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Alexander Project

Surface Water Study for the EIA

SLR Project No.: 750.01080.00005

Report No.: 1

July 2016

Anglo American Inyosi Coal (Pty) Ltd

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SURFACE WATER STUDY FOR THE EIA

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ACRONYMS AND ABBREVIATIONS

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

Acronyms / Abbreviations	Definition
AAIC	Anglo American Inyosi Coal (Pty) Ltd
bgl	Below Ground Level
DDF	Depth Duration Frequency
DEM	Digital Elevation Model
DNWRP	Directorate National Water Resource Planning
DWAF	Department of Water and Forestry
DWS	Department of Water and Sanitation
EIA	Environmental Impact Assessment
FAO	Food and Agriculture Organisation
GN 704	Government Notice 704
HEC-RAS	Hydrologic Engineering Centres – River Analysis System
J&W	Jones & Wagener (Pty) Ltd
mAMSL	Meters Above Mean Sea Level
MAR	Mean Annual Runoff
mcm	Million Cubic Meters
NWA	National Water Act
PCD	Pollution Control Dam
PrSciNat	Professional Natural Scientist
RMF	Regional Maximum Flood
RWQO	Resource Water Quality Objectives
SACNASP	South Africa Council for Natural Scientific Professions
SANRAL	South African National Road Agency
SANS	South African National Standards
SAWS	South African Weather Service
SOTER	Soil and Terrain Database
Tc	Time of Concentration
WRC	Water Research Commission
WRD	Waste Rock Dump

SURFACE WATER STUDY FOR THE EIA

1 INTRODUCTION

1.1 BACKGROUND

SLR Consulting (Africa) (Pty) Ltd (SLR), an independent firm of environmental consultants, has been appointed by Anglo American Inyosi Coal (Pty) Ltd (AAIC) to undertake a Technical Specialist Surface Water Study to support an Environmental Impact Assessment (EIA) for the proposed Alexander project.

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

1.2 PROJECT DESCRIPTION

The Alexander Mining Right (the Project Area) comprises 125km^2 of predominantly agricultural land near the town of Kriel in Mpumalanga province.

AAIC propose to mine the No. 4 Coal Seam beneath the Alexander site by traditional Bord and Pillar method. The excavated coal will be brought to surface via a decline shaft and transported to the nearby Elders Colliery via an 18km long conveyor belt. Following a 3 year construction phase, the mine will be operational for 35 years.

The shaft complex features various surface infrastructure including: decline shaft, ventilation shaft, waste rocks dump, offices, changehouse and lamp room, workshops, stores, Eskom yard, pollution control dams, evaporation dam, water treatment plant, car parking, bus shelter, and various access roads.

1.3 ENVIRONMENTAL LEGISLATION

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

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

- *Condition 5* which indicates that no residue or substance which causes or is likely to cause pollution of a water resource may be used in the construction of any dams, impoundments or embankments or any other infrastructure which may cause pollution of a water resource.

- *Condition 6* which describes the capacity requirements of clean and dirty water systems. Clean and dirty water systems must be kept separate and must be designed, constructed, maintained and operated to ensure conveyance of flows of a 1:50 year recurrence event. Clean and dirty water systems should not spill into each other more frequently than once in 50 years. Any dirty water dams should have a minimum freeboard of 0.8m above full supply level.

- *Condition 7* which describes the measures which must be taken to protect water resources. All dirty water or substances which may cause pollution should be prevented from entering a water resource (by spillage, seepage, erosion etc) and ensure that water used in any process is recycled as far as practicable.

- *Condition 10* which describes the requirements for operations involving extraction of material from the channel of a watercourse. Measures should be taken to prevent impacts on the stability of the watercourse, prevent scour and erosion resulting from operations, prevent damage to in-stream habitat through erosion, sedimentation, alteration of vegetation and flow characteristics, construct treatment facilities to treat water before returning it to the watercourse, and implement control measures to prevent pollution by oil, grease, fuel and chemicals.

1.4 SCOPE OF WORK AND REPORT STRUCTURE

This Surface Water Study includes the following:

- Rainfall and Evaporation – Section 2 presents a review and analysis of various sources of rainfall and evaporation data.
- Baseline Hydrology - Section 3 presents the baseline hydrology of the site and surroundings including topography, watercourse network, catchment delineation, flows data, water users, water quality, wetlands, soils, vegetation and groundwater.
- Flood Hydrology - Section 4 presents estimates of the flood hydrology of the Steenkoolspruit and tributaries in the vicinity of the site which will inform the flood-line modelling.
- Hydraulic Flood Modelling - Section 5 presents hydraulic flood modelling undertaken for the watercourses of interest including methodology, software, results and the flood-lines associated with the 1:50 year, 1:100 year, 1:200 year and Regional Maximum Flood events.

