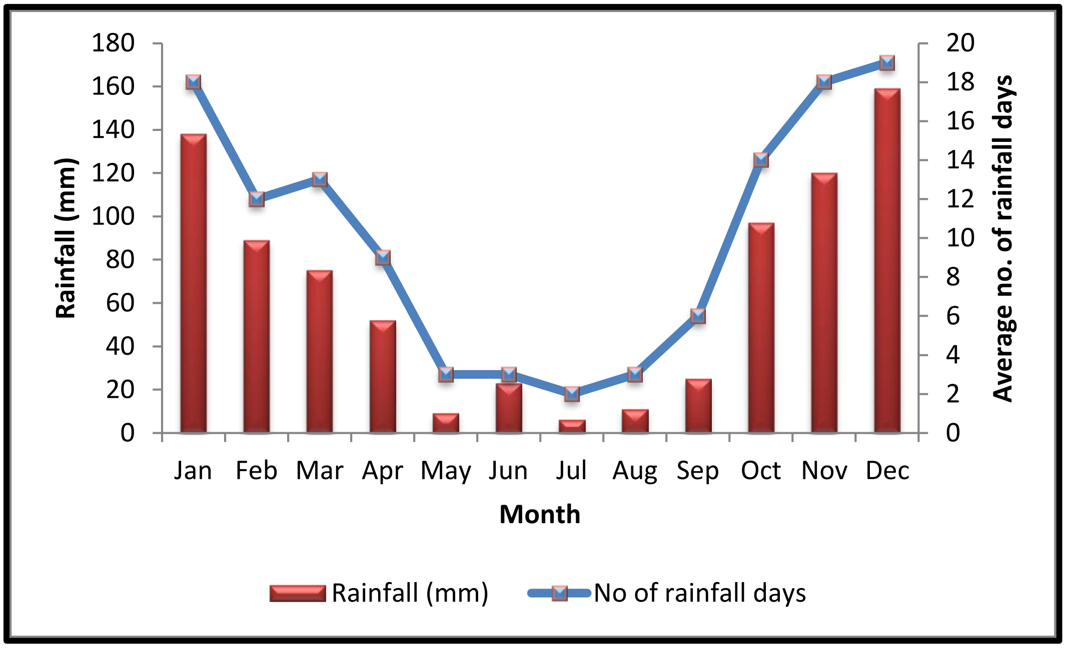


Figure 7: Average monthly rainfall with average number of rainfall days (SA Explorer)

Data from the available DWA rain gauging stations have also been consulted. All the rain gauging stations available from DWA is shown in (Figure 8) and listed in Table 2. The closest rainfall station, B1E003 was chosen as a representative rain gauge for the area.

Table 2: List of rainfall stations

Station ID	Place	Lat	Long
B1E001	Witbank @ Witbank Dam	-25.88807	29.29973
B1E002	Rondevalley	-25.92557	29.69141
B1E003	Rondebosch @ Middelburg Dam	-25.77557	29.54557
B1E004	Rietfontein	-26.35776	29.21640
B1E005	Naauwpoort @ Witbank Dam	-25.97473	29.28057
B3E002	Loskop Nat. Res. @ Loskop Dam	-25.41310	29.36640
B3E003	Loskop Nat. Res. @ Loskop Dam	-25.42143	29.35807

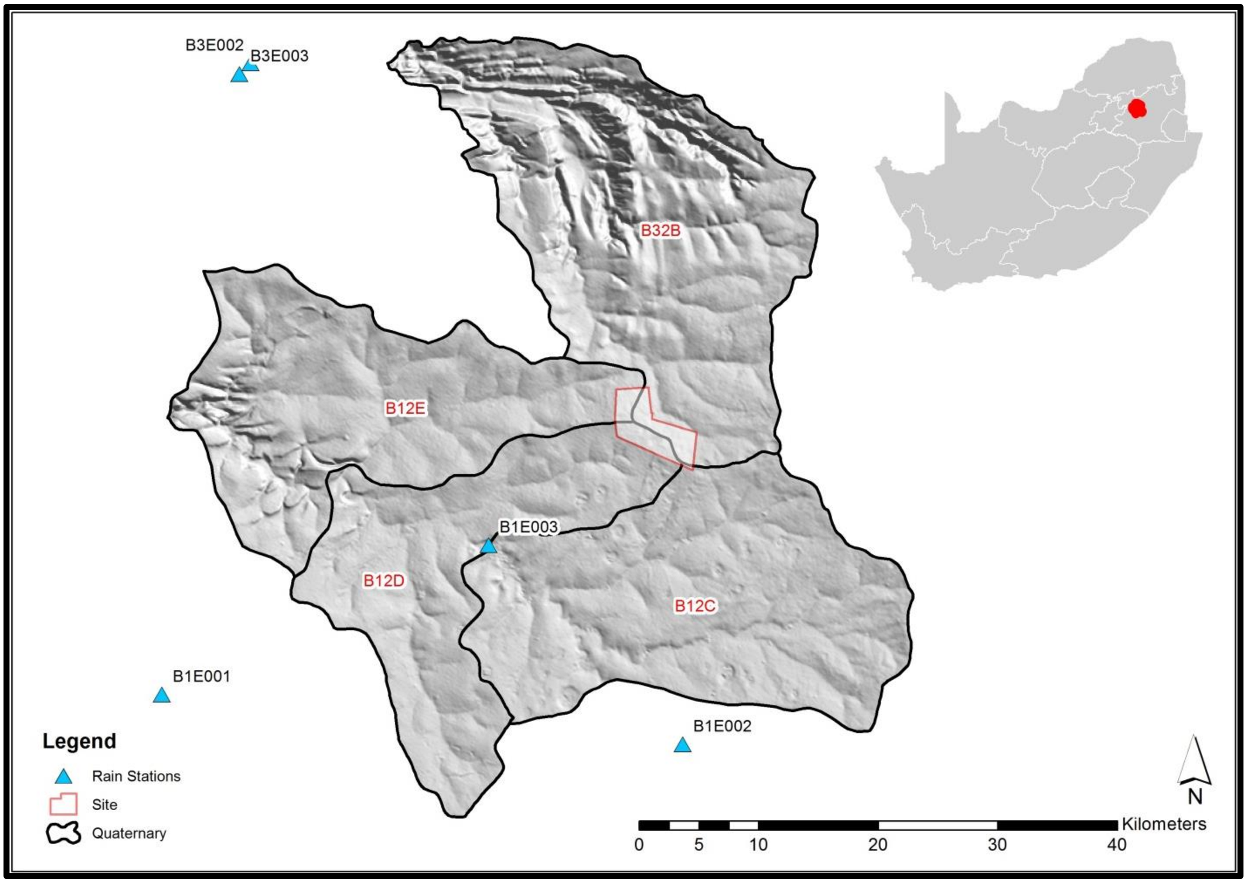


Figure 8: Quaternaries and available DWA rainfall stations around Rietvlei site

Reliable continues daily rainfall data was available from 1980 to 2004 from B1E003 with the following quality DWA code distribution over this period:

- 86% good continuous data;
- 12% good monthly reading; and
- 2% unaudited data.

The rainfall record for the above mentioned period is shown in

Figure **9**. The associated average daily evaporation is shown in

Figure **10**.

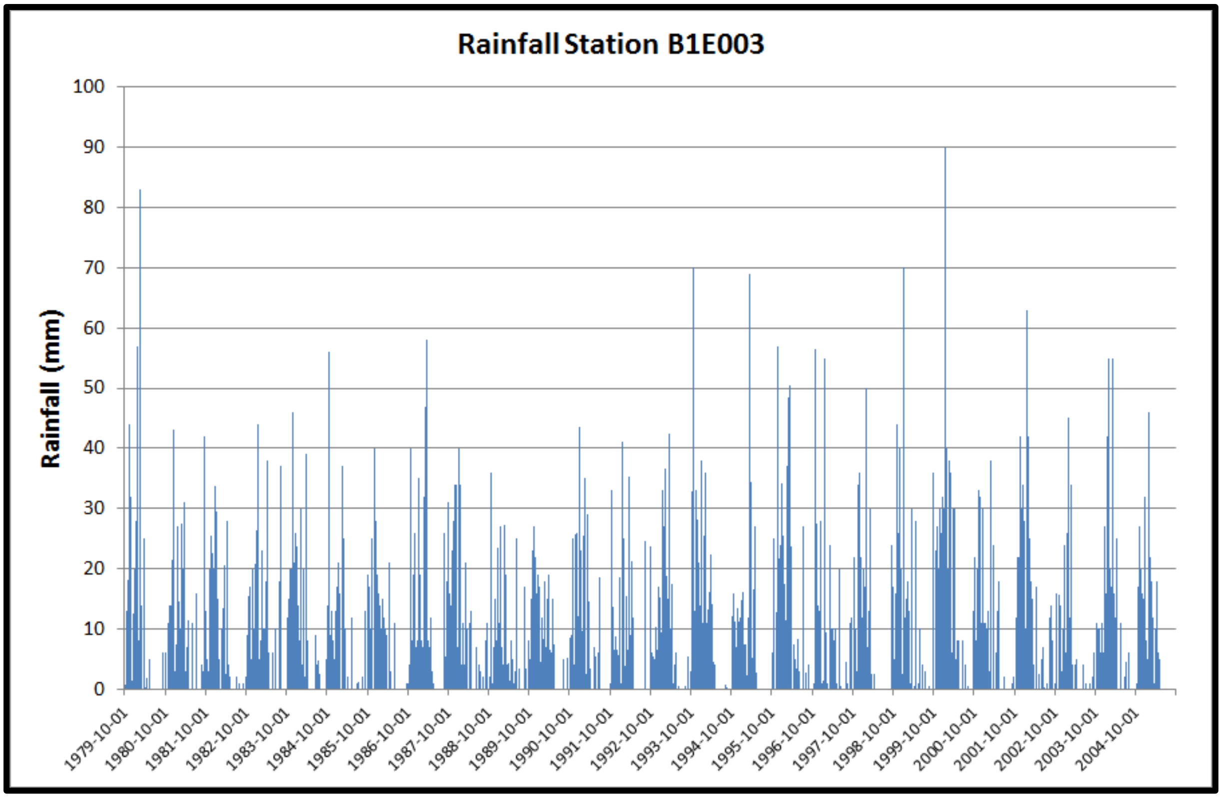


Figure 9: Rainfall record for B1E003 from 1980 to 2005 (DWA)

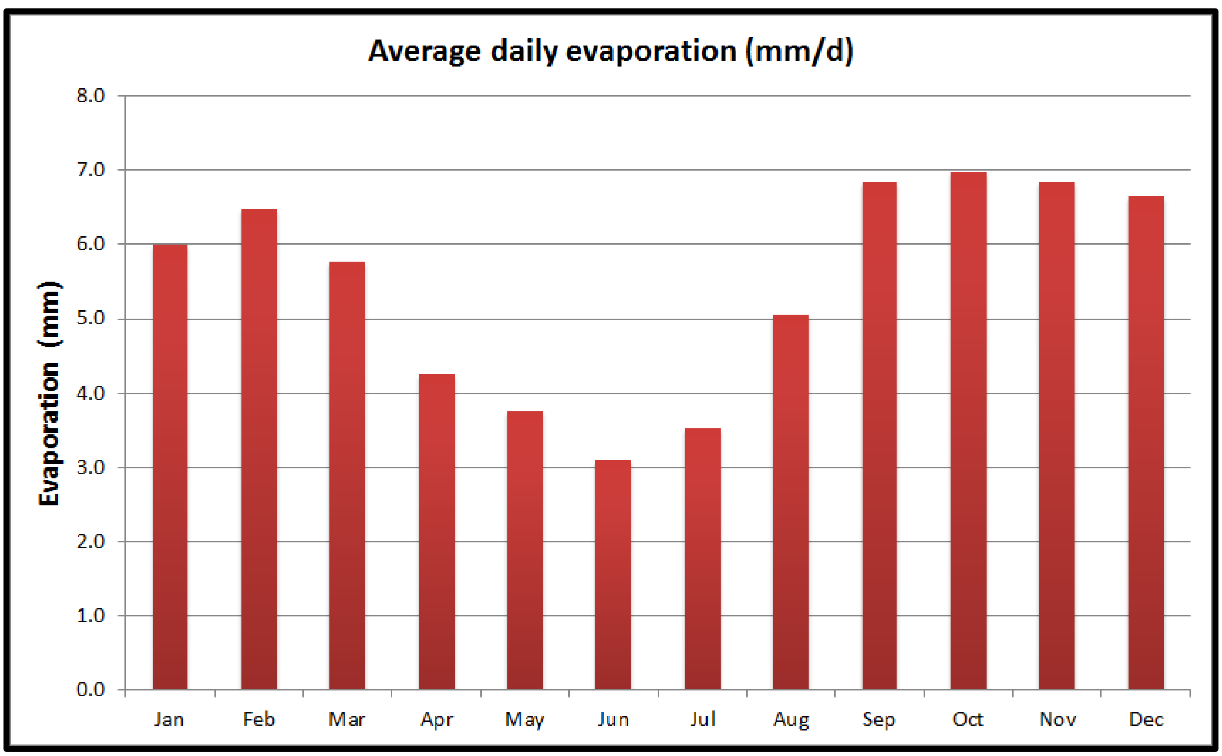


Figure 10: Average daily evaporation

2.4 Geology

The analysis of the 1/250000 Geological Series: 2528 Pretoria has been used to describe the main geology that may be encounter at the mine site.

The mine is located on the Karoo Sequence (Vryheid Formation). The Vryheid Formation comprises mudrock, shales, rhythmite, siltstone and fine- to coarse-grained sandstone (pebbly in places). The Formation contains up to five (mineable) coal seams. The different lithofacies are mainly arranged in upward coarsening deltaic cycles. Since the shales are very dense, they are often overlooked as significant sources of groundwater. The permeability of these sandstones also is usually very low. The main reason for this is that the sandstones are usually poorly sorted, and that their primary porosities have been lowered considerably by diagenesis. These sedimentary formations have been extensively intruded by dolerite dykes.

The Karoo dolerite, which includes a wide range of petrological facies, consists of an interconnected network of dykes and sills and it is nearly impossible to single out any particular intrusive or tectonic event. Dolerite dykes are vertical to sub-vertical discontinuities that, in general, represent thin, linear zones of a lower permeability sandwiched between fracture zones. These fracture zones can have a relatively higher permeability and can therefore act as conduits for groundwater flow within the aquifer. The dykes on the other hand may also act as semi- to impermeable barriers to the movement of groundwater. The dykes are commonly expressed on the surface as a line of green bushes, which can be readily observed during the dry season. The generalised stratigraphy is summarised in Table 3.

Table 3: Generalized stratigraphy

Stratigraphic section	Description
Transport and residual soils	- topsoil - clayey hillwash - clayey siltstone and sandstone

Increasing with depth

Vryheid Formation	-silty, laminated shale - laminated siltstone with sandstone - No 2 seam (coal) - ripple cross-bedded fine grained sandstone
Dwyka Group	Tillite, diamictite and glacial shales
Pre-Karoo basement	Paleo-weathered Selonsrivier felsite

There are numerous fractures within the study area - these fractures can form conduits for groundwater flow. The depth of the coal seam is on average 40mbgl. Figure 11depicts a typical borehole log of the area, while geology of the area is shown in Figure 12.

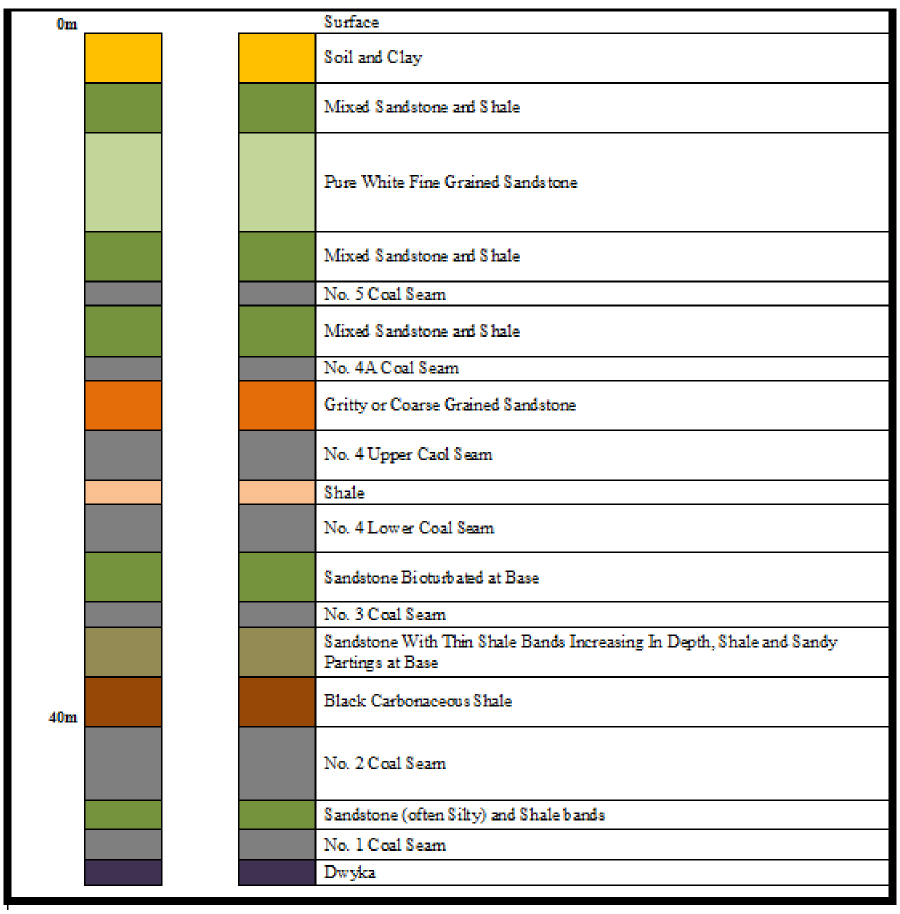


Figure 11: Typical borehole log (site investigation: drilling)

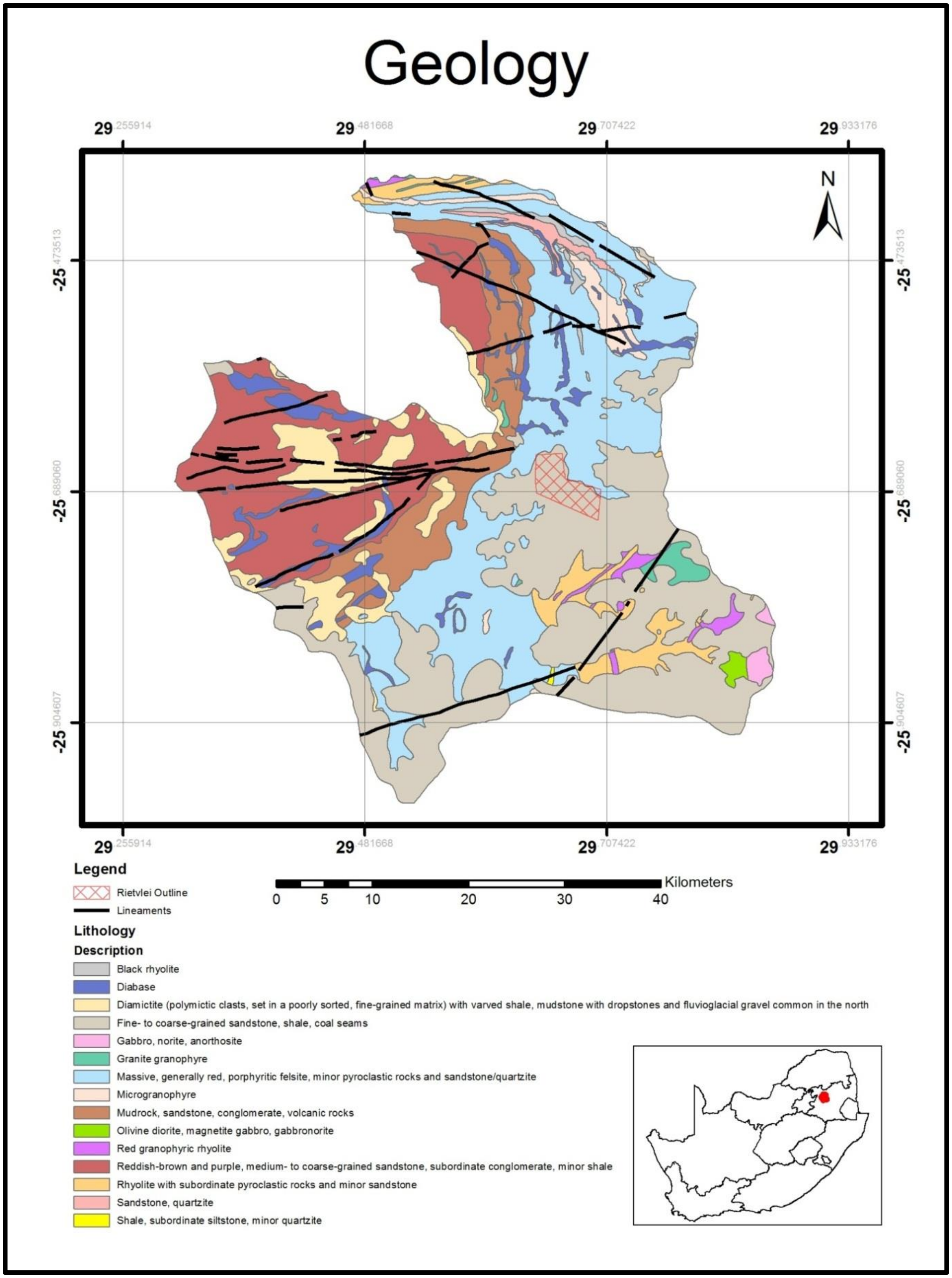


Figure 12: Regional geology (modified from the 1/250000 Geological Series: 2528 Pretoria)

2.5 Soils and land cover

Rehab Green Monitoring Consultants cc conducted a detailed soil, land capability and land use assessment as well as wetland delineation during June 2011 and updated in 2014. The classification and mapping of soil forms (types) according to the South African Taxonomic Soil Classification System as documented is described in that report.

Soil background information and land cover distribution are useful in understanding the behaviour of surface water over the study area.

2.5.1 Hydrological soil

The hydrological soil grouping for each of the quaternaries is shown in

Figure 13 with a dominant grouping of B for B12E, B12D, B12C and the site itself. The classification of the hydrological soil grouping is given in Table 4.

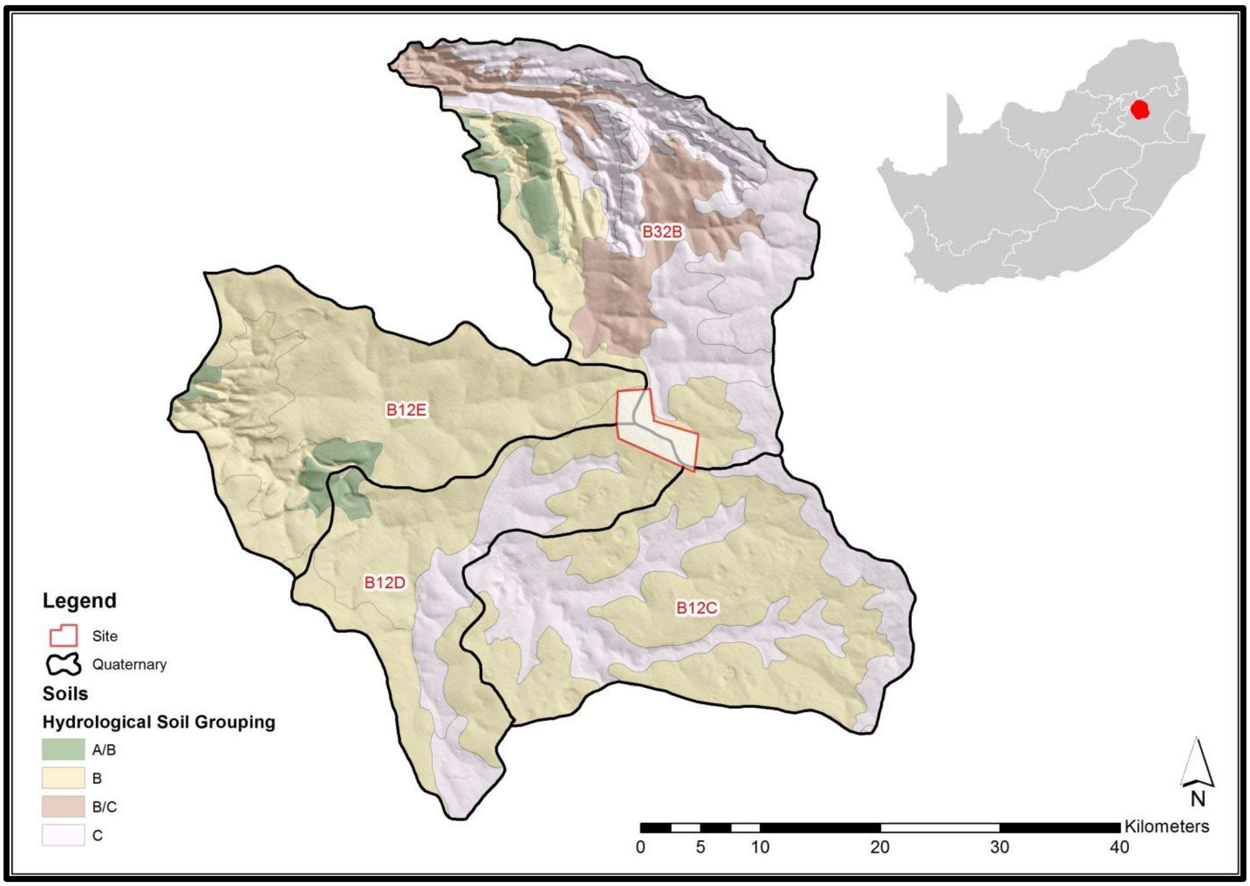


Figure 13: Hydrological soil groupings (modified from Shultze, 2006)

Table 4: Classification of the hydrological soil grouping (taken from Shultze, 2006)

Soil group	Description	Storm flow potential	Infiltration rate	Permeability rate
			mm/h	mm/h
A	Infiltration is High and permeability is rapid. Overall drainage is excessive to well-drained	Low	~25	7.6
B	Moderate infiltration rates, effective depth and drainage, with slightly restricted permeability.	Moderately low	~13	3.8-7.6
C	Low infiltration rate or deteriorate rapidly, with restricted permeability	Moderately high	~6	.3-3.8
D	Low infiltration and highly restricted permeability, with high shrink-swell potential	High	~3	<1.3

2.5.2 Land cover

The land cover distribution for the quaternaries is shown in Figure 14 with the major land cover being cultivation followed by natural veld. The site itself has a large percentage classified as plantations.