- Conceptual Stormwater Management - Section 6 presents the recommended stormwater drainage measures to manage flood risks to the operation and minimise risks of polluting any water resources, including clean and dirty water catchment delineation, estimation of peak flows, channel routing and sizing, and sizing of pollution control dams.
- Site Wide Water Balance – Section 7 presents the water balance for the fully developed mining operation during average wet and dry seasons in order to inform estimates on re-use rates, makeup water requirement and requirements for discharge.
- Conclusions and Impact Assessment – Section 8 presents a summary of the main conclusions and recommendations of this report alongside a qualitative assessment of the impacts of the project on the baseline surface water environment.

2 RAINFALL AND EVAPORATION

2.1 INTRODUCTION

In order to inform the flood studies, design of stormwater management measures and the site wide water balance, an understanding of the local rainfall and evaporation regime is required and this section presents a review and analysis of various sources of rainfall and evaporation data.

2.2 RAINFALL

Daily rainfall records from the nearest South African Weather Services (SAWS) rain gauges were obtained from the Daily Rainfall Extraction Utility program, which was developed by the Institute for Commercial Forestry Research in conjunction with the School of Bio-resources, Engineering and Environmental Hydrology at the University of KwaZulu-Natal. A summary of the nearest rain gauges is presented in Table 2-1.

TABLE 2-1: SUMMARY OF NEAREST RAIN GAUGES

Station Name	SAWS Number	Distance* (km)	Record Start	Record End	Record Length (Years)	% Missing	MAP (mm)	Altitude (mAMSL)
Kriel (Pol)	0478406_W	13.5	Jan 1905	Jan 1992	87	18.8%	613	1541
Tikvoh	0478567_W	14.4	Feb 1924	Feb 1959	35	2.8%	676	1653
Vlaklaagte	0478862_W	14.5	Mar 1906	Aug 1954	48	1.6%	597	1645
Tweedraai	0478386_W	16.6	Jan 1924	Aug 1980	56	0.3%	625	1578
Langsloot	0478292_W	17.7	Feb 1914	Jun 1992	78	3.5%	662	1580
Middelkraal	0478853_W	21	Feb 1931	Dec 1977	46	14.1%	668	1583
Secunda	0478330_W	23.8	Jul 1984	Jul 2000	16	18.4%	719	1613

**distance from proposed shaft complex*

Tweedraai and Langsloot are the closest rain gauges, with a similar altitude, longest record length but the least missing data, and therefore these stations are considered most representative conditions in the vicinity of the shaft complex. Monthly average rainfall for these stations is presented in Table 2-2, whilst analysis of the wettest multi-day periods recorded are presented in Table 2-3.

The largest depth of rain recorded at Tweedraai and Langsloot in 1 day was 192mm and 175mm respectively, which is significantly higher than the design storm estimates for 1:50 and 1:100 years (Table 2-6), suggesting that these events could be expected to be the highest in a much longer time series if one was available. The wettest 30 day period experienced 59-66% of the MAP, whereas the wettest 365 day period experienced 1.6 – 1.9 times the MAP.

The above demonstrates that there is much variation away from the climatic averages in this region.

TABLE 2-2: MONTHLY AVERAGE RAINFALL – TWEEDRAAI AND LANGSLOOT

Month	Tweedraai	Langsloot
January	118.1	119.4
February	88.1	86.9
March	64.2	76.9
April	45.1	37.2
May	21.1	19.5
June	7.0	6.5
July	9.0	5.6
August	8.0	9.3
September	21.6	21.1
October	65.7	75.2
November	105.7	106.9
December	101.3	108.4
Total	**654.9**	**673.0**

TABLE 2-3: MAXIMUM RAINFALL RECORDED ON CONSECUTIVE DAYS – TWEEDRAAI AND LANGSLOOT

Station Name	Tweedraai	Langsloot
SAWS Number	0478386 W	0478292 W
Record Length (Years)	56	78
Mean Annual Precipitation (mm)	625	662
Consecutive Days	**Rainfall (mm)**	**Rainfall (mm)**
1	192	175
2	240	196
3	240	196
5	255	199
7	262	212
10	297	269
15	332	307
30	414	391
60	563	554
120	771	736
240	1028	889
365	1202	1089

Jones & Wagener[1] reviewed daily rainfall records from nearby SAWS stations, and combined records from Langsloot and Secunda stations, which covered different timespans to create an extended record of daily rainfall for the region which was used to indicate extreme wet and dry periods, as presented in Table 2-4.

TABLE 2-4: WETTEST DRIEST PERIODS (SOURCE: JONES & WAGENER)

Station Name	SAWS Number
Wettest 5 Year Period	1992 – 1996
2nd Wettest 5 Year Period	1951 – 1955
Driest 5 years	1961 – 1965

[1] Baseline Surface Water Report for the Anglo American Inyosi Coal Alexander Project (Jones & Wagener, July 2014). Report No.: JW87/14/D715 – Rev 1

2.3 EVAPORATION

Evaporation data is based on records from Bethal (C1E004) Symonds Pan situated 18km south-east of the Shaft Complex, for which 22 years (1962 – 1984) of monthly records were available. A pan coefficient is used to convert S-pan evaporation to evaporation from open water such as a dam or pond, as presented in Table 2-5.