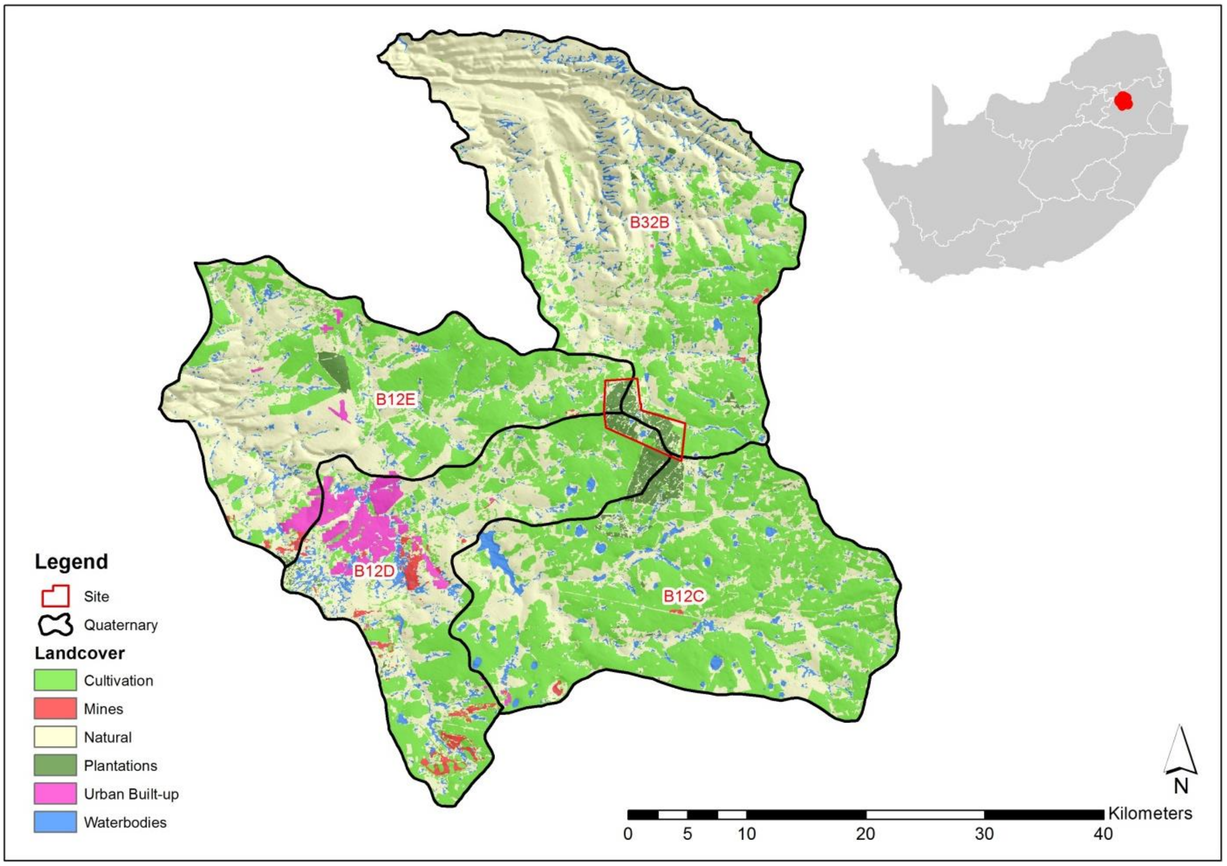


Figure 14: Land cover distribution (modified from SANBI, 2009)

2.5.3 Vegetation

The study area is located in the Grassland Biome of South Africa, across one regional vegetation unit, namely Eastern Highveld Grassland.

The site is covered by plantations, which in some areas have been cut and/or burned, and a number of “vlei” or wetland areas. Three habitat units were identified during the assessment, namely wetlands, grasslands and transformed habitats with historic disturbance as a result of cultivation, plantations and alien floral encroachment.

2.6 Wetlands

In 2011, Scientific Aquatic Services (SAS cc) conducted a wetland assessment. The report has been updated in 2014 as part of the EIA process for the proposed Rietvlei Colliery. The delineated wetlands inside the prospecting area are shown in Figure 15. Only the permanent wetlands in the study area have been considered sensitive and should be treated as required by Mpumalanga Biodiversity Conservation Plan. The varying sensitivities ascribed to the wetlands on site, range from Low Sensitivity to High Sensitivity, and are based on the varying degrees of degradation of the wetlands on site (Figure 15).

Wetlands present outside the boundary of the study area, have not been taken into account in the existing wetland mapping. This will however need to be considered in the mine water management and monitoring plans. Wetlands are connected to many of the streams on site and downstream sites.

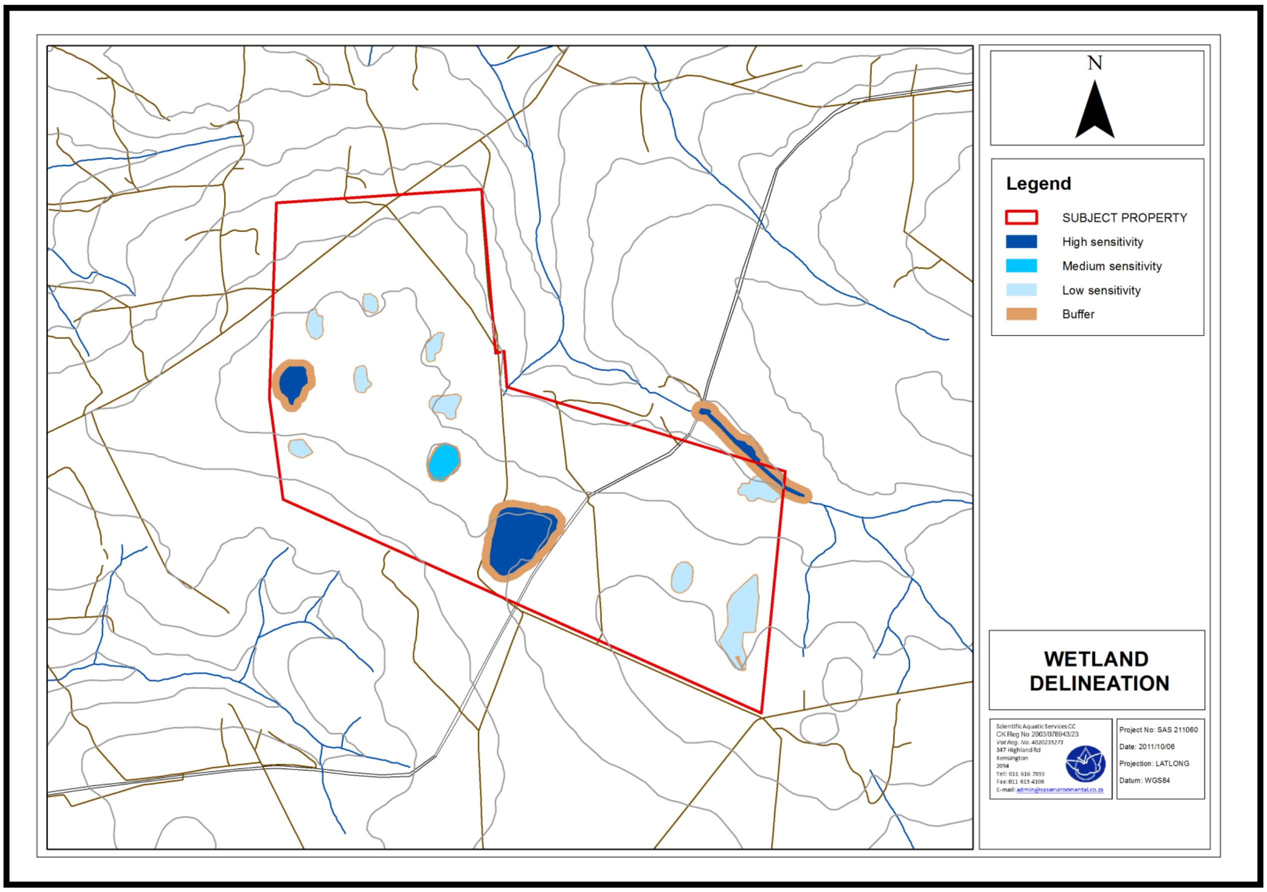


Figure 15: Wetland delineation with associated buffers (after SAS cc)

2.7 Topography and hydrology

The project area is located on the intersection of 3 quaternary catchments B12D, B12E and B32B (Table 5), with a small part (0.255km^2) of the prospect area falling under B12C. The landscape slopes gently towards the different streams and rivers. The general elevations in the concerned catchments range between 1043 mamsl (metre a bove mean sea level) and 1831 mamsl (

Figure 16). The study area is characterised by a land use of mainly agriculture, with blue gum plantations as the main agricultural activity.

Table 5: Information concerning quaternary catchment

Catchment	B12D	B12E	B32B
Area (km^2)	362.3	435.8	613.8
Mean annual runoff (mm/a)	38	53	51
Groundwater contribution to baseflow (mm/a)	7	18	16

The present study focuses on the three main catchments. Rietvlei forms the headwaters of:

- The Olifants River in B12D: A number of small sized dams intercept the South-West furrows (Figure 18) that feed into Olifants River.
- The Selons River in B32B which flows North-West into Olifants River;
- The Keerom stream (B12E) which flows West-West-South into Olifants River; number of small sized dams intercept the South-West furrows (Figure 18) that feed into Keerom stream.

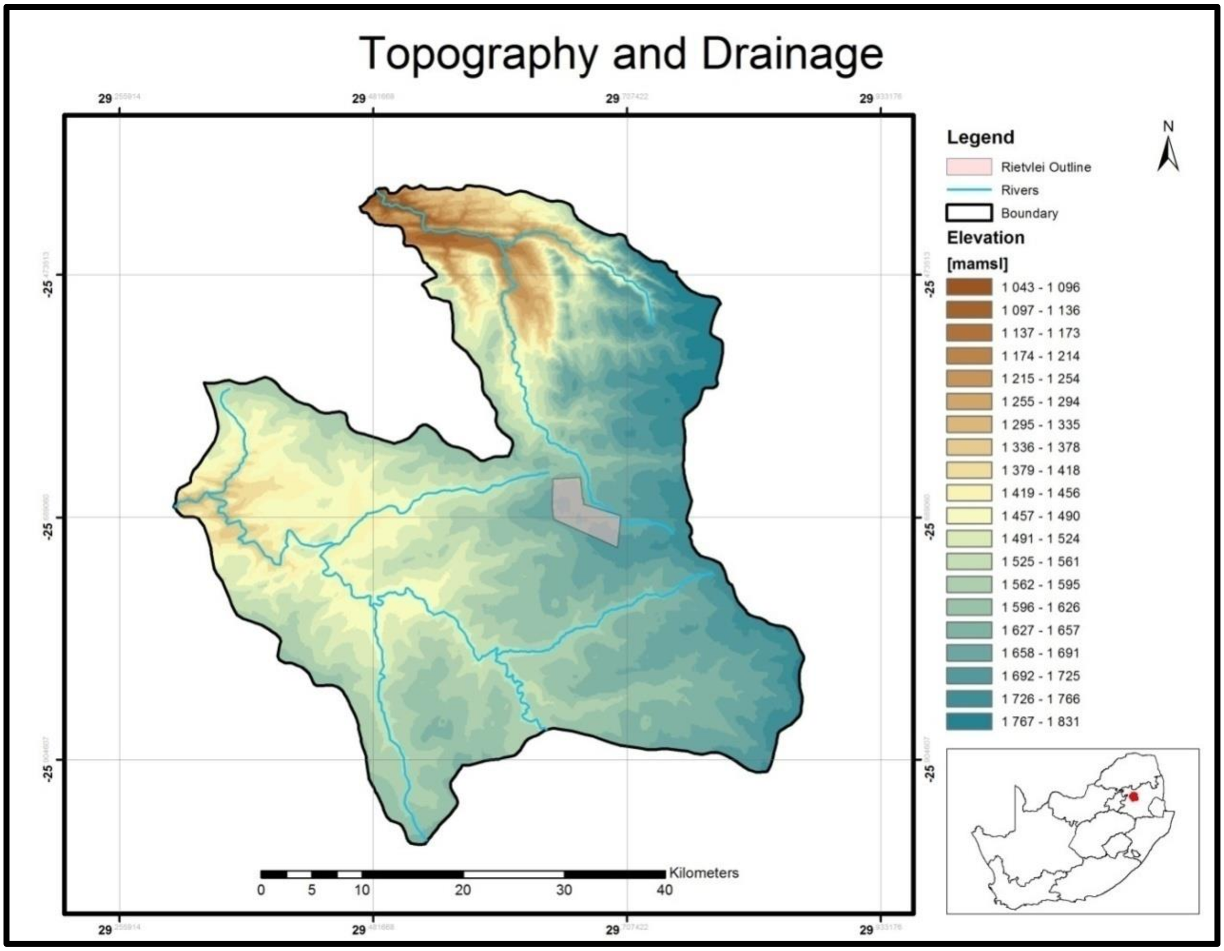


Figure 16: General Topography and drainage

The local elevations prior to mining ranges from 1590mamsl to 1720mamsl as indicted on Figure 17. The maximum fall in elevation (from the highest point on site towards the lowest) is approximately 230m.

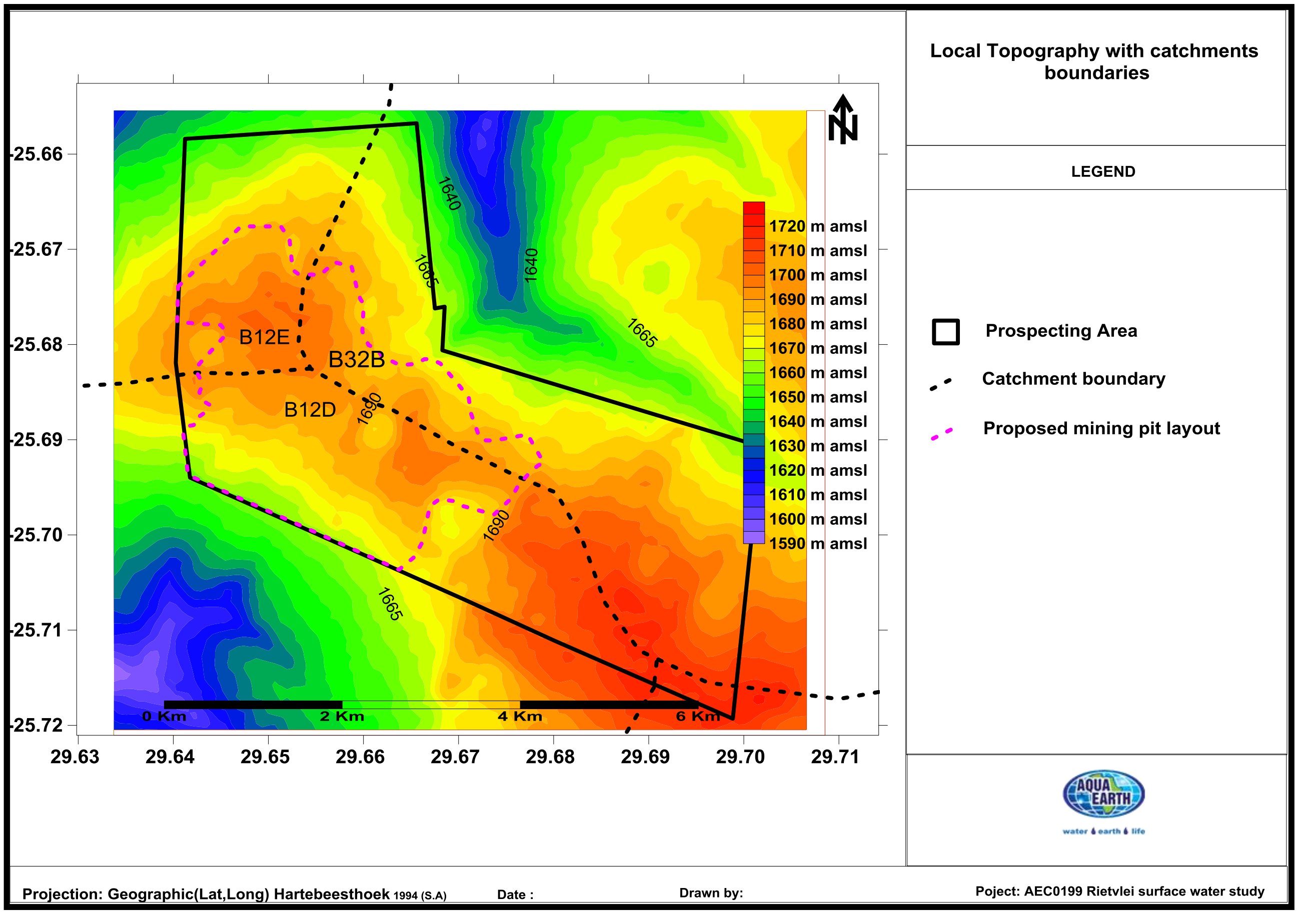


Figure 17: Local topography with catchments boundaries and mining.

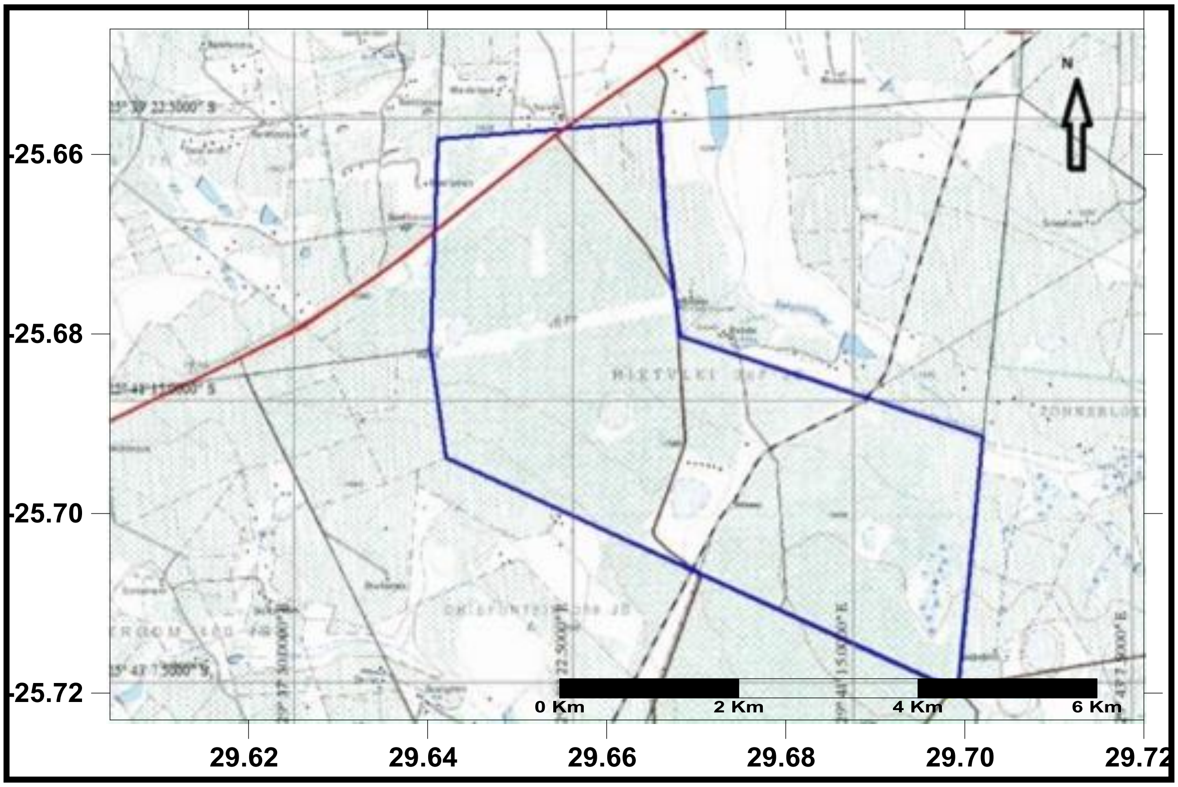


Figure 18: Non perennial rivers and dams surrounding the Rietvlei mine lease area.

Local surface runoff catchments with the associated local drainage are shown together with the mining layout in Figure 19. The way that such local drainage is connected to the pans on the prospecting area is also illustrated.

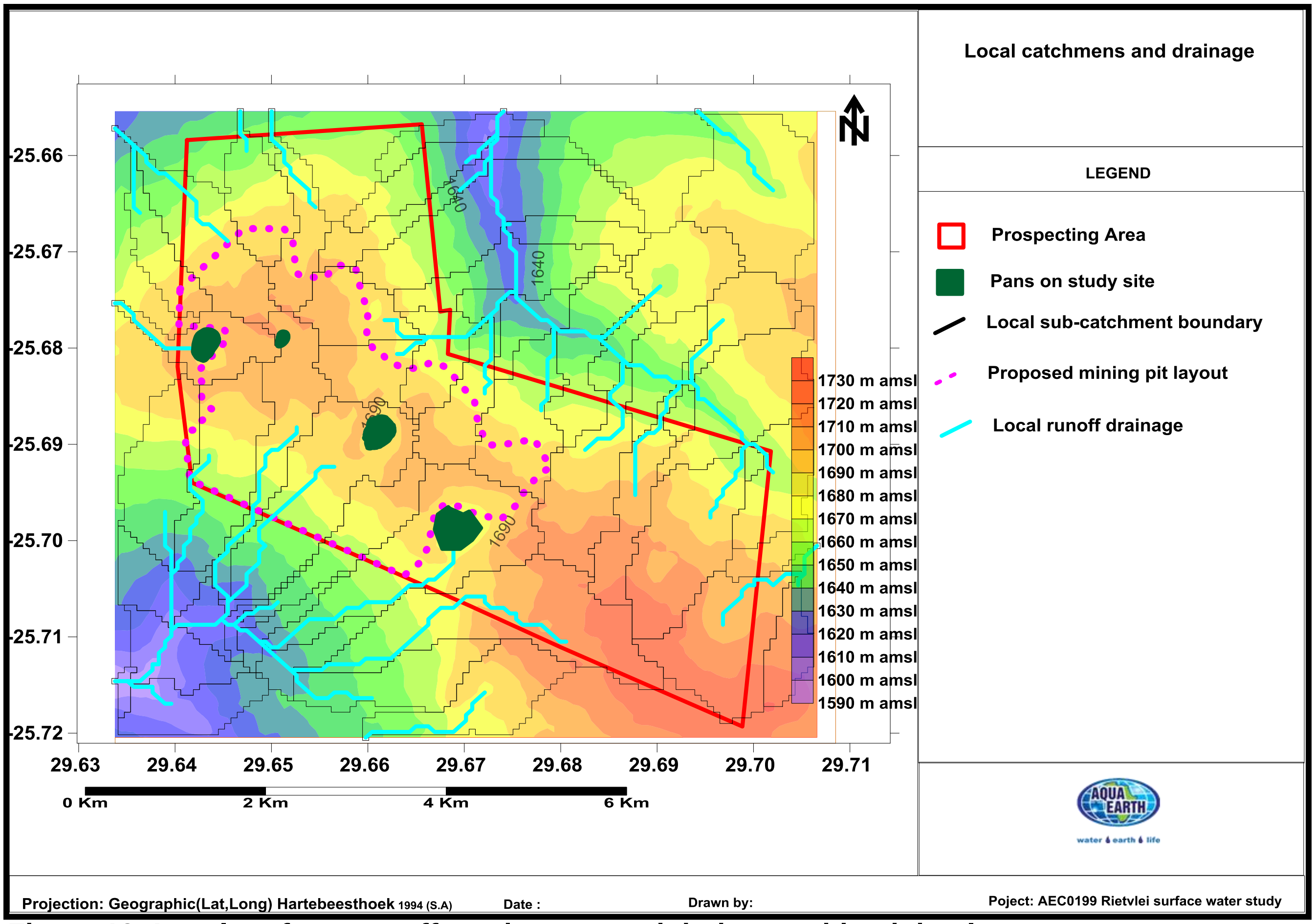


Figure 19: Local surface run-off catchments and drainage with mining layout

2.8 Surface water quality

During a hydrocensus carried out in early 2011, 2 surface water points had been visited and located (Table 6).

Table 6 : Information collected during hydrocensus

Farm Name Owner/ Addr/Te	Water Body	Geographic Coordinate (WGS 84)	
		Latitude	Longitude
Rietvlei	Dam	25°40'47.11"	29°41'12.52"
Wonderhoek	Selons River	25°38'50.56"	29°40'10.28"

Water samples had been collected and sent to an accredited laboratory for analysis. Both samples showed a relatively neutral pH (7.12 and 7.46) and low electrical conductivity values (11mS/m and 13mS/m). The returned results indicated that all the major and minor constituents analysed fall within the recommended operational limits for drinking water (SANS 241; 2005) except for Aluminium (Table 7). The Aluminium concentrations at both monitoring points exceeded the maximum allowable limit.

The Piper (Figure 20) and Expanded Durov (

Figure 21) diagrams show that the water quality within the Selons River showed no sign of pollution, while the one from the dam showed mining or power station related water.

Table 7 : Comparison of results against drinking water quality standards

Sample Number	pH []	EC [mS/m]	TDS [mg/l]	P Alk. [mg/l CaCO3]	M Alk. [mg/l CaCO3]	Al [mg/l]	Ca [mg/l]	Cr [mg/l]	K [mg/l]	Mg [mg/l]	Mn [mg/l]	Na [mg/l]	Si [mg/l]	Zn [mg/l]	F [mg/l]	Cl [mg/l]	NO_3-N [mg/l]	PO_4 [mg/l]	SO_4 [mg/l]
Dam	7.12	11	68	<0.6	19.4	4.29	4.03	<0.05	3.46	2.5	<0.05	11	9.7	<0.05	0.517	11.1	0.88	<0.8	8.67
Selons River	7.46	13	78	<0.6	40.2	1.79	7.64	<0.05	2.92	6.14	<0.05	9.52	7.61	<0.05	0.526	6.18	0.77	<0.8	7.94

SANS 241; 2005

CLASS 1: Recommended Operational Limit																			
CLASS 2: Max Allowable	5-9.5	<150	<1000			<0.3	<150	<0.1	<50	<70	<0.1	<200		<5	<1	<200	<10		<400
Above Class 2 Limits	4-10	150-370	1000-2400			0.3-0.5	150-300	0.1-0.5	50-100	70-100	0.1-1	200-400		5-10	1-1.5	200-600	10-20		400-600

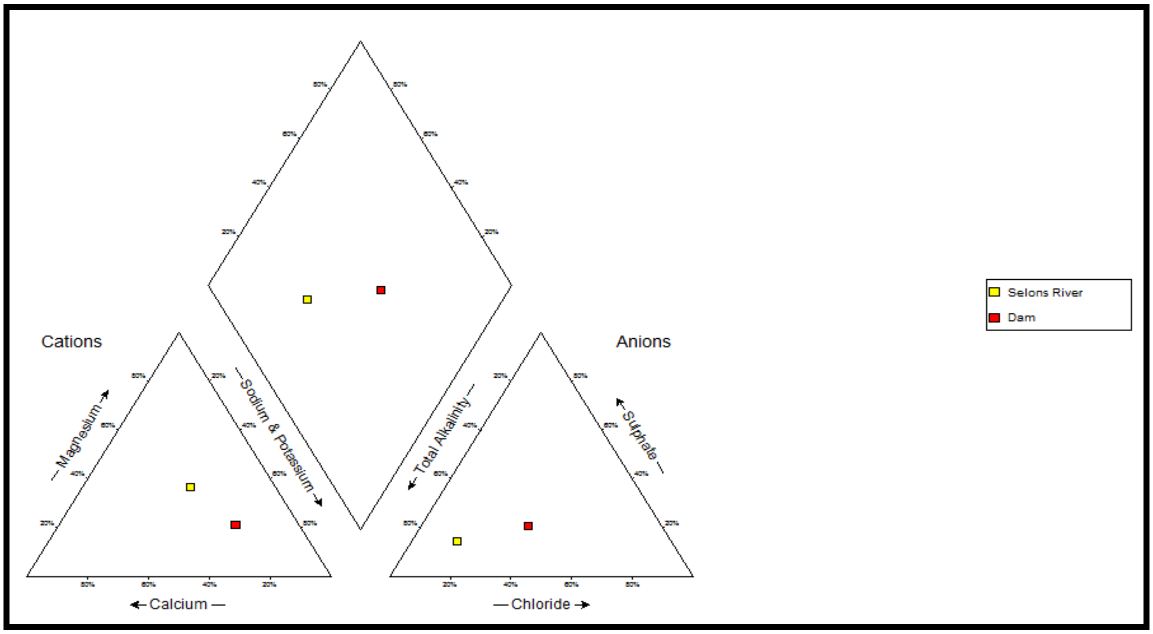


Figure 20: Piper Diagram of Rietvlei surface water quality

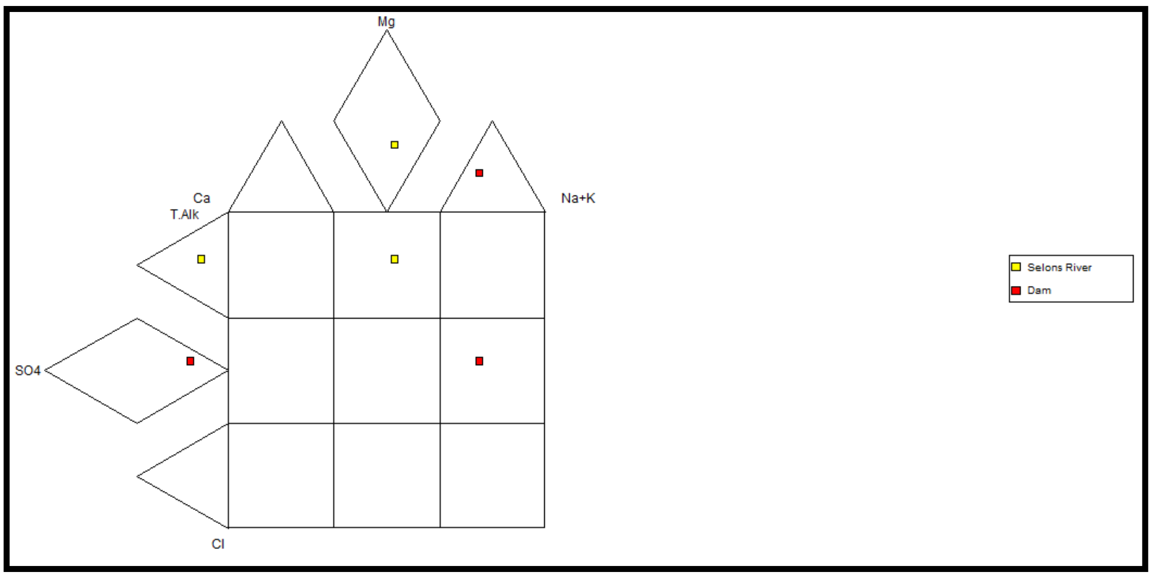


Figure 21: Expanded Durov diagram of Rietvlei surface water quality

3 Base line storm water modelling

3.1 Critical data requirement for surface water modelling

3.1.1 Flow and rain gauging stations

Rain gauge and flow gauge data are required for calibration of surface runoff modelling purposes. The closest flow and rainfall station in the vicinity that had daily records available was used in the present initial site assessment.

As no site specific rain gauge exists, the representative (closest) rainfall station, B1E003 has been used in the surface water modelling.

In the absence of a flow gauge in close vicinity of the study area, calibrated data from WR2005 was utilised as observed data for each of the quaternaries for the surface water model.

3.1.2 Soil and land cover

For surface water modelling (Regional, Local storm water, and Flood peak and lines) purposes, hydrological soil groupings from Shultze (2006) have been used. Land cover distributions as described by SANBI (2009) have also been considered.

3.1.3 Surface elevations and channel cross section

As no detailed field topographic survey (cross sections) was available at the time of the study, a detailed digital elevation model (DEM) was making use of SPOT (Satellite Pour l'Observation de la Terre) heights and existing 5m contours.

3.2 Model purpose and methodology,

The purpose of the surface water modelling is to determine storm water runoff from the proposed site as well as floodline determination. This is accomplished through the use of three surface water models:

- Regional surface water runoff model on quaternary catchment scale
- Local storm water runoff model on site scale based on catchment model parameter
- Flood peak determination through the SCS-SA in conjunction with a channel flow model (HEC-RAS)

3.2.1 Regional surface water model methodology

In the absence of relevant local surface water data (observed flow), the regional surface runoff model was setup to show that calibration could be achieved with the model implemented (WR 2005), and downscaled to the proposed site for storm water modelling. Hydrological response units (HRU) have been delineated in the four quaternaries involved in the proposed mining site, and were used in the model network development.

3.2.1.1 Hydrological response unit

The four quaternaries comprising the regional surface water model was divided into fourteen HRUs as shown in Figure 22.

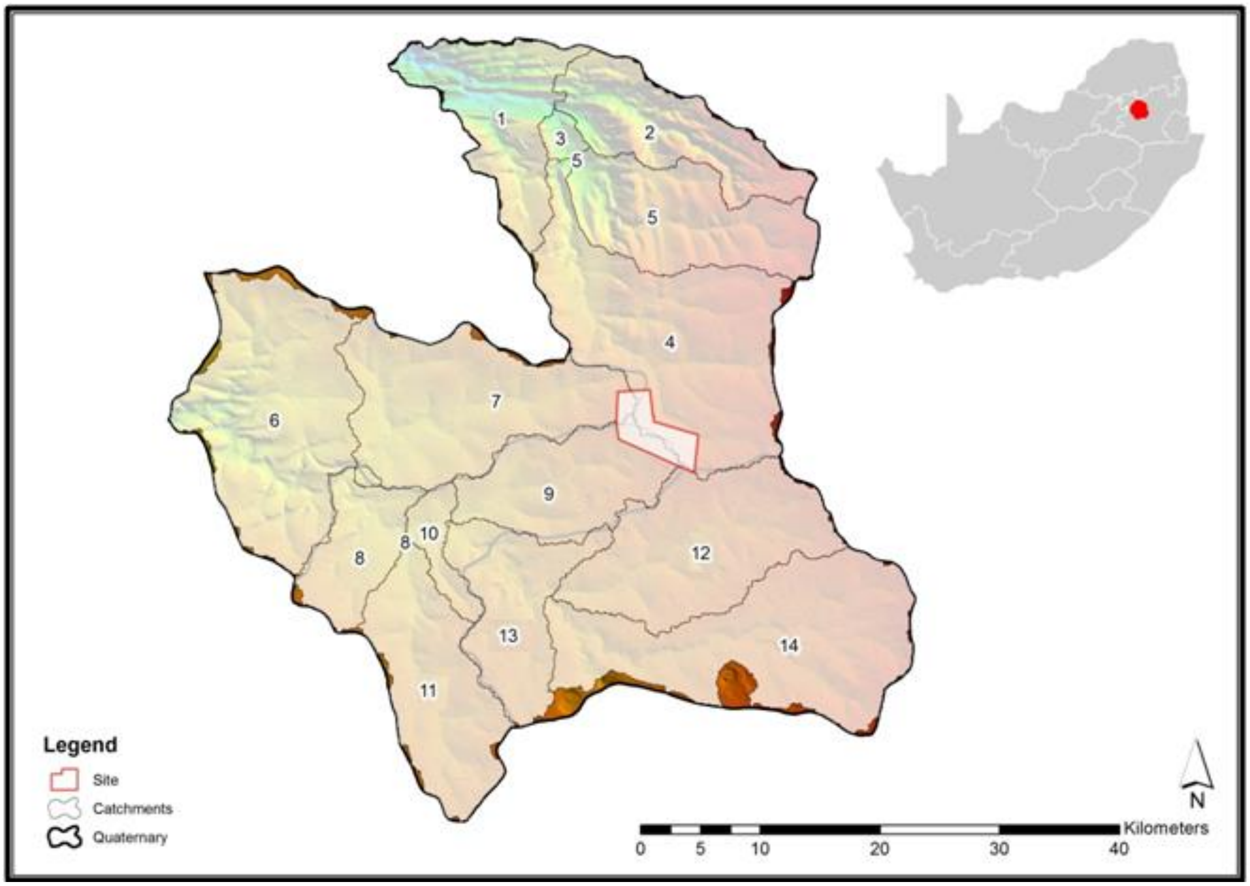


Figure 22: Hydrological response units for regional surface water model

3.2.1.2 Regional surface water model network

The model network representing the regional surface water model is shown in Figure 23. Note that HRUs 12-14 do not form part of the model network as the combined outflow of these three HRUs are represented as the inflow to quaternary B12D and the WR2005 data was used for this input. Three outflows (Out1, Out2 and Out3) are modelled and compared with the WR2005 data for the same catchments.

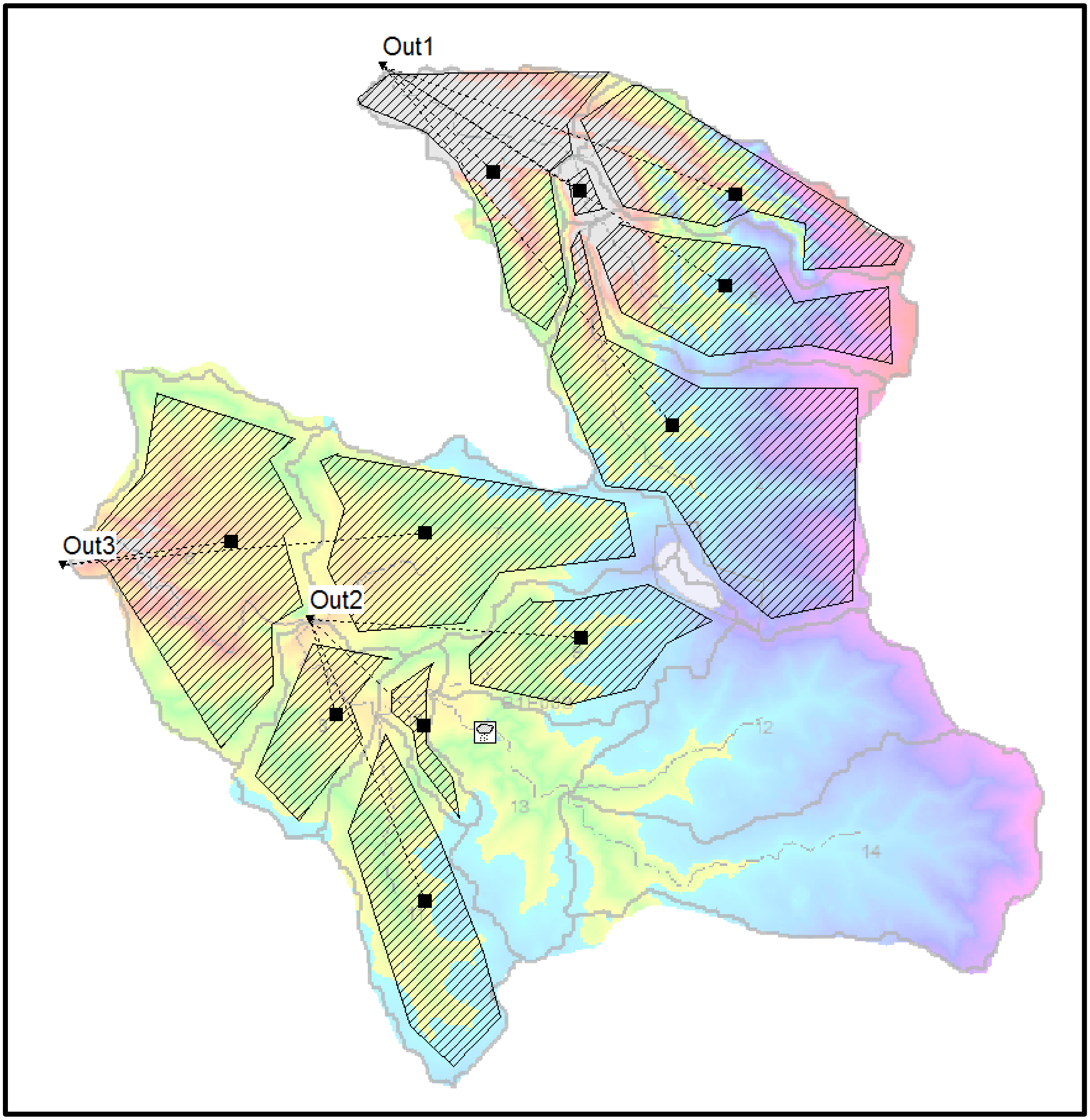


Figure 23: Regional surface water model network

The HRU parameters implemented in the model are presented in

Table 8 and Table 9 respectively. Note that it was assumed that the urban land cover will represent the impervious areas.

Table 8: Land cover distribution per HRU

Class	HRU1	HRU2	HRU3	HRU4	HRU5	HRU6	HRU7	HRU8	HRU9	HRU10	HRU11
Bare Rock & Soil	0.0%	0.0%	0.0%	0.0%	0.0%	3.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Cultivated	7.7%	8.8%	0.6%	56.5%	31.4%	32.4%	66.2%	9.5%	65.1%	29.8%	54.0%
Planted Grasslands	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.4%	0.0%	0.0%	0.0%
Forest Plantations	0.0%	0.6%	0.0%	2.8%	1.1%	1.9%	1.2%	1.5%	5.6%	0.3%	0.3%
Mines & Quarries	0.0%	0.0%	0.0%	0.2%	0.0%	0.5%	0.1%	0.9%	0.2%	2.3%	7.3%
Natural Grassland	38.0%	72.1%	16.2%	39.1%	59.7%	52.2%	31.3%	33.9%	28.0%	56.1%	36.5%
Thicket, Bushland, Bush Clumps	54.1%	18.4%	83.1%	0.9%	7.7%	5.9%	0.3%	0.2%	0.2%	0.0%	0.2%
Urban	0.0%	0.1%	0.0%	0.0%	0.0%	4.2%	0.7%	52.5%	0.0%	11.4%	1.4%
Waterbodies	0.2%	0.0%	0.0%	0.4%	0.0%	0.0%	0.0%	0.3%	0.7%	0.1%	0.4%
Wetlands	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%
Soil Group	B/C	C	B/C	C	B/C	B	B	B	B/C	B	B/C

Table 9: HRU parameters

HRU	Area(ha)	Slope (%)	Imperv (%)	n-Imperv	n-Pervious
1	11418	1.38	0.0	0.01	0.70
2	10898	1.38	0.1	0.01	0.60
3	1048.2	1.38	0.0	0.01	0.60
4	24721	1.38	0.0	0.01	0.70
5	13488	1.38	0.0	0.01	0.60
6	23108	0.54	4.2	0.02	0.50
7	19068	0.54	0.7	0.02	0.45
8	6814.1	0.31	52.5	0.02	0.60
9	11347	0.31	0.0	0.02	0.80
10	2722	0.31	11.4	0.02	0.80
11	13597	0.31	1.4	0.02	0.80

3.2.2 Local storm water runoff model methodology

The purpose of the storm water model is to assist in the establishment of a storm water management plan. Runoff from the site needs to be managed in terms of clean water and dirty water. Storm water channels are required to divert the runoff to the specified dams. The model results (runoff flows and volumes) will be used to suggest sizes for both the channels and dams which should contain peak flow on the site without any releases (or overflow) taking place.

To accomplish this, the site boundary is used as the storm water model boundary, and proposed mining surface infrastructures were considered as can be seen in Figure 50

Three (3) clean water dams (CWD1, CWD2, and CWD3) are placed at critical positions to intercept clean water and five (5) dirty water dams (DWD1, DWD2, DWD3, DWD4, and DWD5) are also placed strategically to intercept the dirty water.

3.2.2.1 Local storm water model Network

The model network for the site is shown in Figure 24. Catchment parameters were scaled down from the regional surface water model. The proposed pit area was removed from modelled area for the purpose of storm water runoff, since storm water runoff will be mostly driven by groundwater seepage once in operation. The areas comprising of waste dumps and the plant were assigned a Manning's Coefficient of Perviousness (MCP) of 0.024 associated with that of cement and rubble surfaces to give a conservative estimate of the storm water runoff on the site.

The model was subject to the same rainfall sequence as that used in the regional surface water model as well as the same daily evaporation.

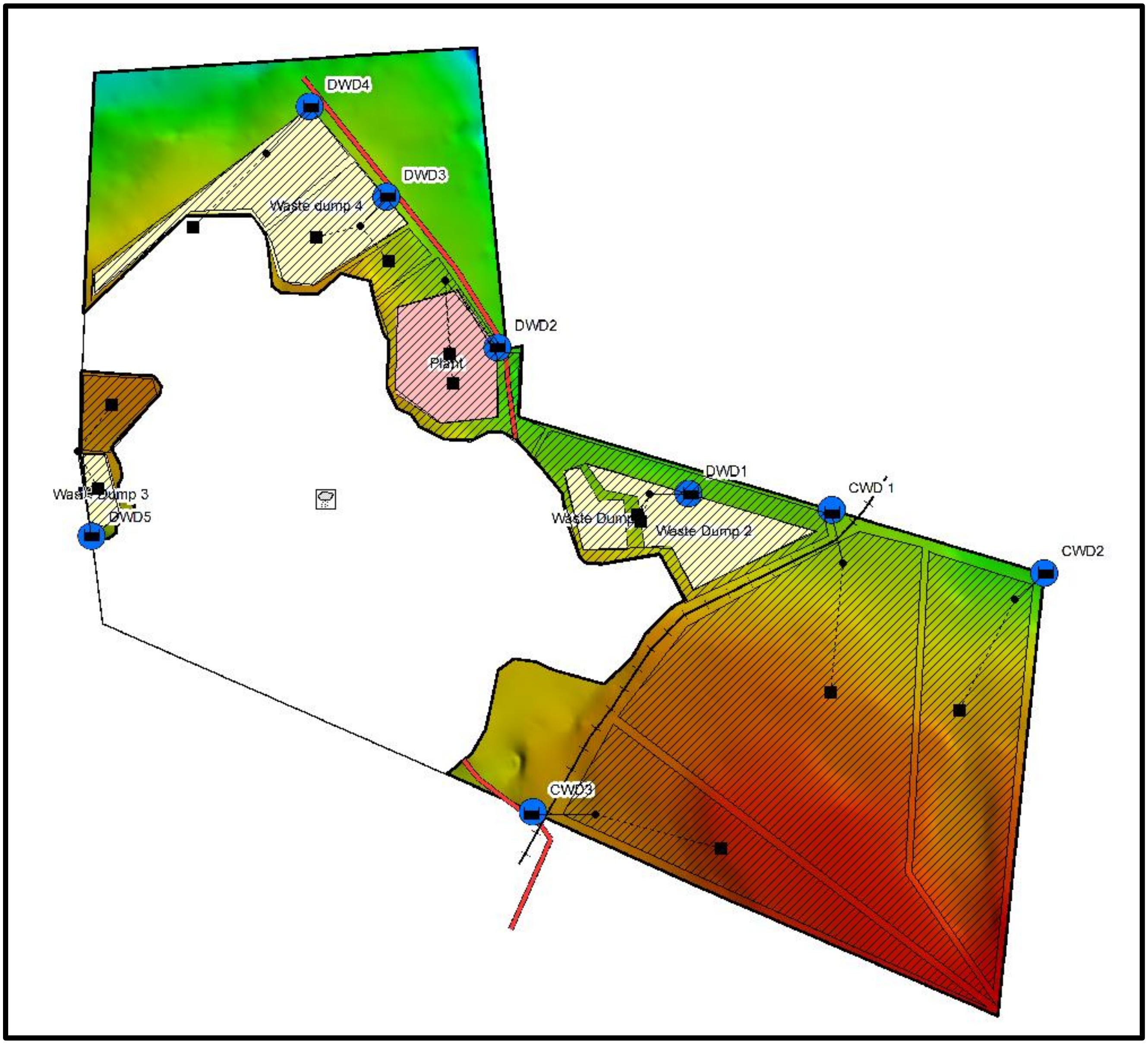


Figure 24: Storm water model network

3.2.3 Flood line calculation methodology

Floodline determination is done in and around the site to ensure that the proposed mine pit will not be affected by surface water flooding and to augment the storm water plan accordingly.

The built DEM (SPOT heights + 5m contours) was used for stream definition and to obtain a cross section.

3.2.3.1 Flood line catchment characteristics

A stream definition of 1 km^2 was applied to the DEM to delineate three catchments (1, 2, and 3) around the site as shown in Figure 26. Elevations over the area range between 1760 and 1555 mamsl.

The longest water course for each of the catchments is shown in Figure 27, Figure 28 and Figure 29 respectively.

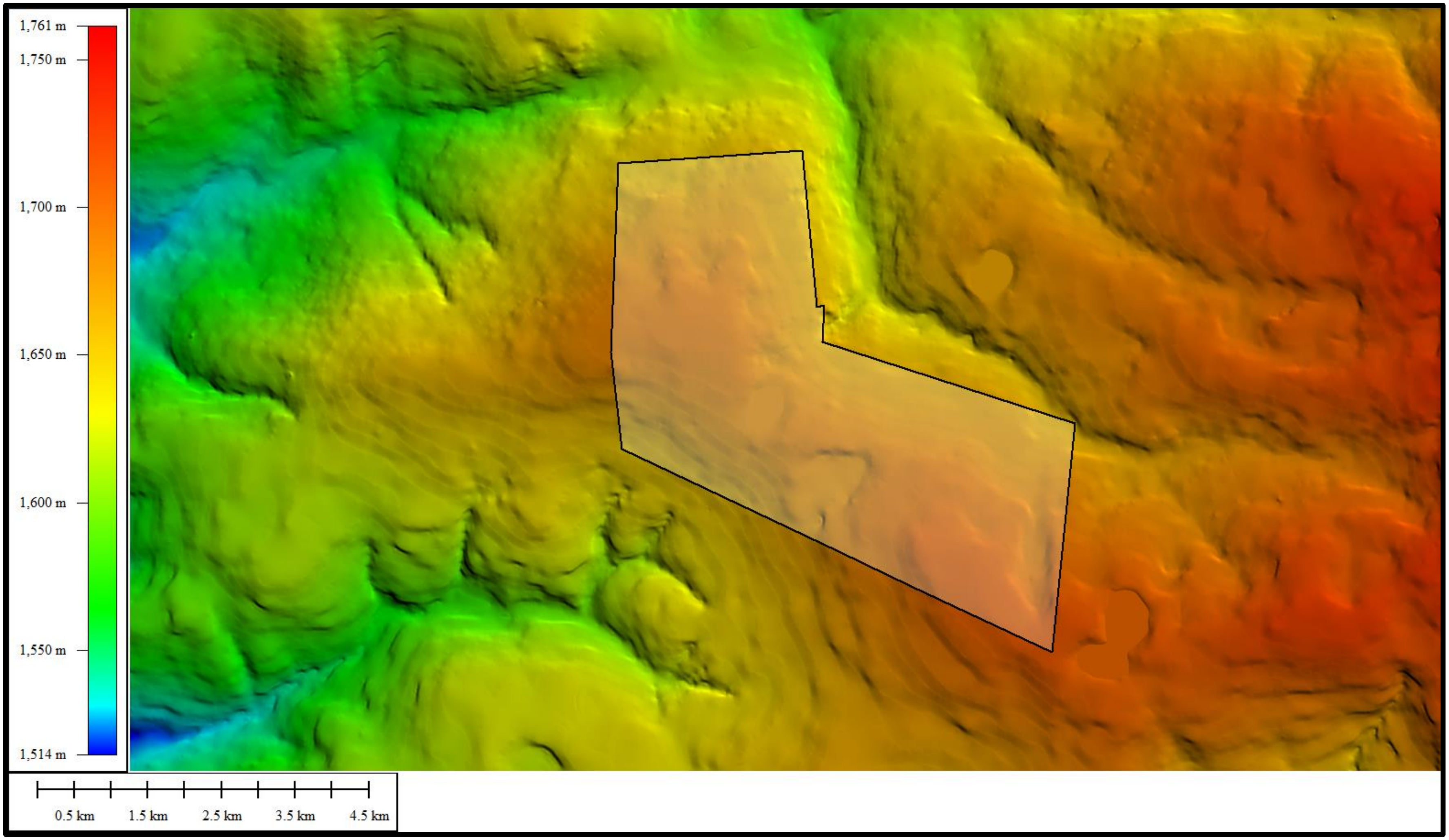


Figure 25: Digital Elevation Model around site (SPOT heights + 5m contours)

1 `

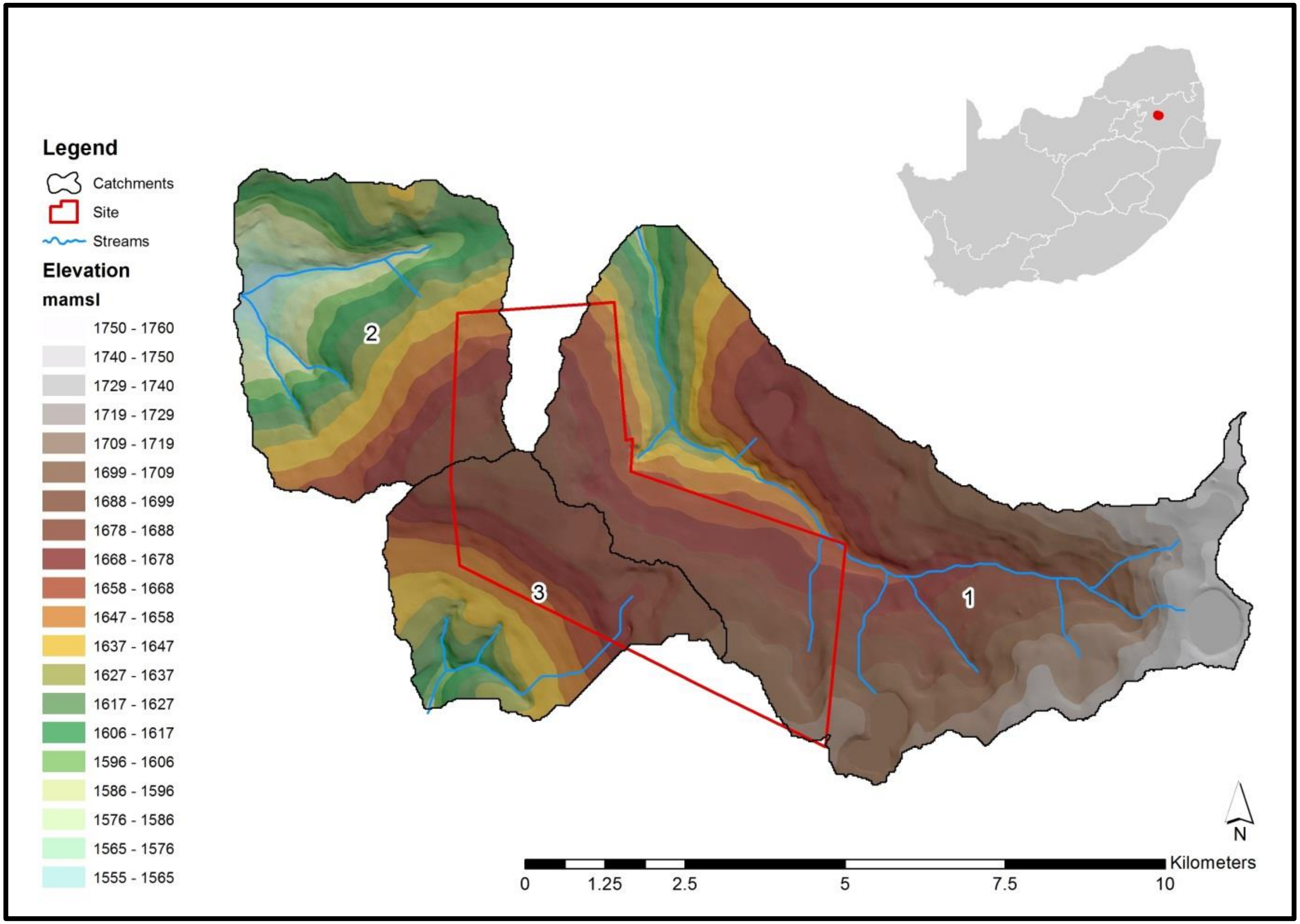


Figure 26: Flood line catchments based on 1km^2 stream definition

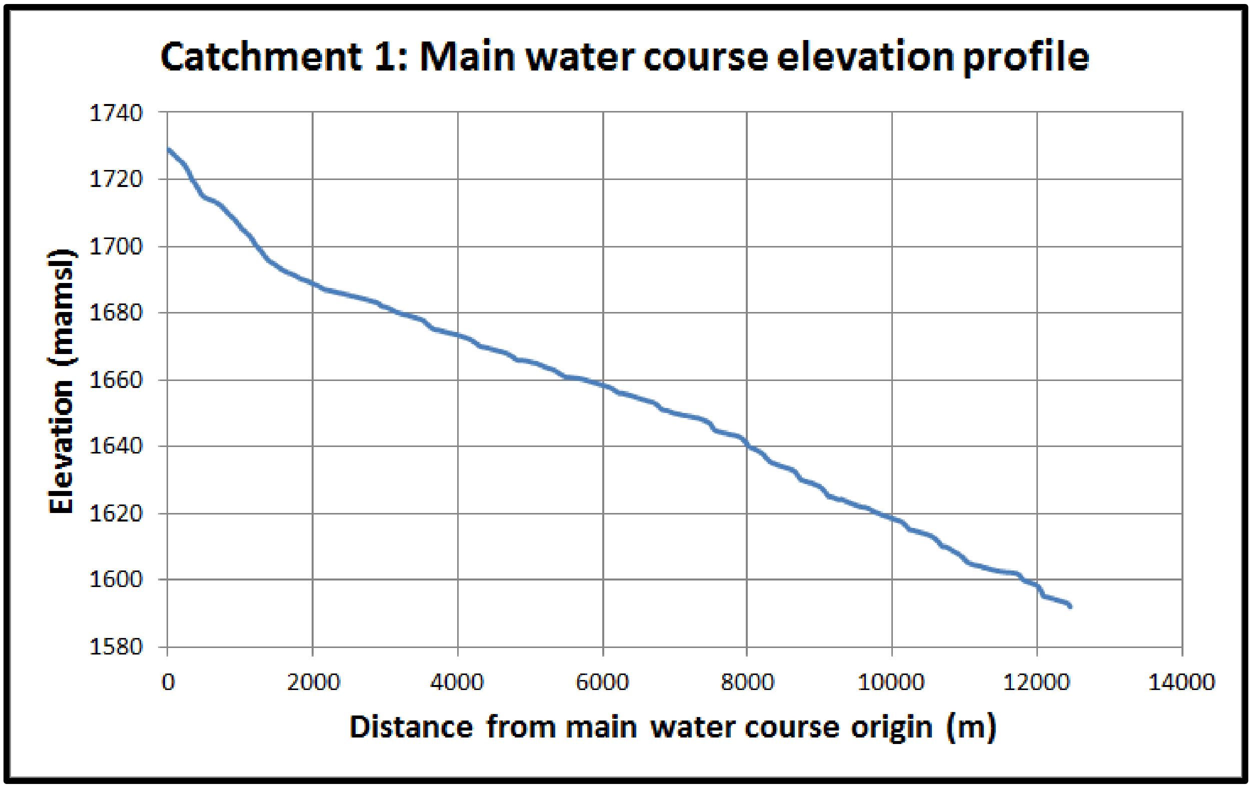


Figure 27: Catchment 1 longest water course

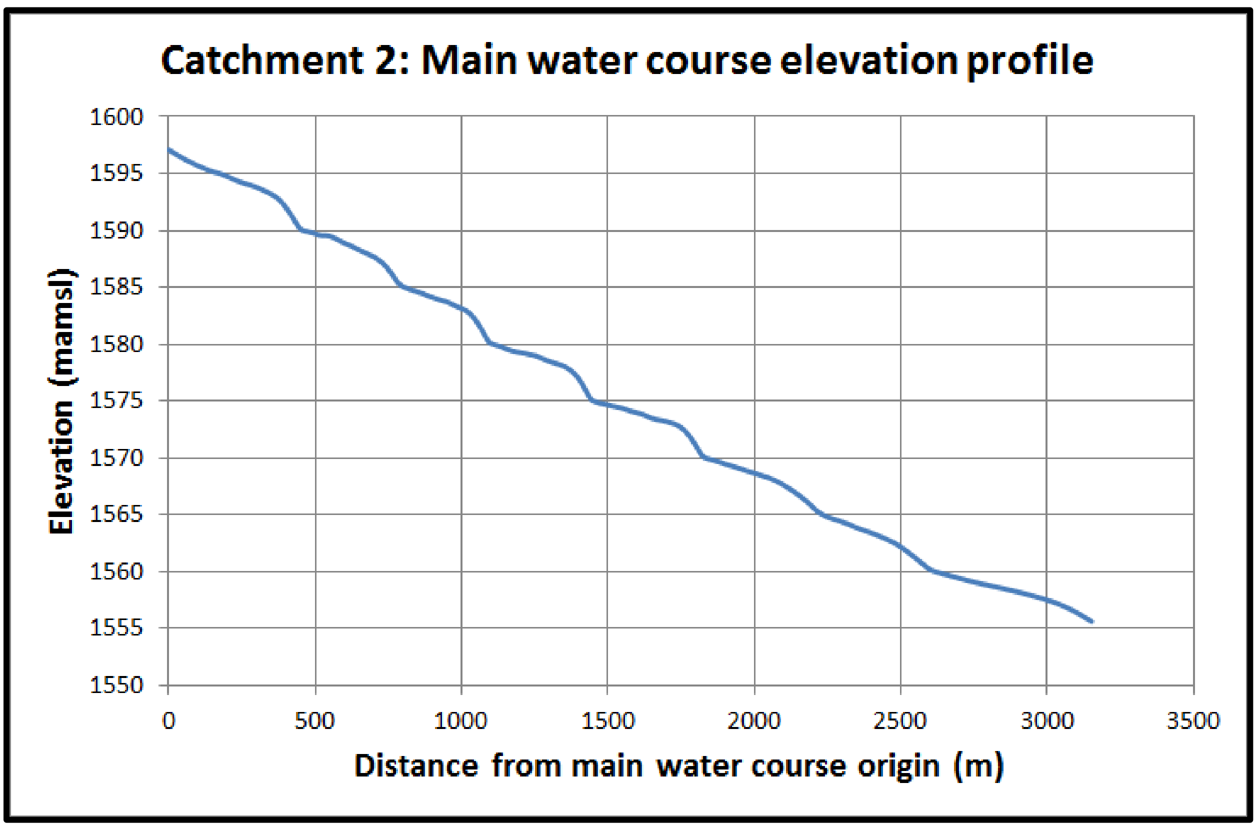


Figure 28: Catchment 2 longest water course

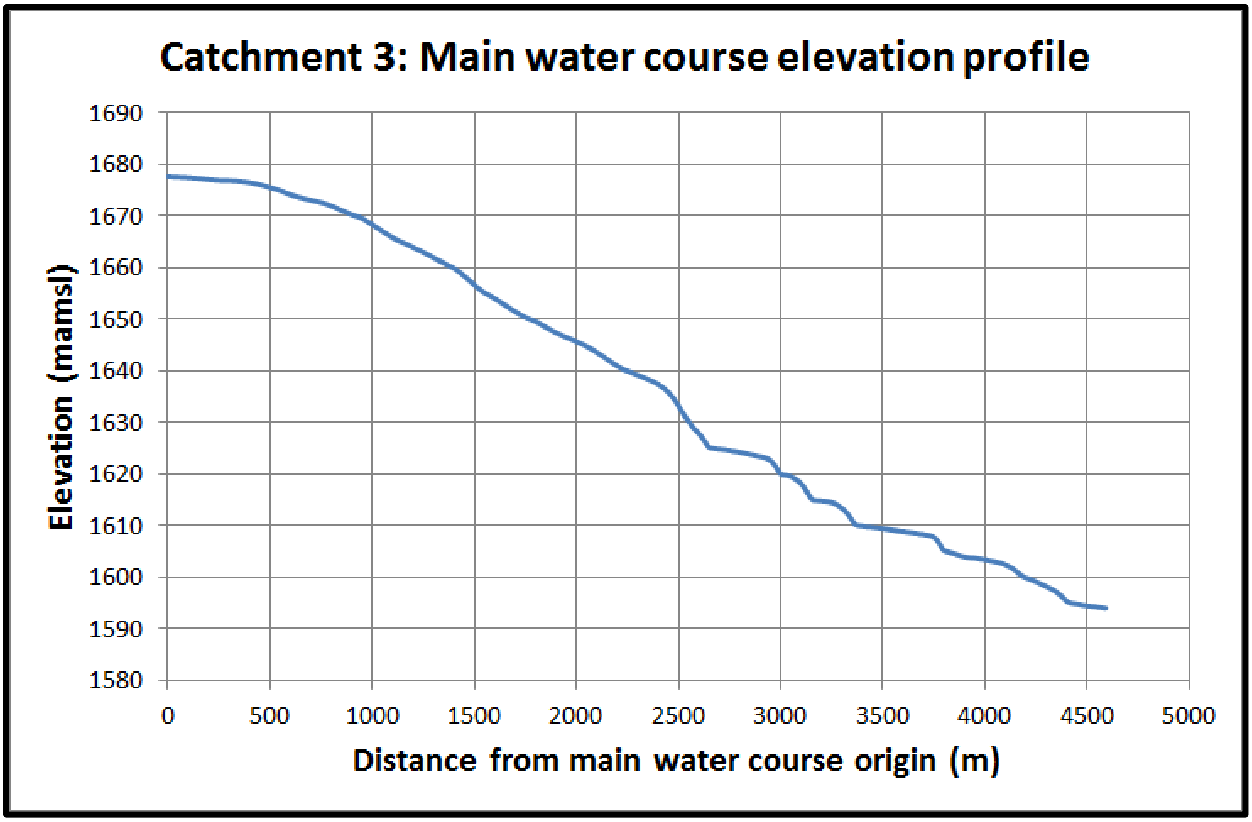


Figure 29: Catchment 3 longest water course

3.2.3.2 Cross section used in flood line calculation

Cross sections obtained from a DEM only represent the "surface profiles" and not the channels itself; therefore the flood lines will be a conservative estimate. Determined cross sections are presented in Appendix 2.

3.2.3.3 Hydrological soil and land cover

The hydrological soils and land cover for the three catchments as derived respectively from Shultze 2006 and SANBI 2009 are shown in Figure 30 and Figure 31 respectively.

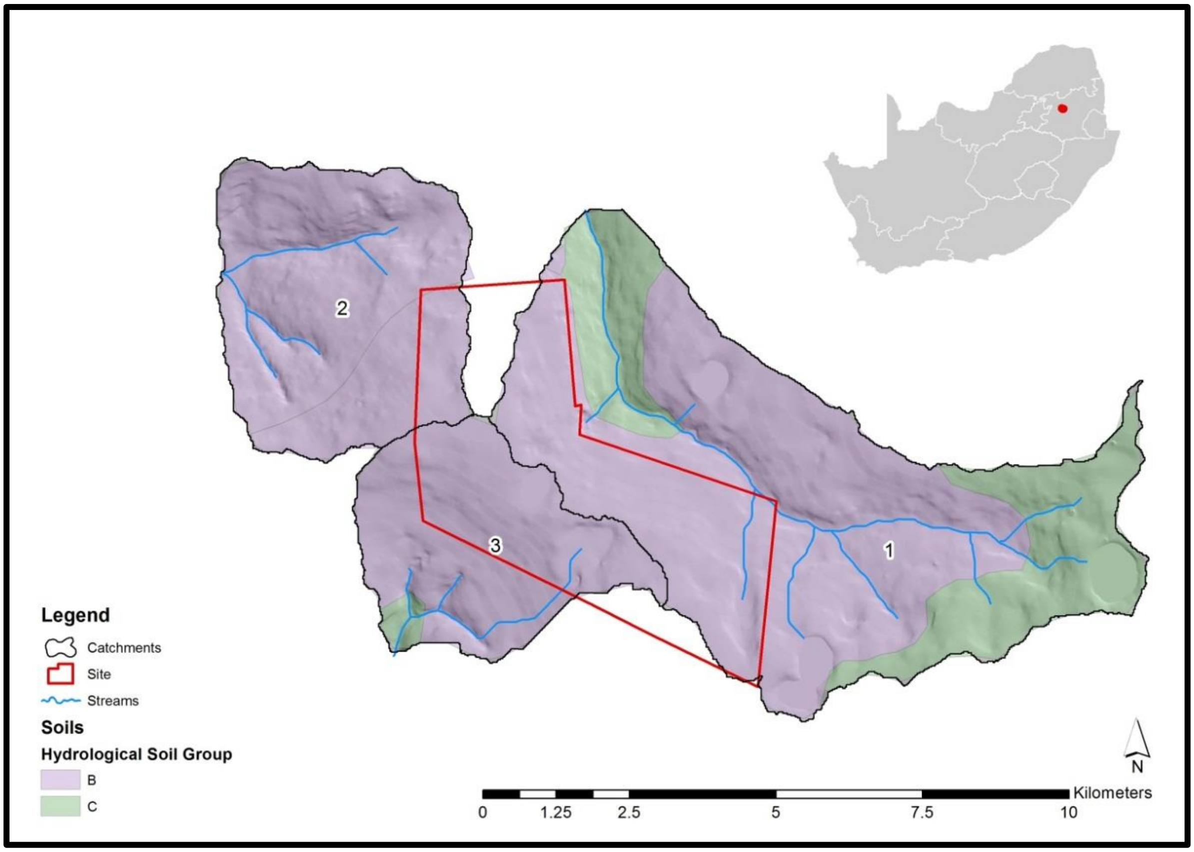


Figure 30: Hydrological soil grouping for floodline catchments

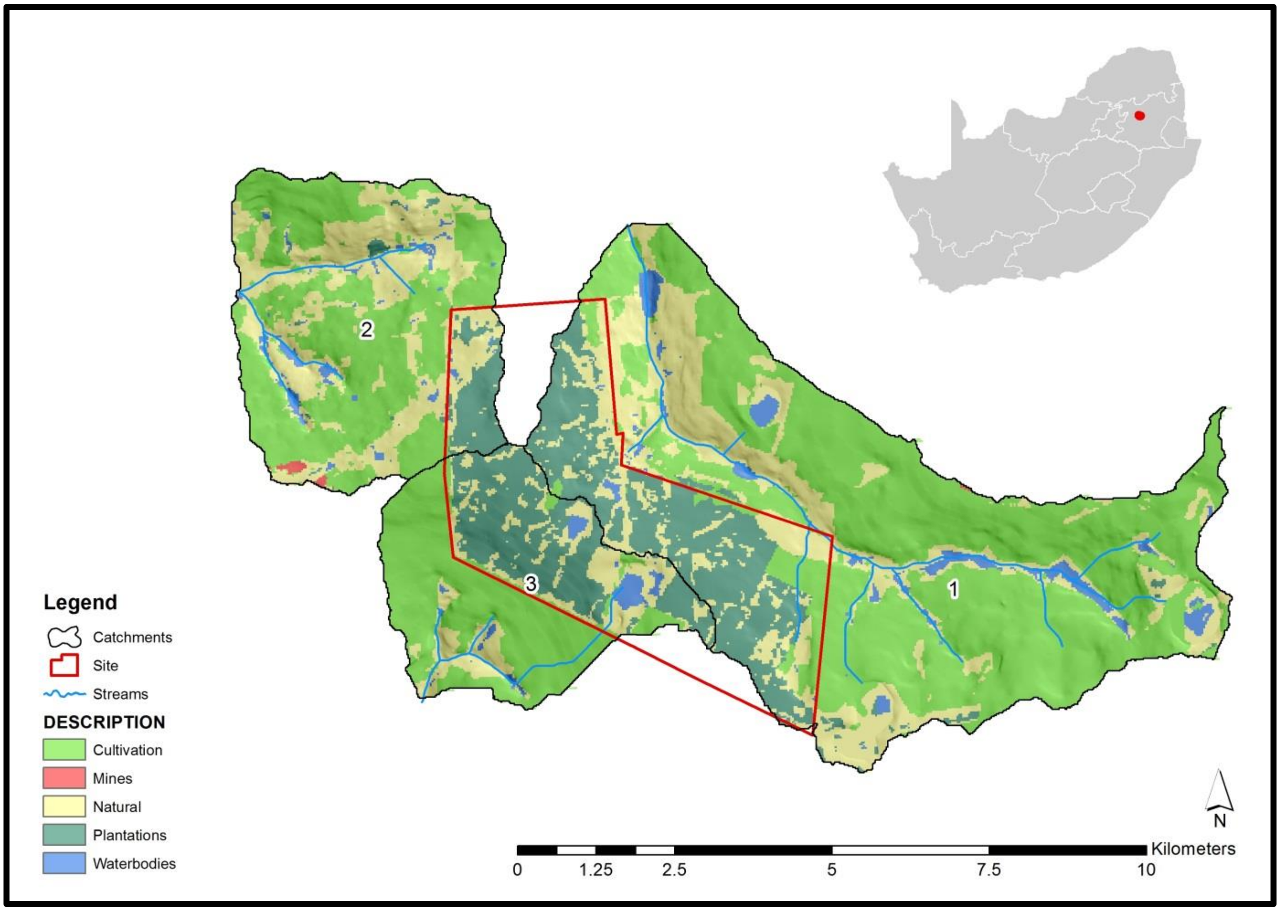


Figure 31: Land cover for floodline catchments

3.2.3.4 Flood peak calculation

To be able to generate flood lines, flood peak values are required. Various methods exist to accomplish this without the use of a rainfall runoff model and the method chosen here is the SCS-SA method. Aerial reduction factors were applied to the catchments making use of the following relationship as described in the SANRAL Drainage Manual:

$$ARF = (9000 - 12800\ln(A) + 9830\ln(60T_C))^{0.4}$$

Where: ARF denotes aerial reduction factor, *Tc* denotes the time of concentration and *A* denotes the area of the catchment. Other catchment parameter was obtained through the use of the soils and land cover maps. The detail calculations are presented Appendix A.

3.3 Models results

3.3.1 Regional surface water model results

The results of the regional surface water model compared to that of the WR2005 are shown in Figure 32, Figure 33 and Figure 34 for Outputs 1 to 3 as shown in Figure 23. Good comparison is obtained for both Output 2 and 3 over all ranges of flow. Output 1 has good calibration with peak flows which is important for storm water simulations, but shows a slightly weaker comparison for the low flow conditions.

The overall results compare very well to that of the WR2005 data in the absence of actual flow gauging data. If assumed that proper calibration was done in the WR2005 project then the regional surface water model can also be considered a well calibrated model. The catchment parameters are scaled down to site level to setup the local storm water model.

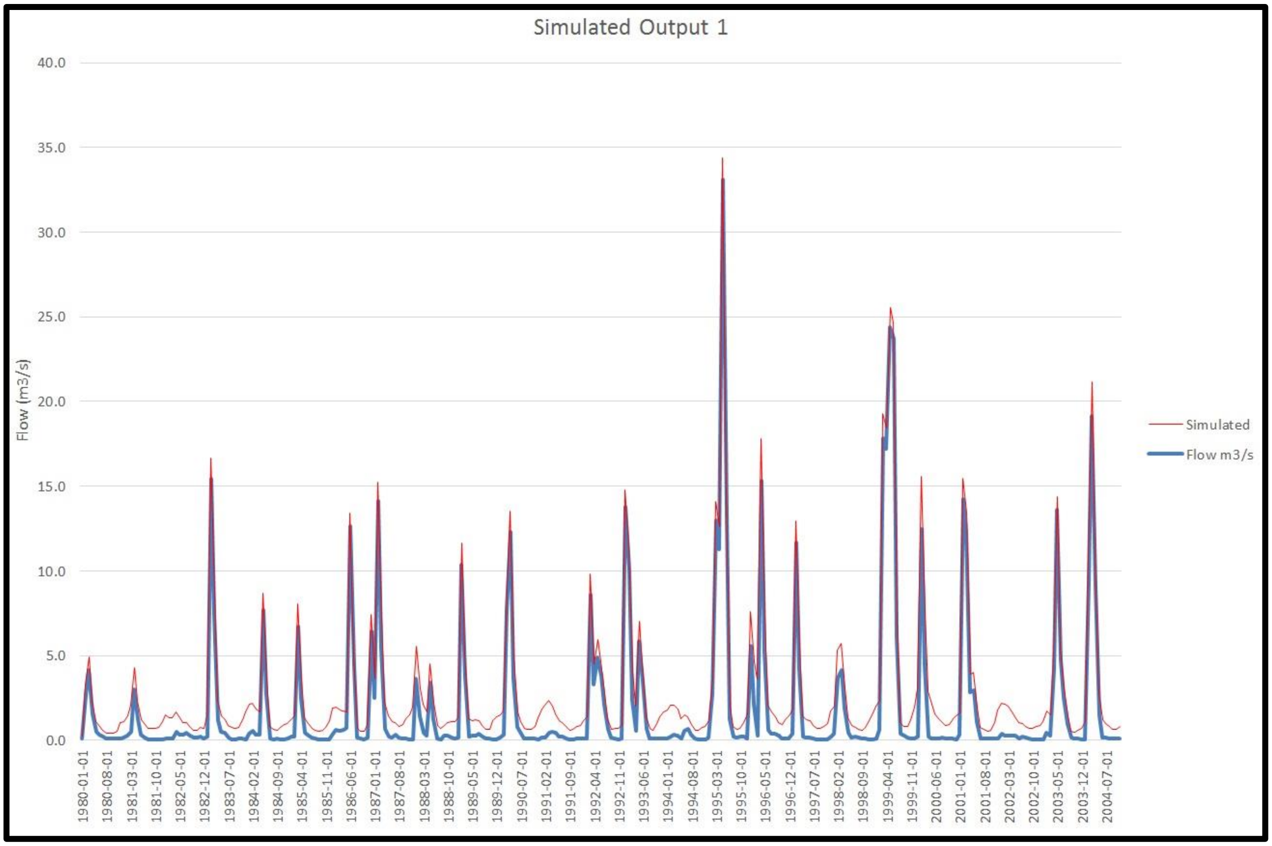


Figure 32: Simulated flow for Output 1

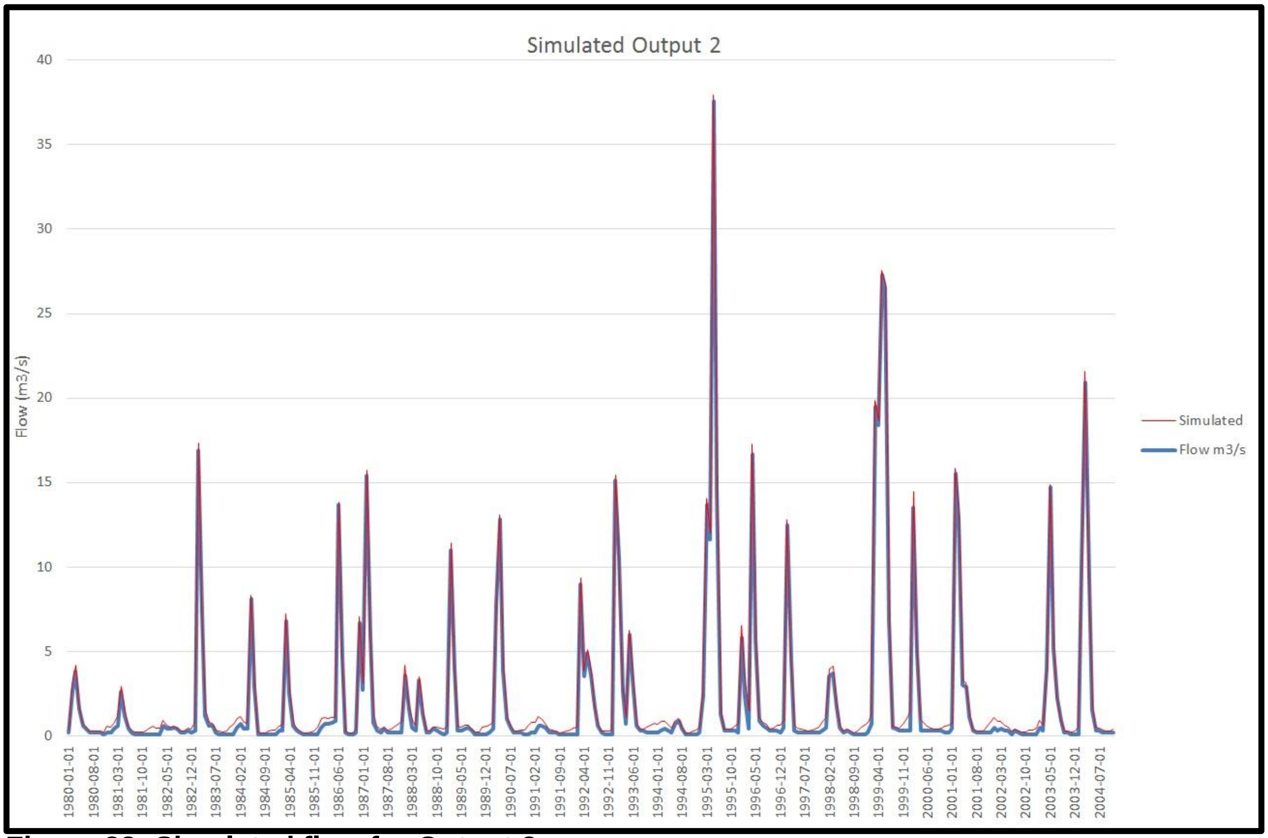


Figure 33: Simulated flow for Output 2

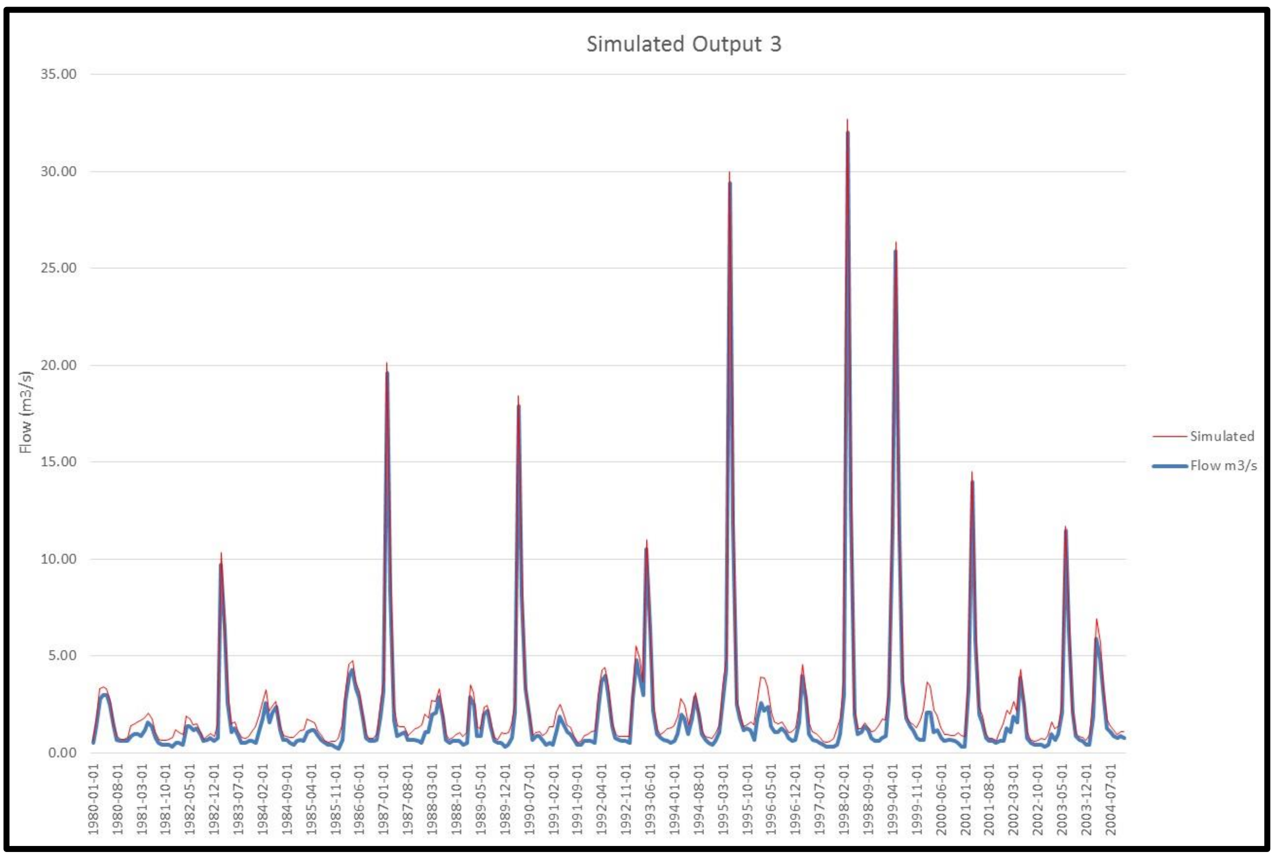


Figure 34: Simulated flow for Output 3

3.3.2 Local storm water model results

The simulated monthly averages for the clean and dirty water dams are presented in Figure 35 and Figure 36 respectively.

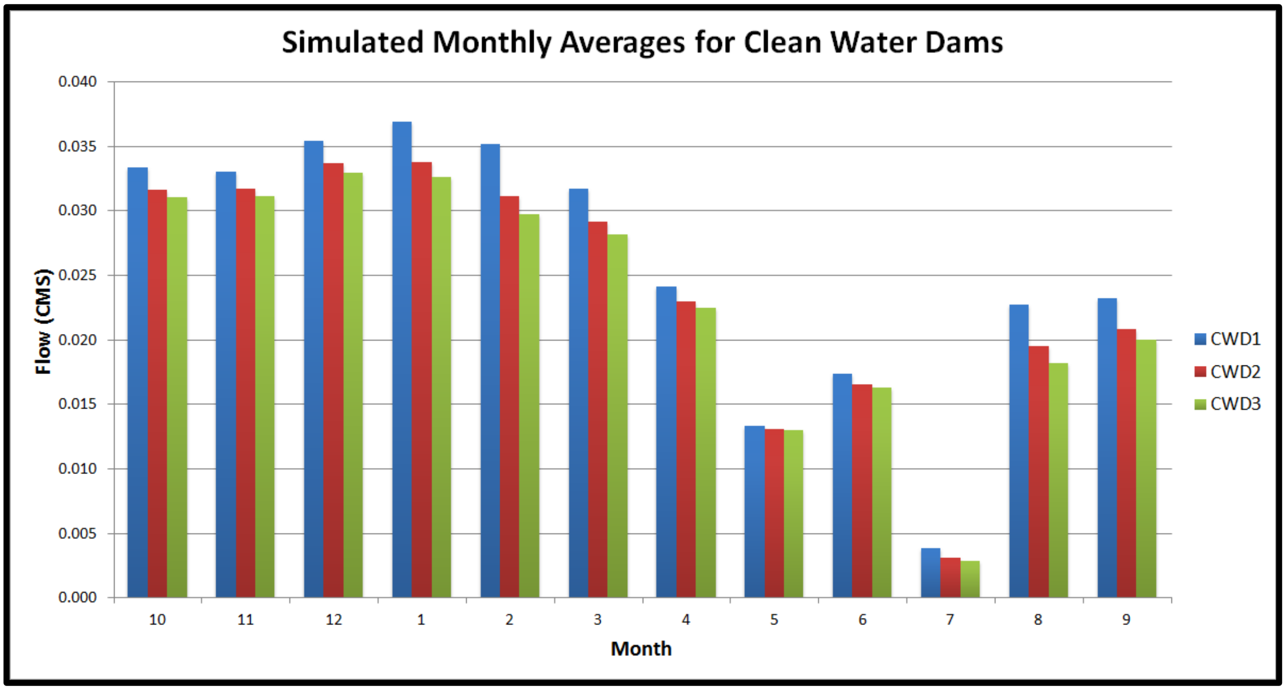


Figure 35: Simulated monthly averages for the clean water dams

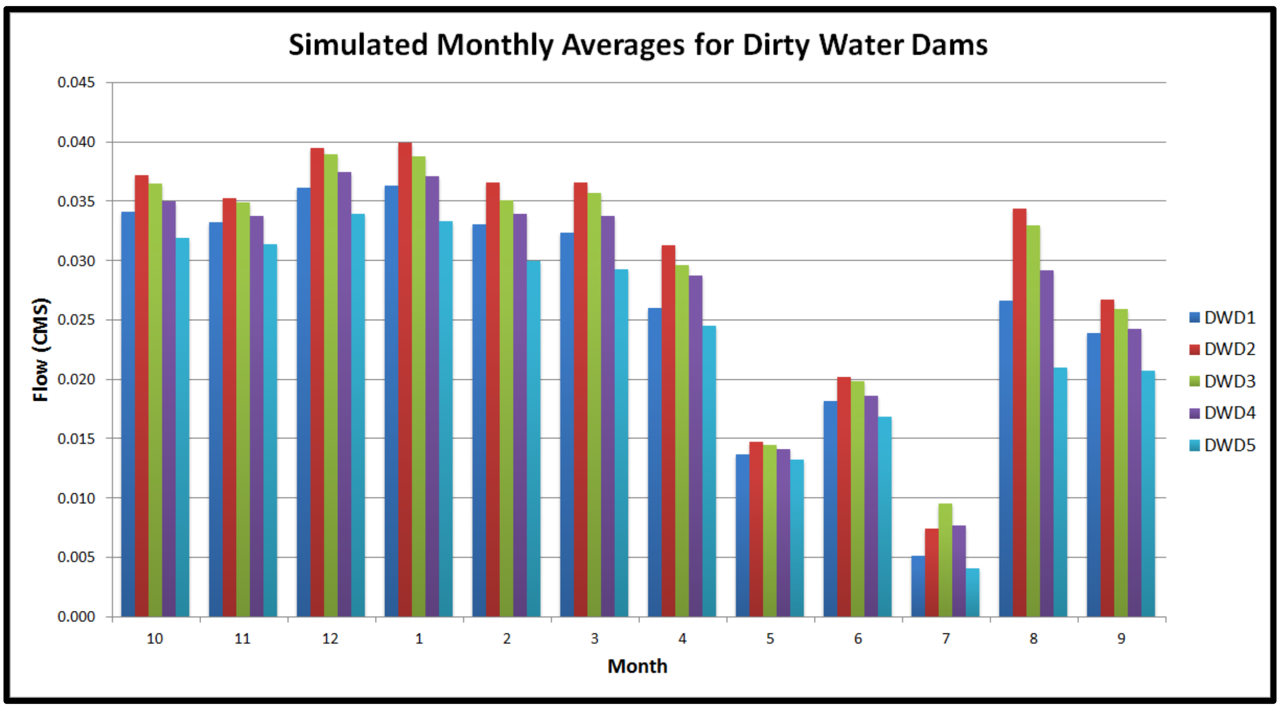


Figure 36: Simulated monthly averages for dirty water dams

A monthly comparison of the total clean water vs. the total dirty water is presented in Figure 37 and the total clean water flow is an estimated 34% of all flow on the site as shown in Figure 38. Note that the total flow on the site presented here excludes the water to be pumped from the pit during operation.

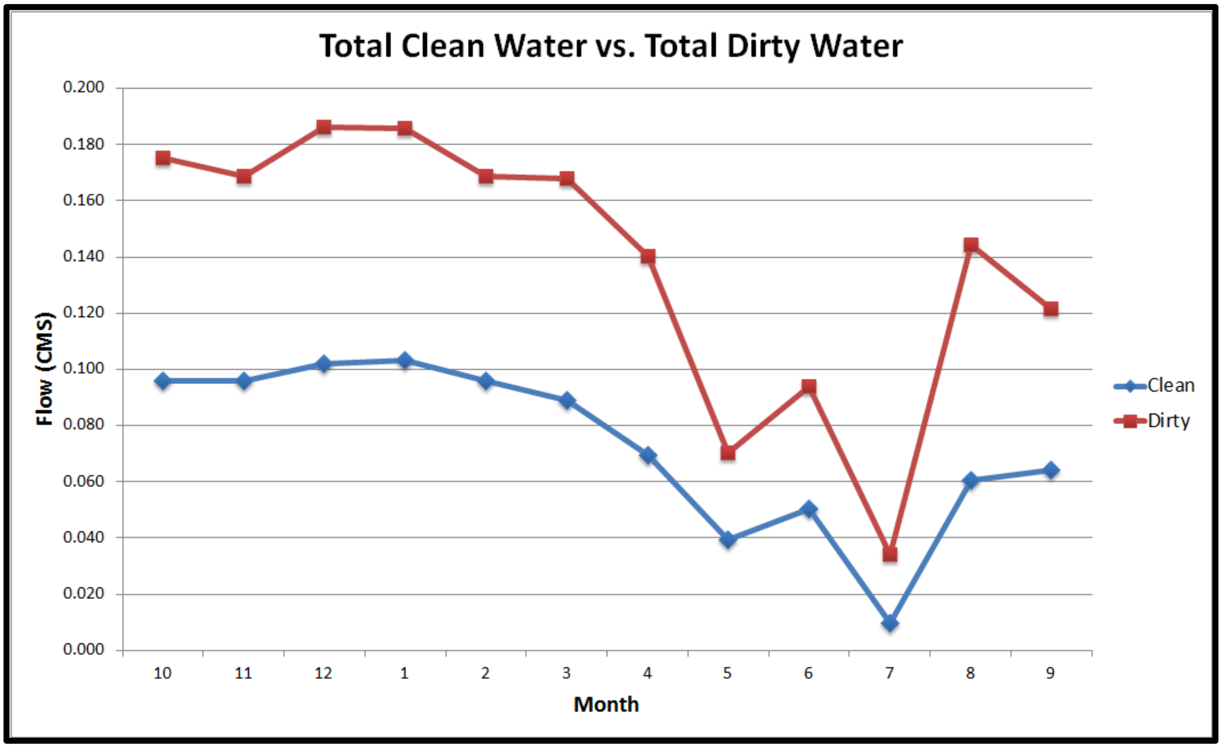


Figure 37: Total clean water vs. total dirty water on monthly basis

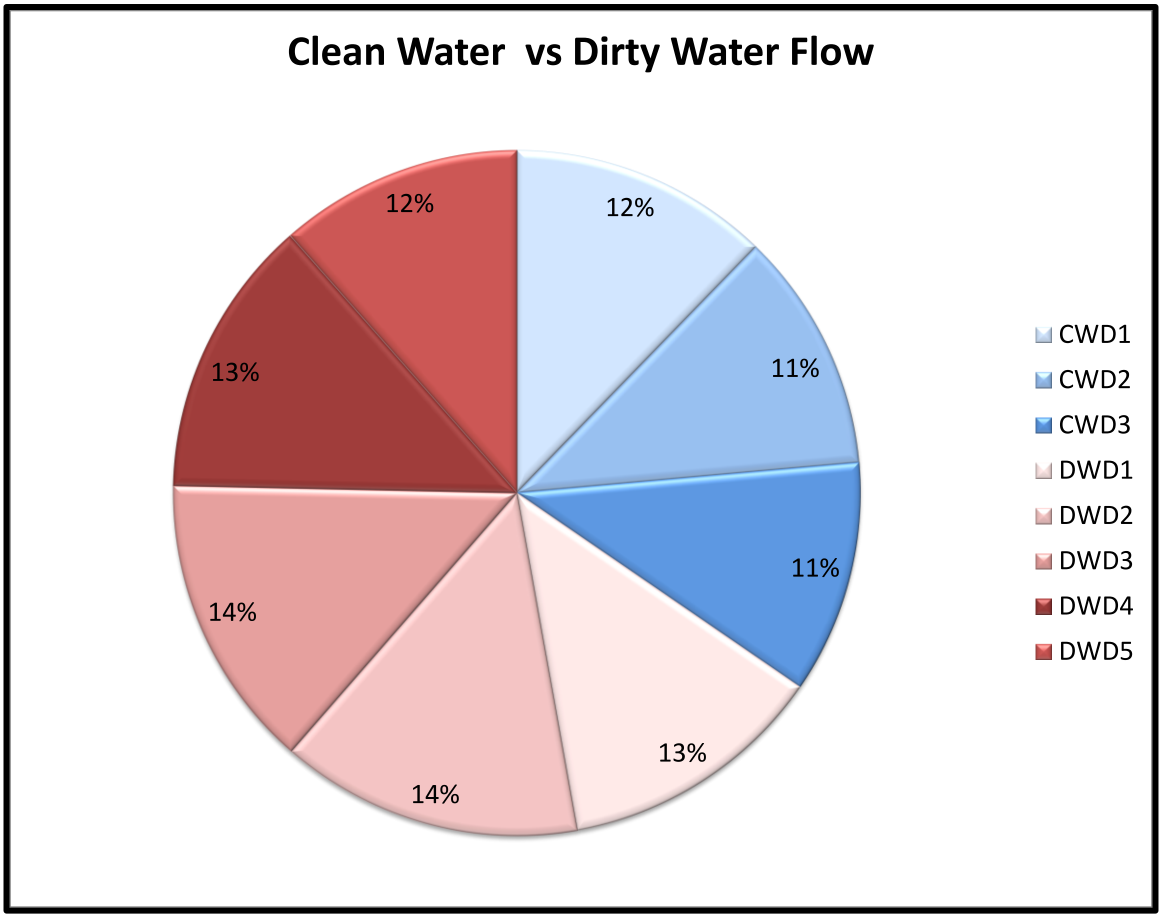


Figure 38: Contribution of flow to each dam

Assuming a general trapezoidal channel shape for all channels as shown in Figure 39, the required sizes to contain peak flow are presented in Table 10

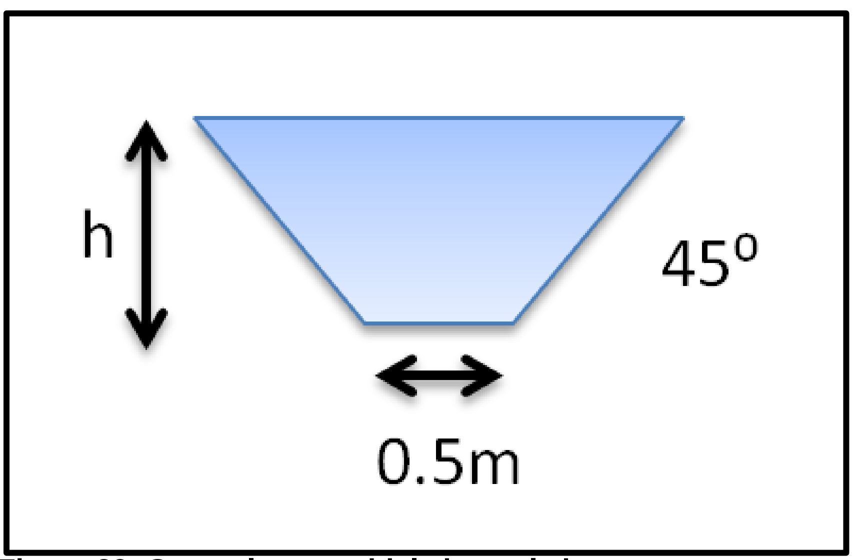


Figure 39: General trapezoidal channel shape

Table 10: Channel sizing based on generic trapezoidal shape

Canal to Dam	h(m) Based on peak flow
CWD 1	0.16
CWD 2	0.12
CWD 3	0.48
DWD 1	0.12
DWD 2	0.14
DWD 3	0.12
DWD 4	0.12
DWD 5	0.09

The individual dam sizes based on a dam with a maximum depth of 1 m that will contain the peak flow in the simulated rainfall records are presented in Table 11. The same evaporation sequences were applied to the storm water model as what was applied in the regional surface water model.

Table 11: Dam capacities to contain peak flow

Dam	Volume (m3)
CWD 1	140,000
CWD 2	55,000
CWD 3	35,000
DWD 1	50,000
DWD 2	82,000
DWD 3	60,000
DWD 4	44,000
DWD 5	18,000

3.3.3 Flood lines calculation results

A summary of the calculated flood peaks (using SCS-SA) per catchment is presented Table 12.

Table 12: Summary of flood peak calculations (m^3/s)

Catchment	Return Period (years)					
	1:2	**1:5**	**1:10**	**1:20**	**1:50**	**1:100**
1	4.43	7.52	9.96	12.60	16.39	19.52
2	7.61	12.89	17.07	21.55	28.00	33.32
3	3.35	5.78	7.73	9.84	12.89	15.43

The 1:100 year flood line is shown in Figure 40. Selected cross sections for the three catchments are presented in Appendix B.

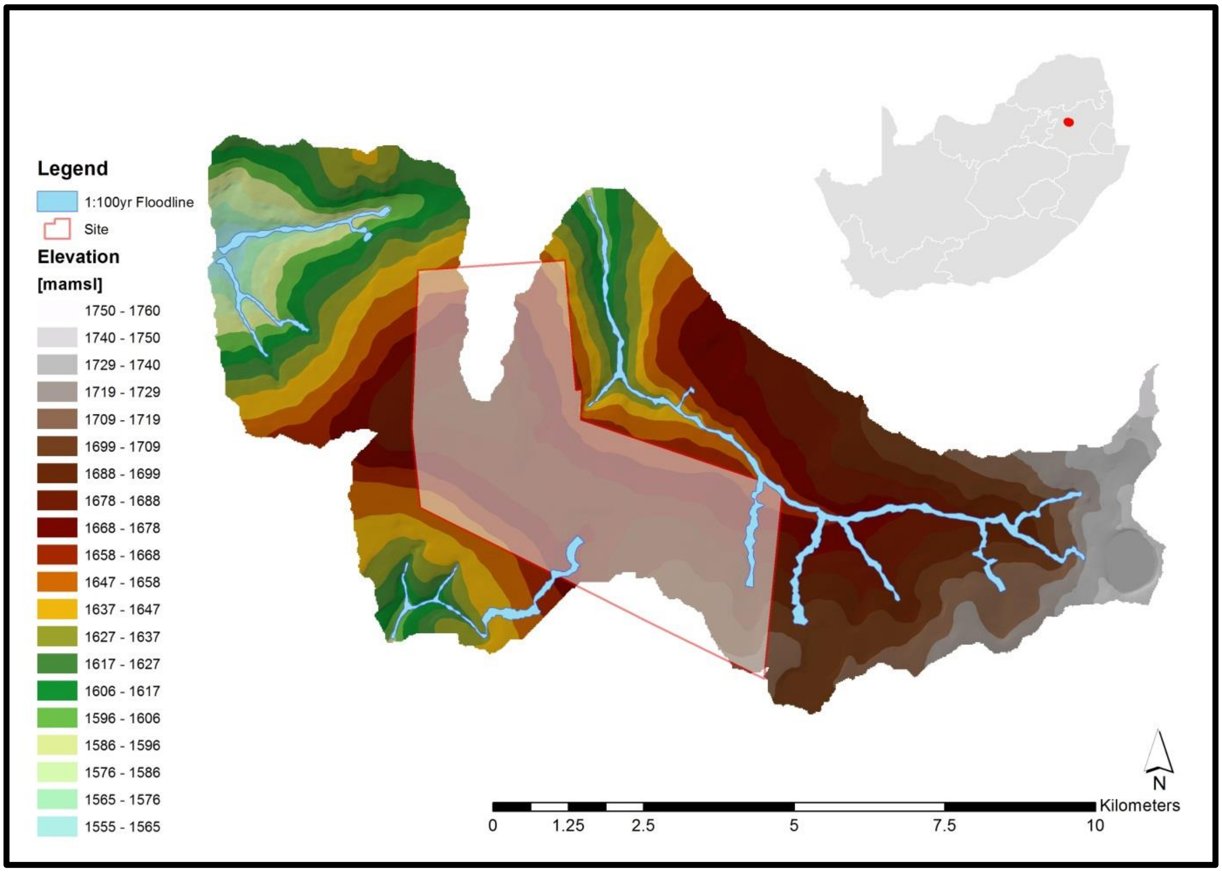


Figure 40: 1:100year flood line

The flood lines in relation to the infrastructure are shown in Figure 41. The flood line in catchment "3" (southern side of mine lease area) is running close to the pit. The flood line profile is broad in these areas because the natural channel is not well defined as it is situated on the watershed. Furthermore, the calculated flood peak is applied to the whole of the catchment resulting in an over estimation of the flood lines upstream. It is proposed to divert part of this water to clean water dam 3 (CWD3) through the use of a storm water channel.

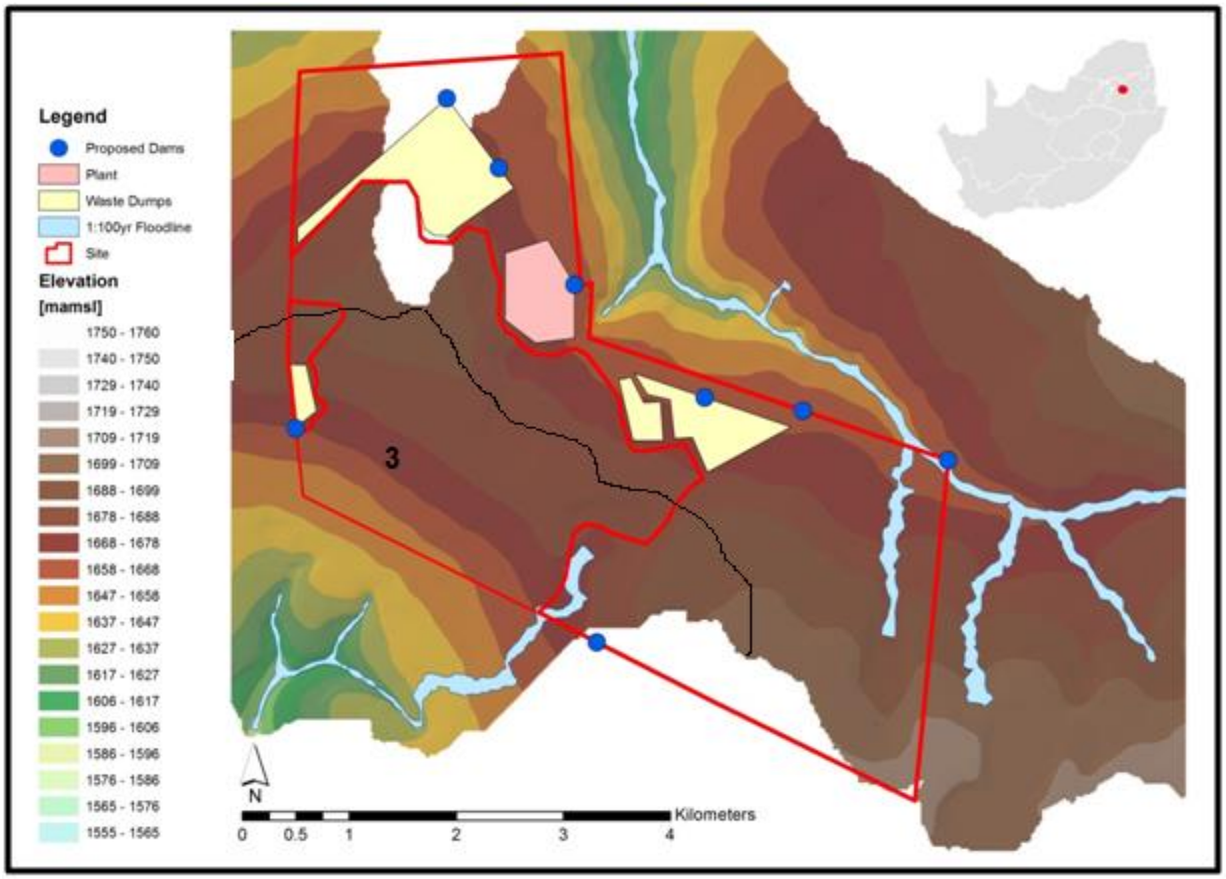


Figure 41: 1:100year flood line in relation to infrastructure

3.4 Key Constraints

The key constraints at this point include:

- DEM data are not sufficient to accurately calculate flood lines. This may results in misestimating of the real cross section, which was supposed to be surveyed.
- Limited flow gauge information, which results in using of WR2005 to set up a regional flow model, and subsequently downscaled to local storm water flow model. Field observation would result in more reliable results.

4 Impacts on surface water

The environmental impact assessment has been undertaken based on DEAT's (1998) Guideline Document: EIA Regulations (Appendix 1).

The overall objective of this assessment is to provide recommendations on how to prevent or minimise impacts arising from the proposed Rietvlei Mine development. The specific actions needed to meet this objective for each project phase are set out. The potential impacts are discussed in light of the following:

- potential surface water impact : the effect on the surface water with respect to who or what will be impacted and how this impact will be felt;
- natural and existing mitigation conditions : natural conditions, conditions inherent in project design and proposed management measures that modify impacts (control, moderate, enhance);
- significance of impact : the significance of the unmanaged and managed impacts taking into consideration the probability of the impact occurring, the extent over which the impact will be experienced, and the intensity/severity of the impacts (requires consideration of unknown risks, reversibility, violation of laws, precedents for future action and cumulative effects).

4.1 Potential project impacts

The potential impacts on are associated with activities during the construction phase, operation phase, and the closure and post-closure phases of the coal mining project.

4.1.1 Construction phase

The mine is situated in the headwater of the catchments and no major build-up of flows is expected to happen,

The clearing of topsoil for footprint areas associated with construction activities (waste site, water control infrastructures, cut and fill) can increase siltation to the surface water resource during soil turning activities. Drainage lines flowing into the mining area will however have to be diverted to prevent clean water from entering the mining area and increase the risk of flooding. Slope associated with berms, and rerouting of the storm water runoff may enhance erosion and siltation, and flood risk at the receiving stream (river)

The construction activities are likely to be associated with accidental spills of hydrocarbons (oils, diesel etc) from the construction vehicles, and other potentially hazardous chemicals during the construction phase. Such spills together with the construction waste constitute potential source of surface water contamination if not properly handled.

The design of the site infrastructure (rock dumps, discard dump, washing crushing plant) should take into account the specification stipulated in GN 36784. Thus construction may result in and the disturbance of Sub-catchment storm water runoff.

The following impacts have been considered and quantified during the construction phase:

- Siltation due to soil disturbance;
- Erosion due to berms and rerouting of natural surface drainage
- Deterioration of water quality due to :
    - construction waste (Chemical in construction material);
    - Hydrocarbon spills and/or leaking from storage (organic contaminants), construction vehicles and equipments.

Without any mitigation measures the impacts significance from construction of the proposed Rietvlei Mine are rated from very low to low (Table 13).

4.1.2 Operational phase

During mining phase, surface water runoff may enter the operating (open pit, crushing/washing plant, stockpiles, etc...) and waste disposal area if not properly managed. This would result on the deterioration of clean surface water runoff. Water (groundwater, rainfall) will need to be pumped from the pit and groundwater, and store at the surface, for mine safety. Water from the operating areas, is considered dirty, and when not stored adequately constitutes a potential source of surface water pollution. Exposed disposed water may increase evaporation rate on site.

Mine activities that may impact on surface water are:

- Overburden dumping: the exposure of rock dumps, result in dirty water that may contaminate surface water, if not properly managed.
- Stockpiling and transport: the exposure of stockpiling and transporting of coal, to water and oxygen, together with hydrocarbon spills from storage (organic contaminants) may also result in contamination of surface water.
- Coal processing: coal will be exposed at the washing plant area to water (with chemical) and oxygen, resulting in dirty water, and spills/slurry from the site can contaminate surface water;
- Tailing disposal: residual from coal processing will be disposed of onsite at designated are or in pit. Such disposal when not handled correctly, constitute a potential source of water contamination;
- Septic tank: spillage from septic may constitute source of bacteriological contamination to surface water. If not properly managed.

Dirty water from any of these activities should be drained, or pumped (where required) to pollution control dams. Pollution control dams, and contaminated water drains constitute potential sources of surface water contamination as result of leakage trough improper barrier system (absent, or leaking).

Handling and transport of waste material have some potential of contaminating surface water, including domestic waste, sewage water, hydrocarbons (storage).

The following impacts have been considered and quantified during the operation phase:

- Erosion due to change in sub catchment drainage disturbance (Increased runoff speed and velocity);
- Siltation due to change in sub catchment drainage disturbance (Increased runoff speed and velocity);
- Water quality deterioration due to :
    - Mining operation (blasting, crushing, washing);
    - Spillage, leaking from hydrocarbon or other hazardous substance storage;
    - Spillage, seepage and/or leak from waste disposal, storage, handling facility;
    - Spillage of septic tank

Without any mitigation measures the impacts significance from the proposed Rietvlei Mine operation activities are rated from Very Low to Medium High (Table 14) with a predominance of low medium. The Medium High impact significance is associated with the potential clean surface water runoff deterioration.

4.1.3 Closure phase

The closing of mining activities and rehabilitation will be concurrently undertaken. Compaction equipment will include driving vehicle. All disused infrastructure will be demolished, and waste from demolition has to be removed from site and disposed at designated site.

Surface water contaminants from the mine (including backfilled opencast pits and return water dams) can be enhanced.

Activities such as covering of the spillages with sand and collection and possibly treatment etc are likely to be associated with accidental spills of hydrocarbons (oils, diesel etc).

Dewatering would be stopped at that stage, and open pit flooding will occur, as recovering of groundwater levels, and subsequent decant to the surface is expected at the lowest mining area. The closure phase is usually too short to see the any evidence of decant. Decommissioning/closure is only complete once the proponent demonstrates no significant impacts. The following impacts have been considered and quantified during the closure phase:

- Erosion due to increase runoff speed and velocity (compaction, shaping);
- Siltation due to increase runoff speed and velocity (compaction, shaping);
- Deterioration of surface water quality due to:
    - Spillage, leaking of hydrocarbon product
    - waste, and spills related to closure activities;

Without any mitigation measures the impacts significance from closure of the proposed Rietvlei Mine are rated from Very Low to Low Medium (Table 15).

4.1.4 Post-Closure phase

At post closure phase, the main potential surface water impacts to be considered and quantify are:

- Deterioration of surface water quality by decanting water,
- Flooding due to decanting water;
- Erosion associated with runoff of decanting water

Without any mitigation measures the impacts significance from closure of the proposed Rietvlei Mine are rated from Very Low to Very High (Table 16).

4.2 Cumulative impacts

No significant pollution source has been identified on site or surrounding, that may cumulatively with the project, impacts on background water quality. However the background water quality as established from two sampling points (Selons River, Dam) is assumed to be related to surrounding activities (agricultural). As no historical observation is available locally, the background flow variation is not known, but it is assumed that flow may be reducing as regional trend. The following impacts have been considered as cumulative impacts:

- Cumulating of reduction of water flow as result of water management (storage, diversion);
- Cumulating of water quality deterioration from mine activities with existing contaminants.

4.3 Mitigation measures

- The development of proposed Rietvlei Mine poses risks to surface water as assessed. The proper design, construction and operation, and maintenance of the appropriate draining and storing facilities, as well as the rehabilitation of the open mine, are part of the key focus areas to mitigate surface water impacts. The following precautions have to be taken into consideration to reduce possible surface water risks posed by the development of proposed Rietvlei Mine:
- Surface water management strategic plan must be implemented to prevent risk of water pollution;

- Surface water monitoring network should be installed before the starting of any construction activities on site and monitoring network can be updated according to the DWA minimum requirements, if required;
- Waste classification is required in order to influence design parameters and make recommendations with regards to design and monitoring requirements. These must be adhered to in order to prevent or minimise seepage from waste disposal areas;
- Any waste and spills (specially during construction, operation and closure) need to be cleaned up immediately according to the DWA minimum requirements;
- Authorities need to be notified in the event of a spill or leachate during construction, operation and closure;
- Clean and dirty water is to be separated;
- Regular maintenance of vehicles must be implemented;
- Trucks need to be capped to minimise spillage of coal or wastes, on roads;
- The reusing dirty water from mine activities must be assessed and implemented as much as possible;
- All hazardous substances must be handle according to the requirements of relevant legislation relating to the transport, storage and use of the substance;
- The area to be used for storage of any hazardous waste and items which contains hazardous substance must be lined with bounded walls to prevent pollution of surface water should a leakage/spillage occur;

4.3.1 Prior to construction

- During design phase, the waste and water management infrastructures at proposed Rietvlei Mine (included dams, drains, waste area) must be designed with the appropriate water barrier system if required, and comply with the DWA minimum requirements (1998/2012/2013), with special focus on the R634, R635, R636 of the NEMWA 2008;
- Design of the mine facilities to be conducted by an accredited or recognised professional designer;
- All dirty surface water control facilities (dam, drain) must be designed to have a minimum freeboard above full supply level, at such manner that they can always handle 1:50 year flood-event on top of its mean operational level;
- Water management infrastructure (separate clean and dirty water systems) should be in place before the commencement of construction activities.

4.3.2 During construction

- A proper construction phase should be carried out under the supervision of an accredited or recognised professional civil engineer, as approved by the designer;
- Storage area for hydrocarbons or any toxic construction material should be bounded according to DWA minimum requirement;
- Compaction of the area should take place during base preparation. t on top of its mean operation level;
- Sloping of the area as to allow for free runoff, towards designated pollution control structure;
- Management of speed versus velocity aspects if and when required as to prevent erosion gullies from forming.

4.3.3 During operation

- Contaminated water drain (within the waste site) and dam must be properly operated and maintained;
- All surface dirty water control facilities (dam, drain) must be operated to have a minimum freeboard above full supply level, at such manner that they can always handle 1:50 year flood-event on top of its mean operation level;
- Keep contamination to a minimum by keeping the pit as dry as possible (dewatering) to reduce contact time of water and oxygen with exposed strata;
- Reduce the amount of water to be removed from the pit area by keeping the operating pit area as small as possible, and by continuously rehabilitating the closed pit area;
- Equip trenches and gullies with energy dissipater, and conduct frequent inspections and maintenances;
- Suspended solids should filter out (silt trap) before dirty water enters pollution control dams, and regular inspections and maintenances should follow;
- Routing of sewage to the municipality sewage works;
- Water and mass balance should be determined and updated regularly.

4.3.4 At the closure and post closure

- Implement closure of open pit progressively;
- Effectiveness of existing monitoring network should be re-evaluated;
- Rubble from waste or contaminated areas should be dismantled and disposed of accordingly;

- Backfill material to be fully compacted and covered, and the entire foot print of waste to be shaped for free-draining;
- Rehabilitation to follow backfilling compaction;
- Rehabilitation should consist of re-vegetating the site using appropriately chosen indigenous grasses. Control of vegetation cover over the rehabilitated area;
- A rehabilitation plan must be implemented and the plan should be done in the line with the contents of NWA (Act No 36 of 1998), to avoid subsequent negative environmental impacts that may occur;
- Continue monitoring until it can be demonstrated that vegetation is self-sustaining and no erosion channels exist;
- Clean water system and dirty water system should be maintained on site;
- Inspection and maintenance should be implemented after removal of materials associated with mining on site.

Table 13: Construction phase impacts

Potential impacts to surface water	Environmental significance score								Recommended mitigation measures	Environmental significance score							
	S	SE	DI	C	FA	FI	L	IS		S	SE	DI	C	FA	FI	L	IS
Construction																	
Siltation due to soil disturbance	1	1	2	4	1	4	5	20	Water management infrastructure (separate clean and dirty water systems) should be in place before the commencement of construction activities. Compaction of the area during base preparation.	1	1	1	3	1	2	3	9
Erosion due to rerouting of storm water runoff	1	1	2	4	1	4	5	20	Sloping of the area as to allow for free runoff, either towards pollution controls structure or away from the site pending on whether the water is clean or dirty. Management of speed versus velocity aspects if and when required as to prevent erosion gullies from forming. Inspections and maintenance.	1	1	1	3	1	2	3	9
Water quality deterioration due to Spill and /or leaking of hydrocarbon product from construction vehicles,	3	3	1	7	2	3	5	35	Hydrocarbon product storage area should be bounded, and collected rainwater to be removed to keep the area dry	1	1	1	3	1	1	2	6

equipments, and storage																	
Water quality deterioration due to seepage from construction waste site to the surface water resource	3	2	3	8	3	2	5	40	Waste classification is required in order to influence design parameters and make recommendations with regards to design and monitoring requirements. These must be adhered to in order to prevent or minimise seepage from waste disposal areas.	1	1	1	3	1	2	3	9

Table 14: Operation phase impacts

Potential impacts to surface water	Environmental significance score								Recommended mitigation measures	Environmental significance score							
	S	SE	DI	C	FA	FI	L	IS		S	SE	DI	C	FA	FI	L	IS
Operation																	
Deterioration of clean storm water runoff quality	3	3	4	10	4	5	9	90	Separate clean water from dirty water at upstream and divert clean water around the operating area (screening and crushing areas, stockpile area) and disposal areas as to prevent it from entering these areas. Contaminated run-off water from the operating area should be drained to a pollution control dam. Waste classification and management will be of great importance	1	1	2	4	1	2	3	12
Increasing of water removal activities due to in pit dewatering	2	2	2	6	2	3	5	30	Reduce the amount of water to be removed from the pit area by means of effective clean and dirty water system, by keeping the operating pit area as small as possible, and by continuously rehabilitating the closed pit area.	1	1	1	3	1	2	3	9
Ponding due to storm water falling onto operating (mining pit, crushing and screening, stockpiling) areas	2	2	2	6	2	3	5	30	Contaminated storm water from operating area (mining pit, crushing and screening, stockpiling) should be drained to a pollution controlled dam, which should be design according to appropriate regulations.	1	1	1	3	1	1	2	6

Erosion due to surface water runoff rerouting	1	1	2	4	1	4	5	20	Equip trenches and gullies with energy dissipater, and conduct frequent inspections and maintenances.	1	1	1	3	1	1	2	6
Siltation due to surface water runoff rerouting	1	1	2	4	1	4	5	20	Suspended solids should filter out (silt trap) before dirty water enters pollution control dams, and regular inspections and maintenances should follow.	1	1	1	3	1	1	2	6
Water quality deterioration due spill and/or leaking of hydrocarbon	3	2	3	8	2	5	7	56	Hydrocarbon product storage area should be bounded, and collected rainwater to be removed to keep the area dry	1	1	1	3	1	2	3	9
Water quality deterioration due to septic tank	2	2	3	7	2	5	7	49	Routing of sewage to the municipality sewage works	1	1	2	4	1	2	3	12
Water quality deterioration due to seepage from waste disposal facility to the surface water resource	3	2	3	8	3	5	8	64	Waste classification is required in order to influence design parameters and make recommendations with regards to design, nd monitoring requirements. These must be adhered to in order to prevent or minimise seepage from waste disposal areas.	1	2	2	5	1	2	3	15
Water quality deterioration due to spillage, seepage and/or leak from waste disposal, storage, handling facility	3	2	3	8	3	5	8	64	Waste classification is required in order to influence design parameters and make recommendations with regards to design, and monitoring requirements. These must be adhered to in order to prevent or minimise seepage from	1	2	1	4	1	2	3	12

to surface water								waste disposal areas.								
Water quality deterioration due to Spillage of dirty water from dirty water control system (Dams, trenches, berms ect..)	3	2	3	8	3	5	8	64	All the different components of the dirty water control system should be design according to appropriate regulations. Water and mass balance should be determined and updated regularly.	1	2	1	4	1	2	3	12

Table 15: Closure phase impacts

Potential impacts to surface water	Environmental significance score								Recommended mitigation measures	Environmental significance score							
	S	SE	DI	C	FA	FI	L	IS		S	SE	DI	C	FA	FI	L	IS
Closure/Decommission																	
Erosion due to increase of runoff speed and velocity	1	1	2	4	1	4	5	20	Rehabilitation should consist of re-vegetating the site using appropriately chosen indigenous grasses. Control of vegetation cover over the rehabilitated area.	1	1	1	3	1	1	2	6
Siltation related to erosion	1	1	2	4	1	4	5	20	Clean water system and dirty water system should be maintained on site. Inspection and maintenance should implemented after removal of material s associated with mining on site	1	1	1	3	1	1	2	6
Deterioration of water quality due to spill and/or leaking from hydrocarbon storage are	3	3	3	9	3	5	8	72	Hydrocarbon product storage area should be bounded, and collected rainwater to be removed to keep the area dry	1	1	2	4	1	2	3	12
Deterioration of water quality due to seepage and/or spillage from waste site facility	3	3	3	9	3	5	8	72	Waste classification is required in order to influence design parameters and make recommendations with regards to design, and monitoring requirements. These must be adhered to in order to prevent or minimise	1	1	2	4	1	2	3	12

									seepage from waste disposal areas.							

Table 16: Post closure phase impacts

Potential impacts to surface water	Environmental significance score								Recommended mitigation measures	Environmental significance score							
	S	SE	DI	C	FA	FI	L	IS		S	SE	DI	C	FA	FI	L	IS
Post closure																	
Deterioration of the surface water quality due decanting water	4	4	5	13	5	5	10	130	Decant water should be contained (pollution control dam) or treated. Clean water runoff from decant area must be maximised by sloping the decant area , to minimise ingress of storm water.	2	3	2	7	2	2	4	28
Flood risk due decant to surface	3	3	4	10	3	4	7	70	Decant water should be drain to a specific pollution control dam.	2	1	1	4	1	2	3	12
Erosion due decant water runoff	1	1	2	4	1	3	4	16	Water run-off direction, and velocity as well as the geophysical conditions of the rehabilitated areas should be measured trough field surveys. A modelling simulation may be useful as management tool. The rehabilitated areas should be covered of vegetation and maintained	1	1	1	3	1	1	2	6

Table 17: Cumulative impacts

Potential cumulative impacts to surface water	Environmental significance score								Recommended mitigation measures	Environmental significance score							
	S	SE	DI	C	FA	FI	L	IS		S	SE	DI	C	FA	FI	L	IS
Construction																	
Reduction of water flow as result of water management (storage, diversion)	1	3	3	7	3	4	7	49	Controlled release of diverted water and treated water into the natural system	1	2	2	5	2	2	4	20
surface water quality deterioration from mine activities with existing contaminants	1	3	3	7	3	5	8	56	Only clean or treated water should be release into natural system	1	2	2	5	2	2	4	20

5 Primary Water balance

5.1 Water balance principles

As a mass balance concept, the water balance concept relies on the basic principle of mass conservation and can be illustrated as in the following illustrative equation:

Total water in = Total water out

5.2 Water balance Objectives and boundaries

As the project is still in design phase, the purpose of the preliminary water balance is to develop an initial water management tool to determine areas to be targeted for water management and assess possible water management measures, for the whole mine (pits, plant, water dams, etc...). It will assist in highlighting information gaps and in identifying points of metering and monitoring in order to develop a realistic and site specific water balance.

This preliminary water balance will first be used by the design team, but also provide a first estimation of the quantity of water that will be used (intake) and of waste water (disposed and discharge) to the regulatory authorities (Department of Water Affair, Department of Environmental Affair).

Due to a lack in data available for the mining project water reticulation system at this time, it is clear that the current objectives should be reviewed and assessed on a regular basis as additional data becomes available.

The water balance is not to be considered as a once off investigation, but rather an iterative process to be updated as the mine's activities commence. The balances should be updated regularly to reflect the dynamic process of change at the mine.

Although the water balance is of a preliminary nature and intends to cover the entire proposed mine site, and includes the following management units:

- Mining pit
- Crushing/washing plant and offices
- Rock waste dumps
    - Waste dump 1 (WD1)
    - Waste dump 2 (WD2)
    - Waste dump 3 (WD3)

- Waste dump 4 (WD4)
- Waste dump 5 (WD5)

- Dewatering dam
- Dirty water dam
  - Dirty water dam 1 (DWD1)
  - Dirty water dam 2 (DWD2)
  - Dirty water dam 3 (DWD3)
  - Dirty water dam 4 (DWD4)
  - Dirty water dam 5 (DWD5)
- Clean water dam
  - Clean water dam 1
  - Clean water dam 2
  - Clean water dam 3

5.3 Available data

To develop a water balance it is necessary to collect data of flow rates (pumping, and runoff water), and dam volumes relevant to the identified water circuits.

At present stage of the project, the main information available on flow rates and dam volumes are from groundwater and storm water runoff model simulations. In addition of the model results, meteorological (rainfall, evaporation) data, mining sequence (layout) and mining schedule as designed presented in section 2.2 of the current report, and the process design plans and criteria as provided in section 6 (Process and metallurgy) of feasibility report by Mindset were also used in the development of the preliminary water balance.

5.4 Water circuits and schematic flow diagram

These defined management units have been used to identify all the main water process units and flow paths.

The general preliminary water balance flow diagram is given in Figure 42, whereas the details respective to each water circuit are given accordingly below.

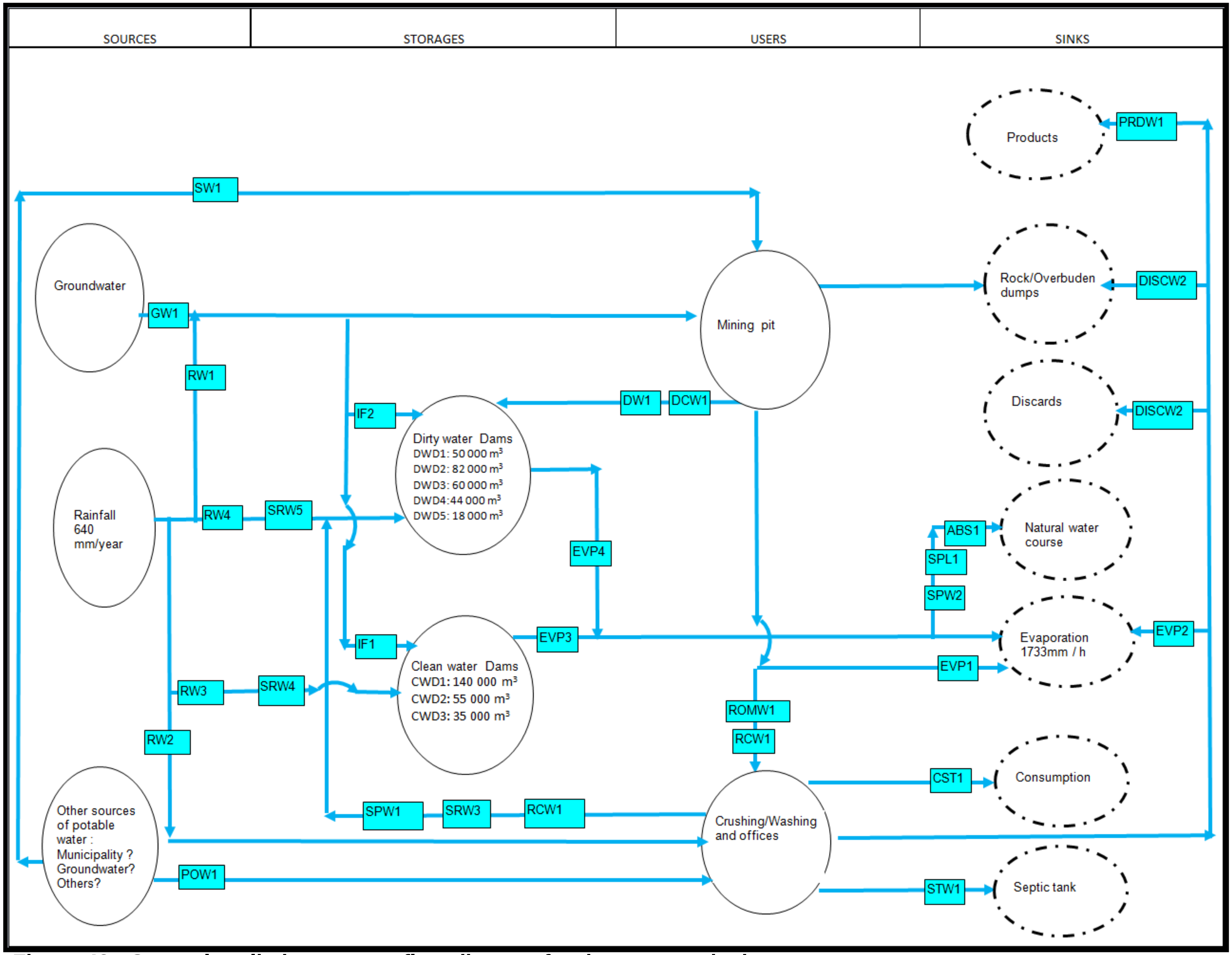


Figure 42 : General preliminary water flow diagram for the proposed mine

5.4.1 Open cast mining circuit

Although concurrent rehabilitation is recommended, the rate of its implementation is not clear at the moment, making difficult to determine the operating pit area when mining will reach steady state. The mining areas as presented in mining schedule have been assumed as operating areas in the preliminary water balance.

As the water management principle does not allow any surface runoff from the clean area to enter into the dirty areas, the surface water (runoff) input and output of mining pit unit has been considered equal to zero (0).

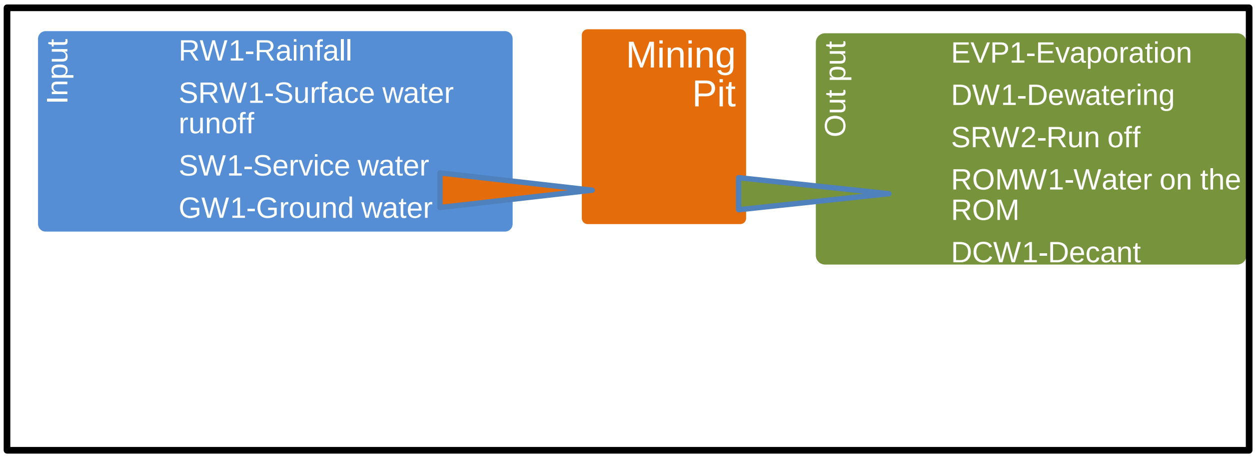


Figure 43: Open cast mining circuit

Water content of the ROM used for coal yield calculations in section 6 (Process and metallurgy) of feasibility report was assumed correct and used in the water balance model. As preliminary water balance it does not yet account for pit flooding and decant of pit water to surface. In pit dewatering volume is found to be for now very sensitive to the high rate of evaporation. Without removing volumes of probable decant water and evaporated water, simulated annual average in pit water dewatering volume is shown together with forecasted class A pan evaporation in Figure 44.

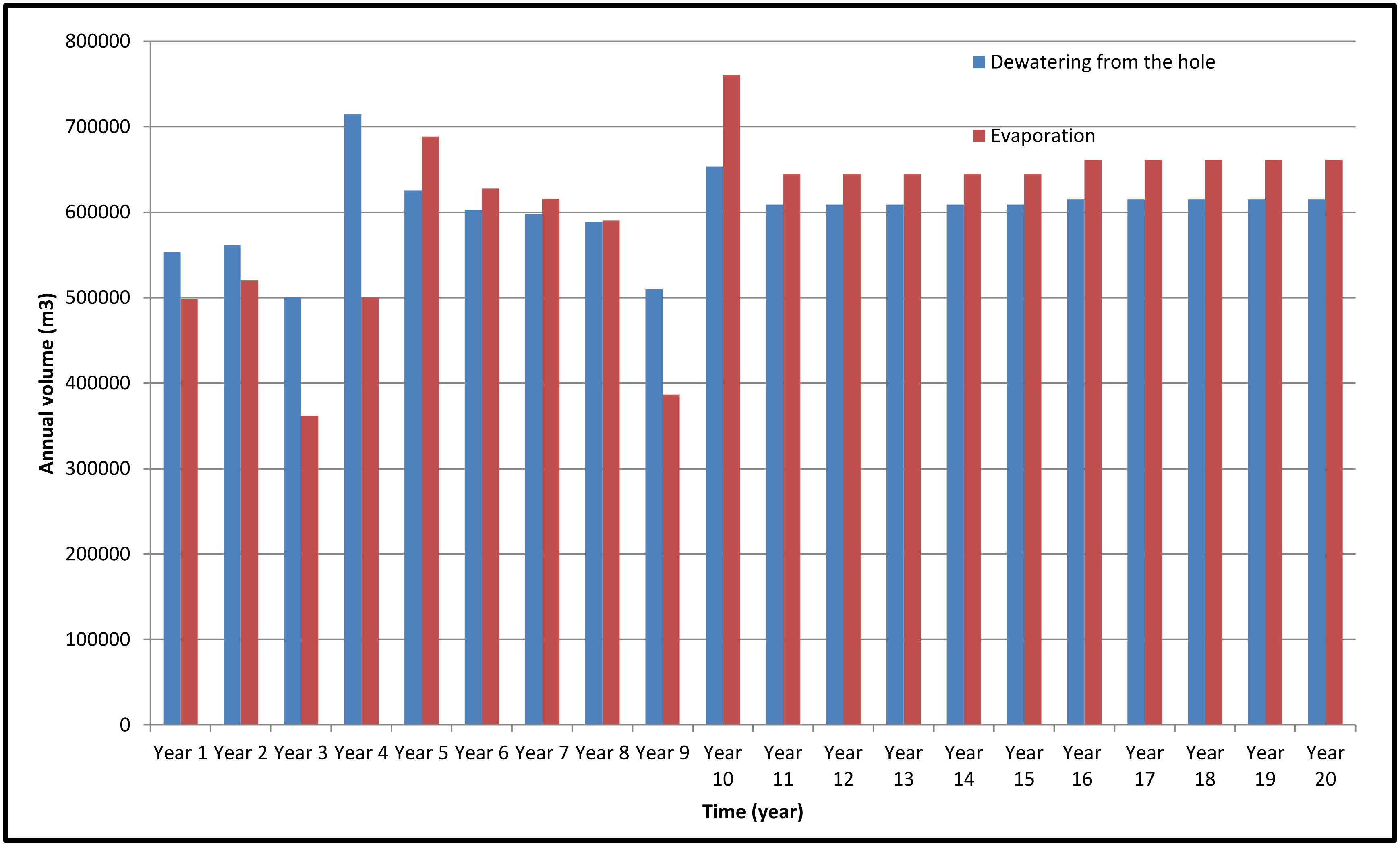


Figure 44: Estimated in pit dewatering and class A pan evaporation as per mining schedule

5.4.2 Crushing/Washing plant and offices circuit

Between 1,000 to 2,000m^3/day are estimated (Section 6 Feasibility study) required as make-up water supplied for coal processing. Water content of the products (Eskom, and Export), had been sourced from coal yield calculations in section 6 (Process and metallurgy) of feasibility report. One of the biggest challenges in ore processing planning and design is the source of water for processing. The coal processing design at the proposed Rietvlei Mine make provision of a standard magnetite recirculation / recovery system and intend to make a maximum use of recycling of available water. If 30 % of total water engaged in coal washing plant is recycled, the potable water demand (for processing) would decrease (Figure 46) to 500000 m^3/year (1370m^3/day). Such remaining demand may be sourced from the dirty water dams. Recirculation/recovery system efficiency may allow up 50% of recycle water, in which case the remaining demand would even be lesser.

It has been assumed that the processing plant and office will be used by a maximum of 150 persons with a maximum need of 50 litres per person per day. Considering such need, a total volume of 1642.5 m^3 is expected per year for human consumption. A maximum of 985.5 m^3 of the waste water will be disposed to in site septic tank per year.

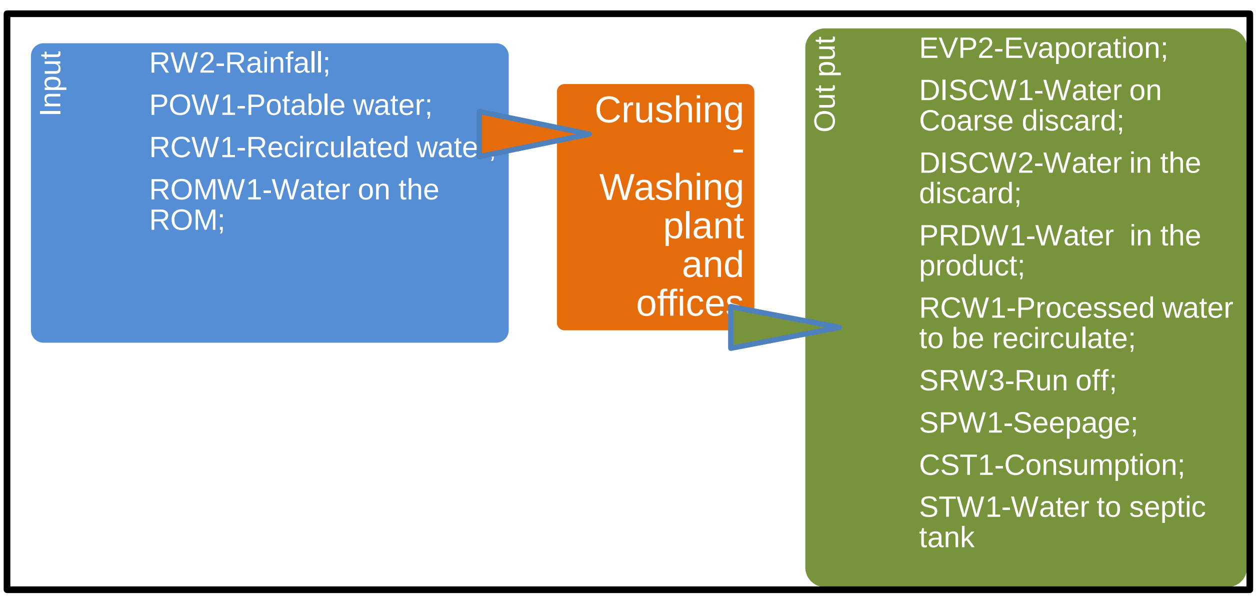


Figure 45: Crushing/washing and Offices mining circuit

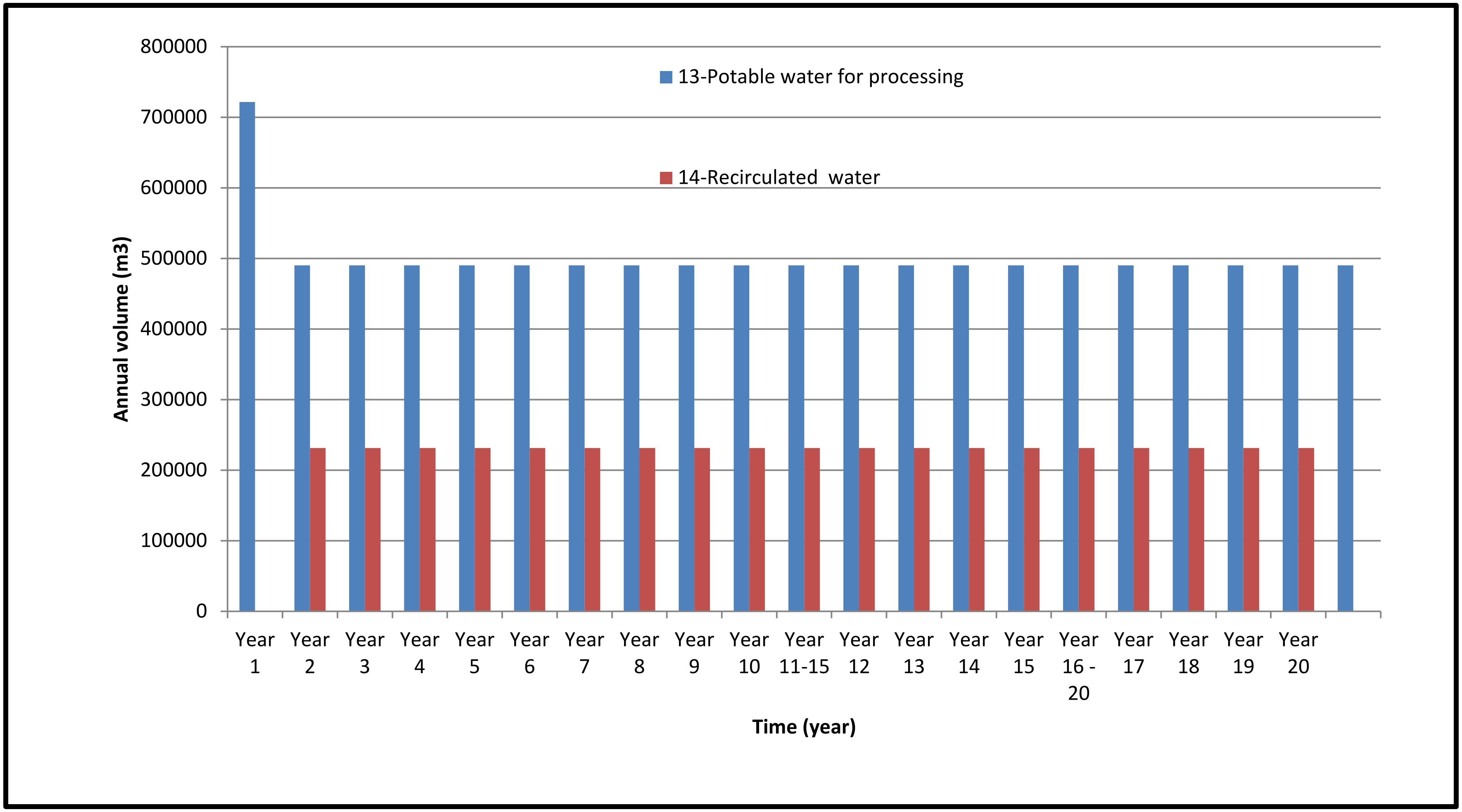


Figure 46 : Estimated need in potable water versus re-circulated water (30%) as per mining schedule

5.4.3 Water storage dam circuits (Clean and dirty water dam)

Only the number of clean and dirty storm water dam have been considered in the preliminary water balance. Volumes of dewatered water (clean and dirty) are assumed to be disposed in proposed clean and dirty water dam. No dewatering dam is proposed for now, but may be required as volumes to be disposed may be measured and/or determined during operation phase. The simulated monthly average runoff flow into the different surface water dams (clean and dirty) constitutes the runoff (input). It is estimated that 4344155 m^3 of dirty storm water runoff and 2 726834 m^3 of clean storm water runoff would be collected in the pollution control dams. Part of such water would be evaporated, but the rest would be available for the mining and processing demand.

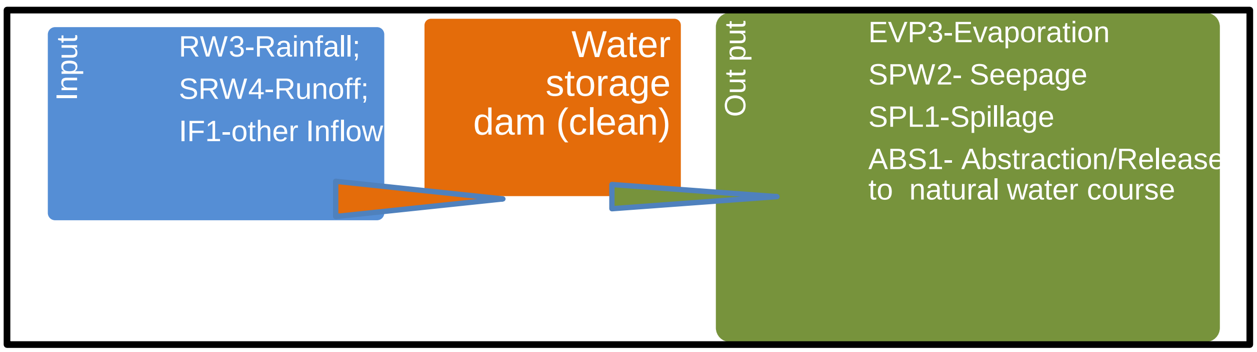


Figure 47: Clean surface water dam circuit

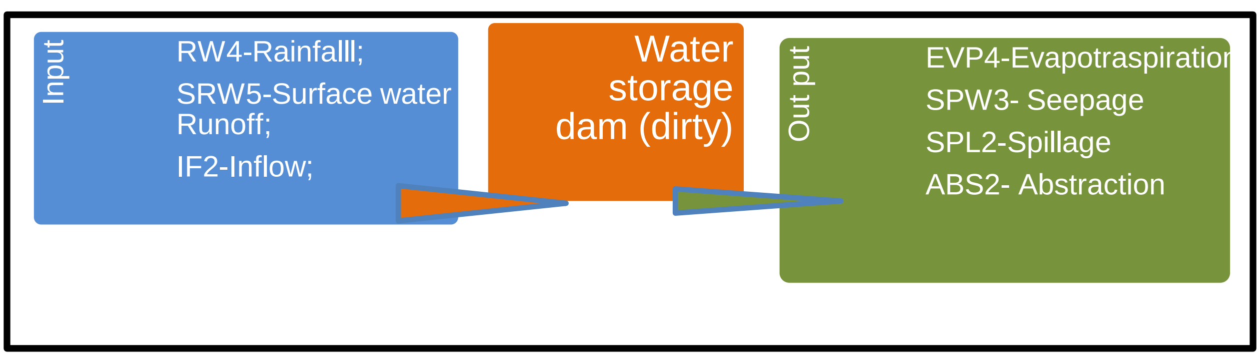


Figure 48: Dirty surface water dam circuit

5.5 Ongoing management of water balance

The water unit circuits considered in the preliminary water balance are based mostly on available information. Most of the inputs to water balance are simulated from groundwater and surface water flow models which have are associated with different sources of uncertainties (homogenisation, downscaling, etc...). It is very important to ensure that the water balance is regularly updated with the latest data according to a defined monitoring programme. To ensure that this happens, the following focus areas for data collection are put forward:

Table 18 : Focus areas for data collection for water balance management

Focus area	Action
Open Pit	Dewatering rate (of in pit water and/or groundwater) should be monitored on daily basis together with water level drop.
Crushing/Washing plant	Inflow and Outflow should be monitored on a daily basis
Water Storage (Clean and dirty)	Inflow and Outflow should be monitored on a daily basis
Rock Dumps	Water content should be monitored
ROM	Water content should be monitored
Products	Water content should be monitored
Discard	Water content should be monitored
Rainfall	Local rainfall measurement station should be installed and rainfall recorded
Evaporation	Evaporation rate should be investigated and recorded

6 Storm water Management Plan (SWMP)

The content of the storm water management plan was informed by the Best Practice Guideline - G1: Storm Water Management (2006). Storm water management and drainage planning are critical components of integrated water and waste management at mining sites. Although the objectives of a SWMP are site-specific, common objectives include:

- Protection of life (prevent loss of life) and property (reduce damage to infrastructure) from flood hazards;
- Planning for drought periods in a mining operation;
- Prevention of land and watercourse erosion (especially during storm events);
- Protection of water resources from pollution;
- Ensuring continuous operation and production through different hydrological cycles;
- Maintaining the downstream water quantity and quality requirements;
- Minimizing the impact of mining operations on downstream users;
- Preservation of the natural environment (water courses and their ecosystems).

The complexity of the SWMP depends largely on the size and nature of the mining operation, the characteristics of the hydrological cycle at the site, and the sensitivity of the area in which the mine is located to environmental impacts.

The SWMP must cover the life cycle of the mine from exploration, through construction, operation, decommissioning, and up to post-closure.

6.1 General principles of storm water management

6.1.1 PRINCIPLE 1: Keep clean water clean

Identify and where possible, maximize areas of the mine that will result in clean storm water runoff as well as infrastructure associated with the mine and ensure that runoff from these areas is routed directly to natural watercourses and not contained or contaminated. Ensure that clean storm water is only contained if the volume of the runoff poses a risk (erosion, siltation due to high speed and velocity), if the water cannot be discharged to watercourses by gravitation, for attenuation purposes, or when the clean area is small and located within a large dirty area. This contained clean water should then be released into natural watercourses under controlled conditions.

6.1.2 PRINCIPLE 2: Collect and contain dirty water

Ensure the minimization of contaminated areas, reuse of dirty water wherever possible and planning to ensure that clean areas are not lost to the catchment unnecessarily.

Ensure that seepage losses from storage facilities (such as polluted dams) are minimized and overflows are prevented.

Ensure that all possible sources of dirty water have been identified and that appropriate collection and containment systems have been implemented and that these do not result in further unnecessary water quality deterioration.

Ensure that less polluted water or moderately polluted water is not further polluted. Where possible less and more polluted water should be separated. This will assist in the reuse water strategy and improve possibilities for reuse based on different water quality requirements by different mine water uses.

6.1.3 PRINCIPLE 3: Sustainability over mine life cycle

Ensure a commitment from management and staff, including making available adequate human resources and adequate financial resources for both the design and implementation of the SWMP.

Ensure that the SWMP is formulated concurrently with the mine planning and layout of infrastructure and that it takes account of all life cycle phases of the mine from planning through to post-closure.

Identify and quantify the risk of failure of components of the SWMP and the consequences of such failure.

6.1.4 PRINCIPLE 4: Consideration of regulations and stakeholders

Identify items of legislation relevant to the environment and water resources and ensure compliance with these.

Include effective liaison with the Department of Water Affairs, Catchment Management Agencies and all other interested and affected parties.

6.1.5 Considerations for opencast pits

The size of unrehabilitated areas (pit, spoils, and vegetated areas) that produce contaminated runoff should be minimized.

Development of the pit should be planned to promote maximum diversion of clean water. The diversion works may therefore need to be moved as the mine develops.

Rehabilitation should be planned to promote free drainage and to minimize or eliminate ponding of storm water. On-going rehabilitation as mining operations progress is required.

The capacity to rapidly pump water out of the pit into storage dams should be maintained. This will assist in minimizing water quality deterioration due to long-term retention of storm water in contact with materials that may cause water quality deterioration.

6.2 Preliminary storm water management plan

The proposed SWMP states all that are needed to be included in the detailed plan, by considering surface infrastructures as proposed in Figure 7.2 of "Section 7 : feasibility study report". Once more information becomes available, the plan must be updated and detail included. Areas that need to be taken into account are discussed in Table 19.

Table 19: Areas that need to be addressed in SWMP

Classification	Area	Potential type of contamination
Clean water	Undisturbed land area	Regional geology or agricultural practices may contaminate runoff.
	Administrative offices	Generally only suspended solids (SS) to consider
	Tarred roads	Tarred roads are not expected to be contaminated by waste, coal or discard, but may have a run off volume implication.
	Newly rehabilitated areas Clean water dams	SS to be considered
Moderately dirty water	Poorly rehabilitated areas	SS and other contaminants to consider
	Roads	If it carries traffic that bears coal, discard, slurry, waste rock, slimes, etc.
Dirty water	Workshops and storage yards where oil is handled or ground is covered in fines	Oils, grease and soap, dissolved and suspended Contaminants
	Opencast pits	SS and other contaminants to consider

Classification	Area	Potential type of contamination
	Residue deposits	Includes coal discard, slurry facilities, slimes dams, waste rock dumps and sand dumps.
	Raw material or product stockpiles	Dissolved and suspended contaminants
	Unrehabilitated areas	Dissolved and suspended contaminants
	Haul roads	Dissolved and suspended contaminants
	Pollution control dams	Depends on contents of dams

Basic issues that must be included in the SWMP are:

- **Operating areas**

These areas will include stockpiles, roads, workshop, stores and refuelling areas. Pollution sources include runoff from the stockpiles and haul roads spills of hydrocarbons and other chemicals within the workshops, stores and refuelling areas. To limit the impact to surface water bodies, water flow from this area will be directed through dirty water drainage system (earth channels, beams and culverts) towards a silt trap just upslope of a pollution control dam. The silt trap will remove suspended solids, while the lined pollution control dam will contain any polluted runoff.

Groundwater is expected to decant. Decant rates are provided in the groundwater report and the pH of the ground water is expected to drop. Capturing and returning of decant water as a minimum measure should be implemented, while consideration could be given to for the design of a water treatment system (plant) based on the expected decant volumes and associated water quality.

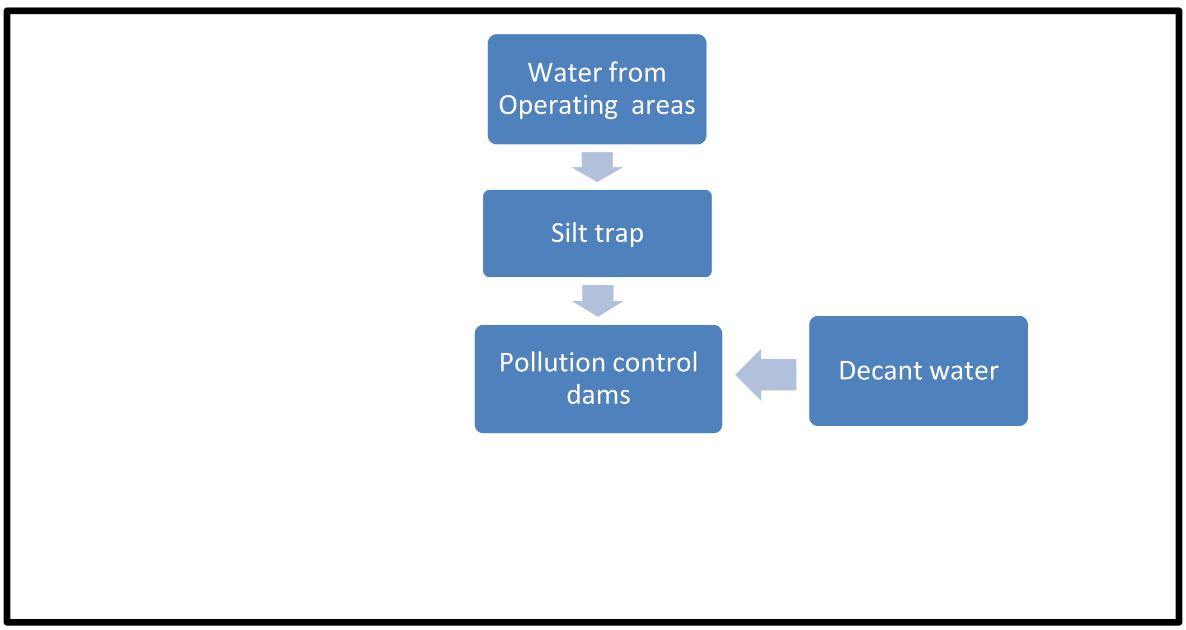


Figure 49: Operation water process

- **Clean water dam**

Although the main undisturbed areas (none polluted) would allow discharging diverted clean storm water to watercourses by gravitation, a system of clean water dams is proposed to control potential risks (erosion, flooding, etc.) that the volume of runoff may pose. Irrigation water during rehabilitation may also be sourced from the clean water dam.

The dam should be fed by water filtered through a silt trap to remove suspended solids. The clean water dam(s) will not overflow for recurrence events up to the 1:50 year event. In addition, the dam embankments will also not overflow for the 1:200 year recurrence event. The clean water dam should then be released into natural watercourses under controlled conditions.

- **Pollution control dam**

The pollution control dam(s) will not overflow for recurrence events up to the 1:50 year event. In addition, the dam embankments will also not overflow for the 1:200 year recurrence event. The dam(s) must be lined with a 1.5mm thick HDPE liner. A sub-surface drainage system will be installed to ensure that all seepage water within the dam area is also collected.

- **Stockpiles (Dumps)**

An erosion containment and dirty water berm must be constructed around the outside of each stockpile. Containment berms must also be constructed perpendicular to the outside berm to ensure that dirty water "coffers" are created. The area between the berms and stockpile will be vegetated to promote rapid evaporation, to reduce ponding within these areas. A 15m wide thickly vegetated "buffer" zone must also be constructed around the outside of berms to contain sediment.

Overburden stockpiles must be separated, with one portion containing carbonaceous waste and the other containing inert materials. The treatment of each of these stockpiles will differ:

- Carbonaceous stockpiles: Surface water will be contained within the stockpile and berms. Groundwater contamination will be prevented by placing a 125mm clay liner at the bottom of the stockpile. Captured water will be lost through evaporation.
- Inert stockpiles: Dirty water will be contained within the stockpile and berms. Surface water seepage through the containment berms can be accommodated, with the provision that siltation is prevented.

- **Mining area**

Dirty water containment berms will need to be constructed around the mine to separate dirty water from clean water. Dirty water should be diverted back into the pit whilst clean water will be directed into the clean water catchment areas.

The pit must be rehabilitated as work progresses. Rehabilitated areas can be vegetated and contour berms will be constructed to slow surface water and to prevent erosion from taking place. It should furthermore be ensured during rehabilitation that buffer zones, containing thick vegetation, are established downstream of the rehabilitated areas. This will ensure that erosion and subsequent sedimentation is minimised. Rehabilitated areas will be classified as clean water areas and the surface water will be released into clean water areas.

Coffer dams will also be constructed along the mining areas to prevent a significant amount of surface water from being concentrated at one specific point.

- **Haul roads**

Pit access roads could either traverse rehabilitated or mining areas and may exhibit some pollution potential. Wherever pit access roads traverse rehabilitated areas, small coffer dams, constructed adjacent to the road, are proposed. This will prevent pollution from entering newly defined clean water areas.

6.3 Proposed water management infrastructures

Subsequent to the proposed management plan, the infrastructure that needs to be considered is summarised in Table 20. It is anticipated that each pollution control dam will be joined through silt traps located at upslope of the dam.

Table 20 : Proposed water management infrastructure

Basic management issues	Proposed infrastructure
Operations area	Earth channels Containment berms Culverts
Pollution control dam	Silt trap Water treatment plant
Stockpiles	Erosion containment Dirty water berms Containment berms

	Vegetated “buffer” zone
Mining area	Depression (coffers) Containment berms (clean and dirty waters) Dewatering dam
Haul roads	Small coffer dams
Dewatering dam	Water treatment plant

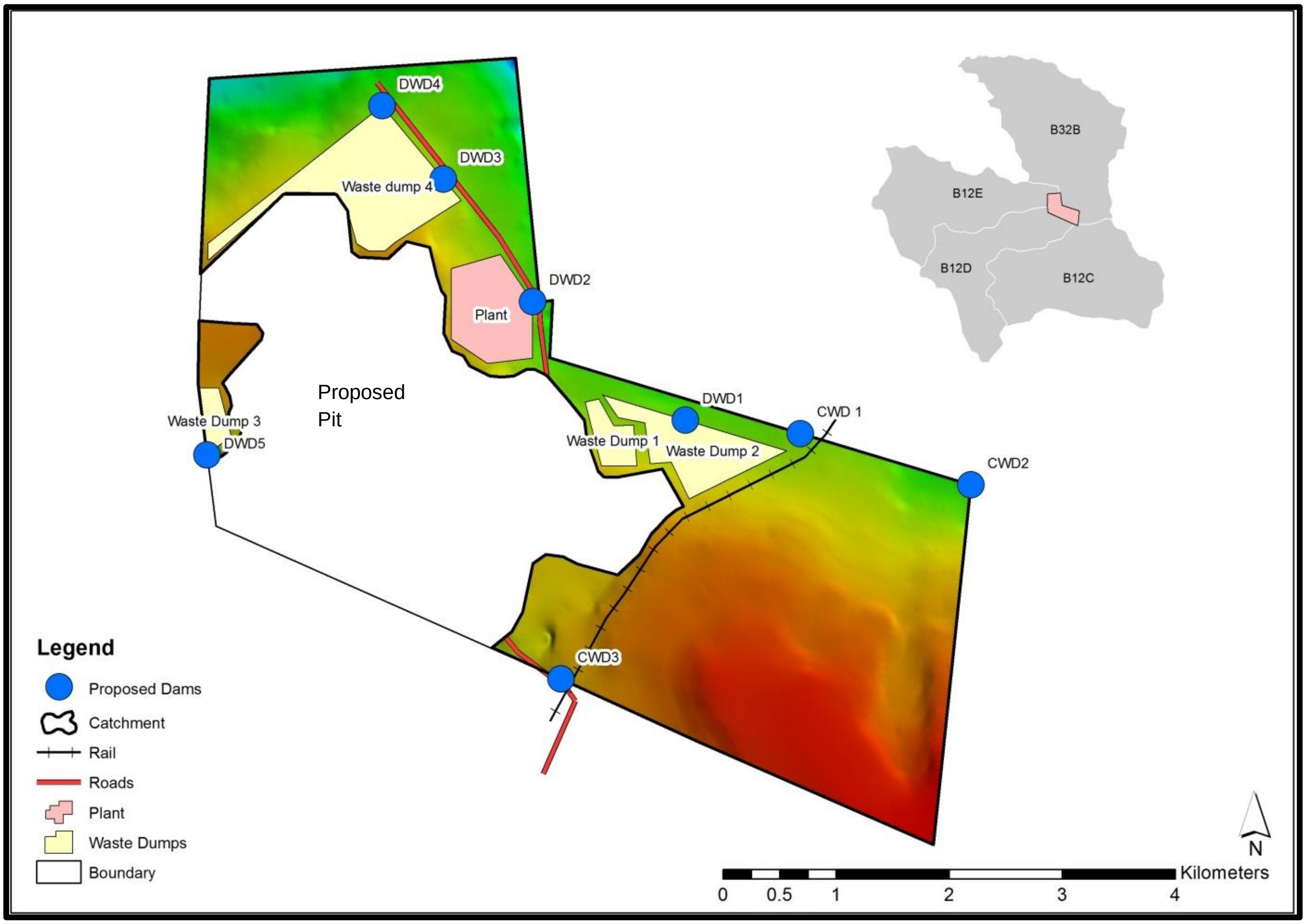


Figure 50: Proposed water management infrastructures

7 Monitoring Plan

7.1 Preamble

A long-term monitoring programme has been developed based on the guideline documented in *Best Practice Guideline G3. Water Monitoring Systems (2007)* available from DWA.

A monitoring plan is necessary for the following reasons (DWA, 2006):

- Accurate and reliable data forms a key component of many environmental management actions;
- Water monitoring is a legal requirement;
- The most common environmental management actions require data and thus the objectives of water monitoring include the following:
  - Development of environmental and water management plans based on impact and incident monitoring (facilitate in decision-making, serve as early warning to indicate remedial measures or that actions are required in certain areas) for the mine and region;
  - Generation of baseline/background data before project implementation;
  - Identification of sources of pollution and extent of pollution (legal implications or liabilities associated with the risks of contamination moving off site);
  - Monitoring of water usage by different users (control of cost and maximizing of water reuse);
  - Calibration and verification of various prediction and assessment models (planning for decommissioning and closure);
  - Evaluation and auditing of the success of implemented management actions (ISO 14000, compliance monitoring);
  - Assessment of compliance with set standards and legislation (EMPs, water use licenses);
  - Assessment of impact on receiving water environment.

7.2 General Principals of Monitoring

Monitoring on a mine consists of various components as illustrated by the overall monitoring process (Figure 51). It must be recognized and understood that the successful development and implementation of an appropriate, accurate and reliable monitoring programme requires that a defined structured procedure be followed. A monitoring programme must include the location of all monitoring points (indicated on a map), the type of data to be collected, as well as the data collection (protocol/procedure/methodology, frequency of monitoring and parameters determined, quality control and assurance), management (database and assessment) and reporting procedures. This programme must then be implemented. The results from the monitoring programme should be representative of the actual situation. To ensure that the monitoring programme functions properly, an operating and maintenance programme should be developed and implemented. A data management system is necessary to ensure that data is stored/ used optimally and is accessible to all the relevant users. The monitoring programme must include quality control measures. It is important to note that this programme is dynamic and should change as the mine and water management needs change.

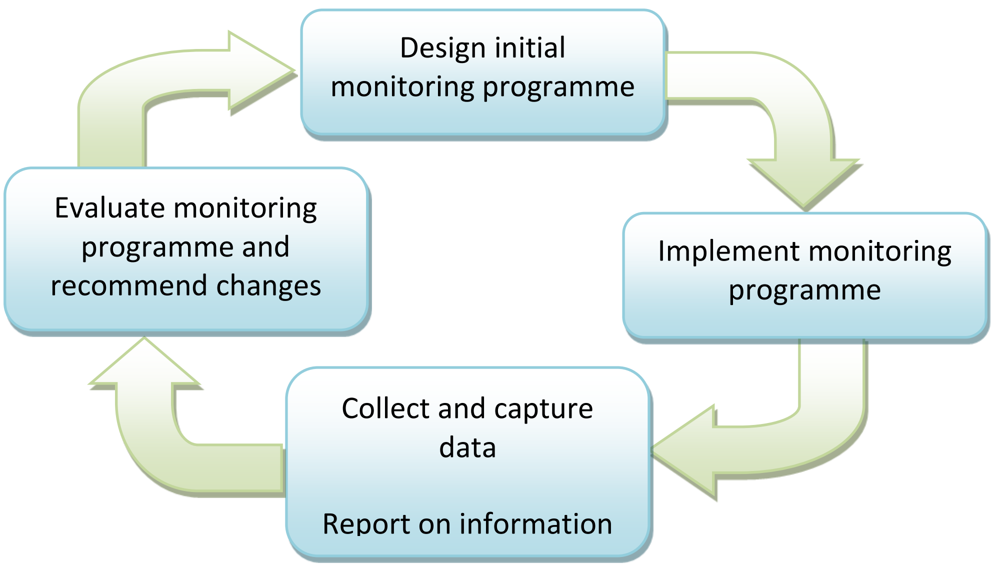


Figure 51: Monitoring process (DWA, 2007)

Effective surface water monitoring systems on a mine consist of the following components:

- Surface water quality monitoring system.
- Surface water flow monitoring system.
- Data and information management system.

When designing the monitoring system the following issues must also be taken into consideration:

- Potential or actual water use

- Catchment vulnerability
- Toxicity of chemicals
- Potential for seepage or releases
- Quantities and frequency of release to the environment (point and non-point).
- Management measures in place to minimize risk.

7.3 Surface water monitoring plan for the project area

7.3.1 Management action

As part of the water management at the project area, it is necessary to understand:

- The changes in surface water flow within the mine boundaries and to monitor how this changes with time.
- The pollution on the mine and to monitor how the pollution changes with time.

The overarching water management action that is of interest for this specific mine can, therefore, be defined as:

- Develop an understanding of the current surface water flow patterns on the mine and monitor how it changes over time.
- Assess impacts of the changes of these flow patterns on the receiving environment and the performance of associated prevention measures.
- Prevent pollution and thereby protect the receiving water environment.
- Develop an understanding of the current pollution on the mine and monitor how it changes over time.
- Assess performance of pollution prevention measures, i.e. compliance with license conditions and catchment objectives.

7.3.2 Objectives of intended management action

The objectives of the management action are defined as:

- Identify, quantify and monitor surface water flow in the vicinity of the mine.
- Identify, quantify and monitor all point and diffuse pollution sources and associated plumes on the mine.

These objectives must adhere to the requirements of being specific, measurable and feasible.

7.3.3 Data requirements

The data requirements are dictated by:

- Area influenced by changes in surface water flow and associated quality.
- Point and diffuse sources of pollution and associated pathways.

7.3.4 Location of monitoring points

The potential monitoring points are chosen to:

- Determine any changes in surface water flow and quality on the mining property before affecting the down gradient environment.
- Perform a regional surface water screening to ensure that the monitoring points on site are sufficient.

The positions of the proposed initial monitoring points are presented in Table 21 and their locations indicated on Figure 52

Table 21: Proposed initial surface water monitoring points

SW Points inside Rietvlei colliery property	SW Points outside Rietvlei colliery property
Pollution water control Dam 1	SWM1
Pollution water control Dam 2	SWM2
Pollution water control Dam 3	SWM3
Pollution water control Dam 4	SWM4
Pit water (?)	SWM5
Clean water dam	SWM6
Dewatering dam	SWM7
--	SWM8
--	SWM9
--	SWM10
--	SWM11
--	SWM12
--	SWM13

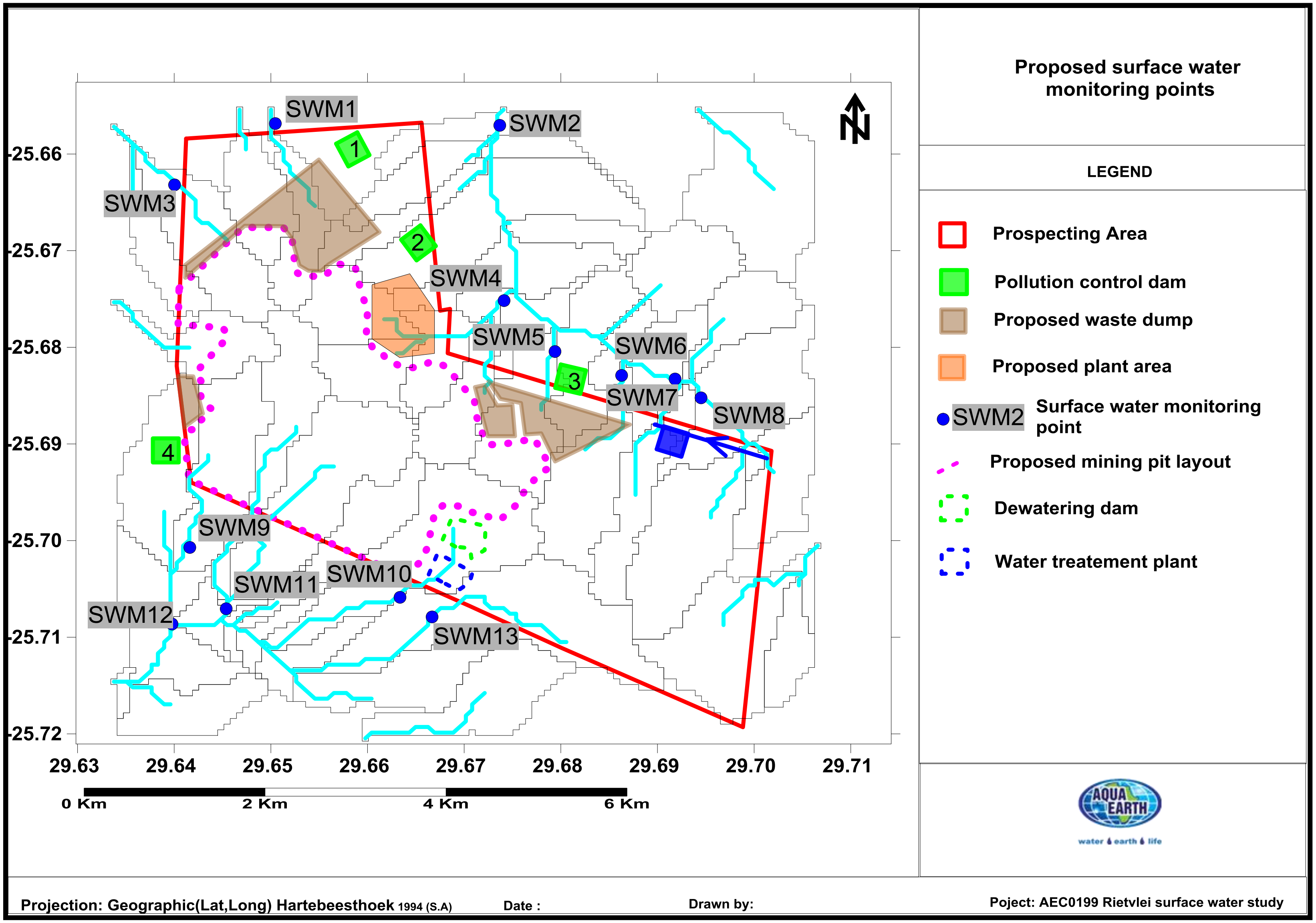


Figure 52 : Proposed initial surface water monitoring points

7.3.5 Parameters to be measured and frequency of measurements

There are two sets of monitoring parameters. A comprehensive analysis must be conducted on surface water points within or close to the mine and a screening analysis must be conducted on surface water points further away. In addition samples must be tested for trace elements once mining commences. The parameters that must be sampled for are listed in Table 22.

Table 22: Sampling parameters

A (Standard set of parameters)	B (Screening parameters)	C (Trace elements)
pH	pH	Ba
EC	EC	As
Ca		Co
Mg		Cr
Na		Ni
K		Pb
Total Alk		Se
F		Sr
Cl		V
NO_2(N)		Zn
NH_4 (N)		Nb
NO_3(N)		Mn
PO_4		Cu
SO_4		Ga
Al		Ge
Fe		Rb
Mn		Y
		Zr
		Sn
		W
		Bi
		Th
		U
		Hg

The frequency and type of sampling is summarised in Table 23.

Table 23: Frequency and type of sampling

Sampling point	Parameter list[1]	Type of sampling	Type of measurement/	Frequency
Surface water points within mine boundaries	A, C*	Grab	Flow	A = Every 4 months C = Once per annum
Surface water points outside mine boundaries	B**	Grab	Flow	Once every 6 months

*** If any parameters exceed SANS241-1: 2011 guidelines (or WHO guidelines if no SANS guideline available) then that parameter must become part of list A.**
****If any parameters * If any parameters exceed SANS241-1: 2011 guidelines (or WHO guidelines if no SANS guideline available) then that borehole must be sampled according to the A, C list.**

IMPORTANT NOTES: Laboratory analysis techniques will comply with SABS guidelines. Laboratories must be accredited.

7.3.6 Data storage and reporting

Data must be stored electronically. It is suggested that a well-known database such as WISH, Aquabase or Access be used. A backup of the data base must be stored in a safe place. Backups should be made every time the database is updated.

On the completion of every sampling run a monitoring report must be written. Included in the report must be time series trends, Piper and Durov diagrams. These will be used to determine if there are any changes in the system. These changes must be flagged and explained in the report.

It is recommended that Rietvlei colliery submit a compliance report to DWA on an annual basis.

[1] A, B and C are parameters documented in Table 22

8 Conclusions

Following this investigation, the following conclusions can be made:

- The site straddles mainly three surface three surfaces run off catchments.
- Available information for this project included a limited number of surface water samples and publicly available topography, regional flow and rainfall data;
- Local storm water runoff model has been set up for the site, from a regional rainfall-runoff model;
- 1:100, flood line has also been calculated for the main three surface water drainage line;
- The main catchment of impact is considered to be catchment B32B;
- The 1:100, flood line is likely going to intersect the pit on the southern side.
- Managing dirty and clean water will be important for each considered run off catchment and the water management plan has been developed taking this into consideration;
- Water storage facilities proposed in this document are based on calculated volumes, and no designs are included for the individual facilities;
- Water balance was developed with the available information (regional meteorological data, flow simulation from groundwater and surface water numerical model) for 20 years of operation;
- The water balance developed during this investigation is considered a preliminary water balance and should be refined once more specific site information (storage facilities) and water use (for operating and processing) monitoring data will be available;
- Focus areas for data collection have been identified and actions recommended;
- A water management and monitoring plan has been developed and it would be important to populate and update this on a regular basis.
- Generally, impacts on surface water are manageable and with a strict application of the proposed mitigation measures, impact significances would be reduced to between very low and medium low.

9 Recommendations

Based on the results from this assessment the following recommendations are put forward for consideration:

- Once the final decision has been made on mining, the monitoring network in terms of surface water monitoring should be revisited and the monitoring points confirmed.
- When more detailed digital elevation data becomes available the model could be re-run to confirm flood lines and confirm surface water management infrastructures. In this regard topographical surveys like for example a Lidar survey, providing higher density DEM data are strongly recommended.
- The water management plan developed during this study should be considered a baseline and further development thereof should take place in conjunction with the infrastructure development, keeping the water management plan relevant and updated in real time.
- The water balance developed should be considered a baseline water balance and special effort should be made to have sufficient measuring points to collect real data for updating the water balance on a regular basis.
- A water treatment facility has been recommended for consideration, but further investigation into the feasibility and costs benefits is recommended.

10 Appendixes

10.1 Appendix I: Impacts assessment methodology

Environmental impacts which could result from the project activities are described in this section. The following terms are used in describing the environmental impacts:

- Environmental issues – an "environmental issue" is an environmental concern encompassing a number of similar or related impacts that have been grouped under the issue heading;
- Environmental impact – a discrete (definable) interaction between a project activity and one or more components of the environment (biophysical and social);
- Natural and existing mitigation – natural conditions, conditions inherent in the project activities and existing management measures that alleviate (control, moderate, curb) impacts;
- Significance – the significance of the unmanaged and managed impacts is assessed through the consideration of the probability of the impact occurring, the extent of the area over which the impact will be experienced, the timing of the onset and the duration of the impact, and the intensity/severity of the impact.

The environmental impact assessment has been undertaken according to SRK Consulting's standard criteria for impact assessment which are detailed below.

The first stage of impact assessment is the identification of environmental activities, aspects and impacts. This is supported by the identification of receptors and resources, which allows for an understanding of the impact pathway and an assessment of the sensitivity to change.

The above terms, used in relation to significance, are defined in Table 9-1. The cut-off points have been defined in relation to characteristics of mining, but those for Probability, Severity/Intensity and Significance are subjective, based on rule-of-thumb and experience.

The significance of the impact is then assessed by rating each variable numerically according to defined criteria as outlined in Table 9-1. The purpose of the rating is to develop a clear understanding of influences and processes associated with each impact. The severity, spatial scope and duration of the impact together comprise the consequence of the impact and when summed can obtain a maximum value of 15. The frequency of the activity and the frequency of the impact together comprise the likelihood of the impact occurring and can obtain a maximum value of 10. The values for likelihood and consequence of the impact are then read off a significance rating matrix as shown in Figure 9-1.

The results are tabulated for each identified impact. In the tables, a negative significant rating (results) indicates a negative impact while a positive rating indicate a positive impact, or benefit.

The assessment of significance has been undertaken twice. Initial significance should be based on only natural and existing mitigation measures (including built-in engineering designs). The subsequent assessment takes into account the recommended management measures required to mitigate the impacts.

Some of the specialist consultants have used variations of these procedures.

Table 9-1: Criteria for assessing significance of impacts

SEVERITY OF IMPACT	RATING
Insignificant / non-harmful	1
Small / potentially harmful	2
Significant / slightly harmful	3
Great / harmful	4
Disastrous / extremely harmful	5

SPATIAL SCOPE OF IMPACT	RATING
Activity specific	1
Project specific (within the project boundary)	2
Local area (within 5 km of the activity boundary)	3
Regional	4
National	5

DURATION OF IMPACT	RATING
One day to one month	1
One month to one year	2
One year to ten years	3
Life of operation	4
Post decommissioning / permanent	5

CONSEQUENCE

FREQUENCY OF ACTIVITY / DURATION OF ASPECT	RATING
Annually or less / low	1
6 monthly / temporary	2
Monthly / infrequent	3
Weekly / life of operation / regularly / likely	4
Daily / permanent / high	5

FREQUENCY OF IMPACT	RATING
Almost never / almost impossible	1
Very seldom / highly unlikely	2
Infrequent / unlikely / seldom	3
Often / regularly / likely / possible	4
Daily / highly likely / definitely	5

LIKELIHOOD

Figure 9-1: Significance Rating Matrix

CONSEQUENCE (Severity + Spatial Scope + Duration)

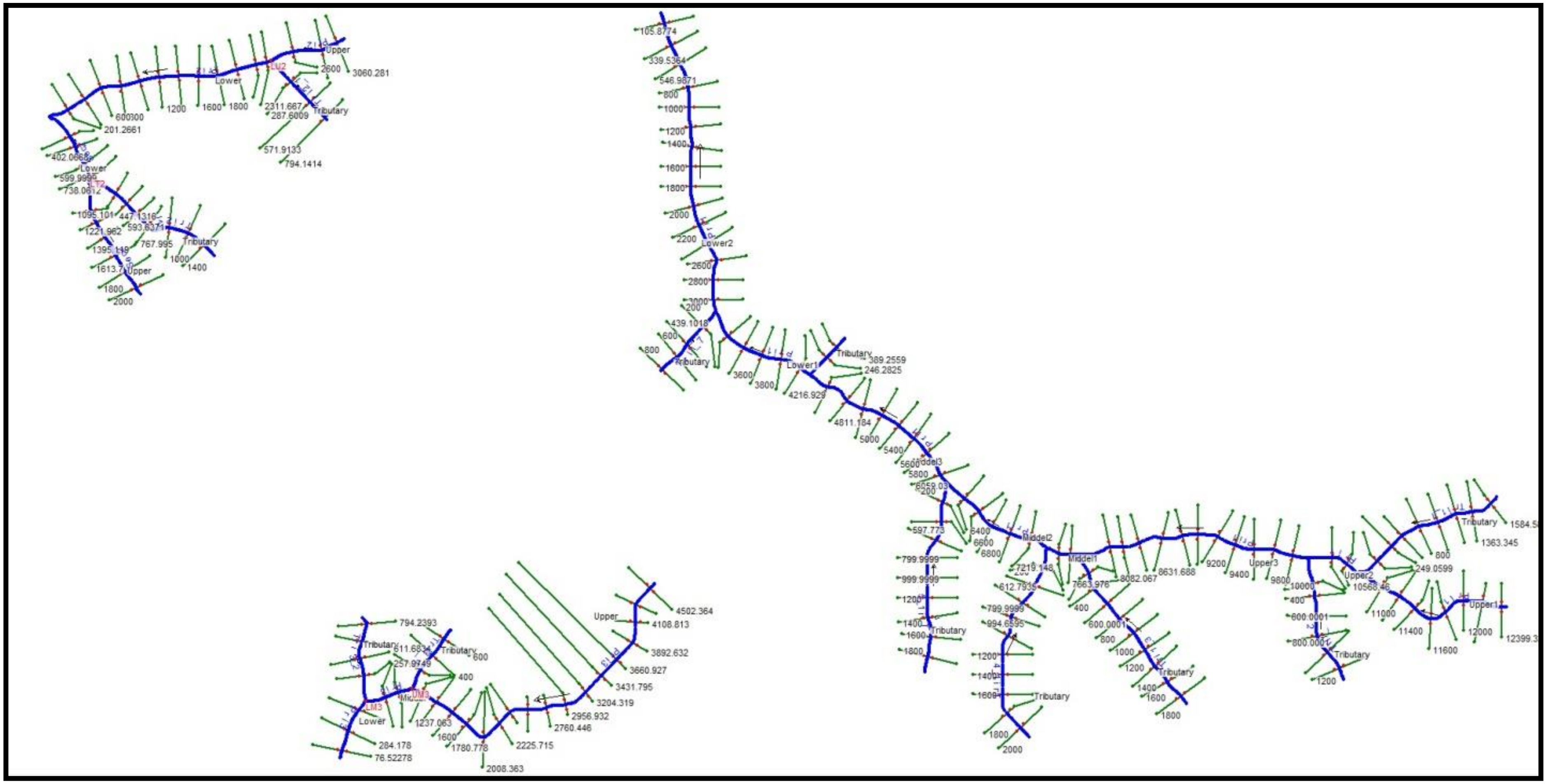
LIKELIHOOD (Frequency of activity + Frequency of impact)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
3	6	9	12	15	18	21	24	27	30	33	36	39	42	45
4	8	12	16	20	24	28	32	36	40	44	48	52	56	60
5	10	15	20	25	30	35	40	45	50	55	60	65	70	75
6	12	18	24	30	36	42	48	54	60	66	72	78	84	90
7	14	21	28	35	42	49	56	63	70	77	84	91	98	105
8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
9	18	27	36	45	54	63	72	81	90	99	108	117	126	135
10	20	30	40	50	60	70	80	90	100	110	120	130	140	150

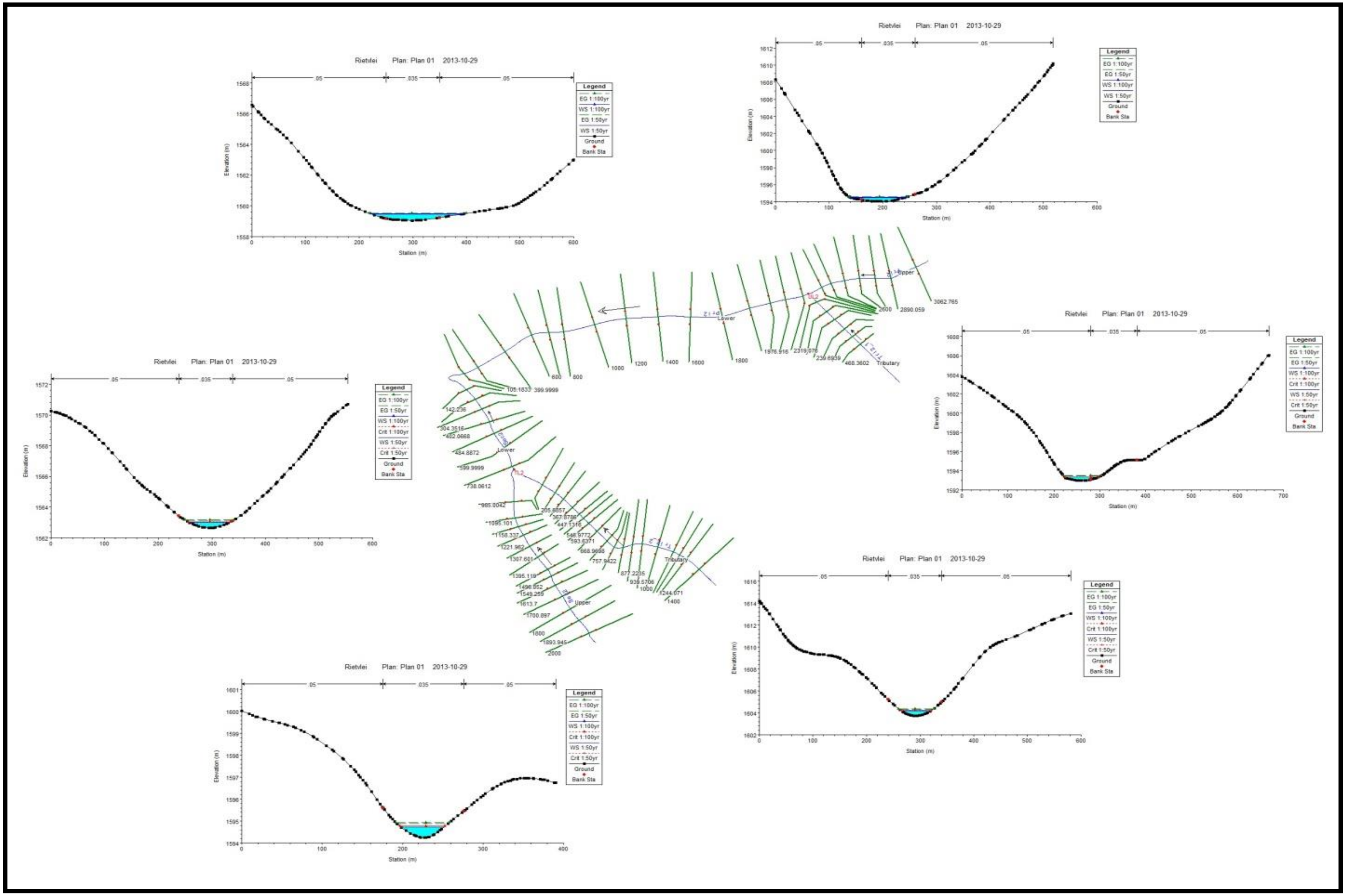
Table 9-2: Positive / negative migration ratings

Colour Code	Significance Rating	Value	Negative Impact Management Recommendation	Positive Impact Management Recommendation
	Very high	126-150	Improve current management	Maintain current management
	High	101-125	Improve current management	Maintain current management
	Medium-high	76-100	Improve current management	Maintain current management
	Low-medium	51-75	Maintain current management	Improve current management
	Low	26-50	Maintain current management	Improve current management
	Very low	1-25	Maintain current management	Improve current management

The impacts described below under the various environmental components are assessed for the different phases of the project, from preconstruction through to decommissioning and closure.

10.2 Appendix II: Cross sections for flood line calculations




Rietvlei Plan: Plan 01 2013-10-29
Legend
EG 1:100yr
EG 1:50yr
WS 1:100yr
WS 1:50yr
Crit 1:100yr
Crit 1:50yr
Ground
Bank Sta
Elevation (m)
Station (m)
Lower
Upper
Tributary