TABLE 2-5: MONTHLY AVERAGE EVAPORATION - BETHAL C1E004

Month	S-Pan Evaporation (mm)	Pan Coefficient[1]	Open Water Evaporation (mm)
January	162.3	0.84	136.4
February	151.8	0.88	133.6
March	148.1	0.88	130.4
April	100.0	0.88	88.0
May	93.9	0.87	81.7
June	73.4	0.85	62.4
July	83.2	0.83	69.0
August	128.2	0.81	103.8
September	152.6	0.81	123.6
October	190.1	0.81	154.0
November	154.1	0.82	126.4
December	197.6	0.83	164.0
Total	**1635.3**		**1373.2**

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

2.4 STORM DEPTH-DURATION-FREQUENCY (DDF)

Design storm estimates for various return periods and storm durations were sourced from the Design Rainfall Estimation Software for South Africa, developed by the University of Natal in 2002 as part of a WRC project K5/1060 (Smithers and Schulze, 2002). The software extracts the storm depth-duration-frequency (DDF) data for the six closest rainfall stations, and was used to interpolate DDF data for the project area, as presented in Table 2-6.

TABLE 2-6: STORM DEPTH-DURATION-FREQUENCY (DDF) RAINFALL FOR PROJECT SITE

Duration	Rainfall Depth (mm)						
	1:2 year	1:5 year	1:10 year	1:20 year	1:50 year	1:100 year	1:200 year
5 minutes	9	12.1	14.3	16.6	19.7	22.2	24.9
10 minutes	13	17.4	20.6	23.9	28.4	32	35.8
15 minutes	16.1	21.6	25.5	29.5	35.1	39.5	44.2
30 minutes	20.6	27.7	32.7	37.9	45	50.7	56.7
45 minutes	23.9	32	37.8	43.8	52	58.7	65.6
1 hour	26.5	35.5	42	48.6	57.7	65	72.8
1.5 hours	30.6	41.1	48.5	56.2	66.8	75.2	84.2
2 hours	33.9	45.6	53.8	62.3	74	83.4	93.3
4 hours	40.7	54.7	64.6	74.8	88.9	100.1	112
6 hours	45.3	60.8	71.9	83.2	98.9	111.4	124.7
8 hours	48.9	65.6	77.5	89.8	106.7	120.2	134.5
10 hours	51.9	69.6	82.2	95.2	113.1	127.5	142.6
12 hours	54.4	73	86.3	99.9	118.7	133.7	149.6
16 hours	58.7	78.8	93.1	107.7	128	144.3	161.4
20 hours	62.3	83.5	98.7	114.3	135.8	153	171.2
24 hours	65.3	87.7	103.6	119.9	142.4	160.5	179.6
1 day	56.6	75.9	89.7	103.9	123.4	139.1	155.6
2 day	69.9	93.8	110.8	128.3	152.5	171.8	192.3
3 day	79.1	106.2	125.4	145.2	172.5	194.4	217.6
4 day	86.1	115.5	136.4	158	187.7	211.5	236.7
5 day	91.9	123.3	145.6	168.6	200.3	225.8	252.6
6 day	96.9	130	153.6	177.8	211.3	238.1	266.5
7 day	101.4	136	160.7	186	221	249.1	278.7

3 BASELINE HYDROLOGY

3.1 INTRODUCTION

In order to inform the flood studies, design of stormwater management measures and the site wide water balance, an understanding of the baseline hydrology is required. This section presents a comprehensive desk based review of various information sources, draws upon observations from a site visit on 26 May 2016 (start of the dry season) and defines the baseline climatic and hydrological conditions of the site and surroundings.

3.2 REGIONAL HYDROLOGY

The regional hydrology is presented in Figure 3-1. The project area is within Water Management Area 4, and is split between four quaternary catchments associated with the Steenkoolspruit and Olifants river as presented Table 3-1. The shaft complex (and most of the project area) falls within the Steenkoolspruit catchment (B11C), which has a Mean Annual Runoff (MAR) of 21.55 million cubic meters (mcm).

TABLE 3-1: QUATERNARY CATCHMENTS

Quaternary Catchment	Catchment Area (km^2)	Mean Annual Runoff (mcm)	Main Watercourse	% Project Area
B11A	945	59.61	Olifants	0.4%
B11B	435	23.65	Olifants	2.8%
B11C	385	21.55	Steenkoolspruit	73.9%
B11D	551	26.41	Steenkoolspruit	22.8%

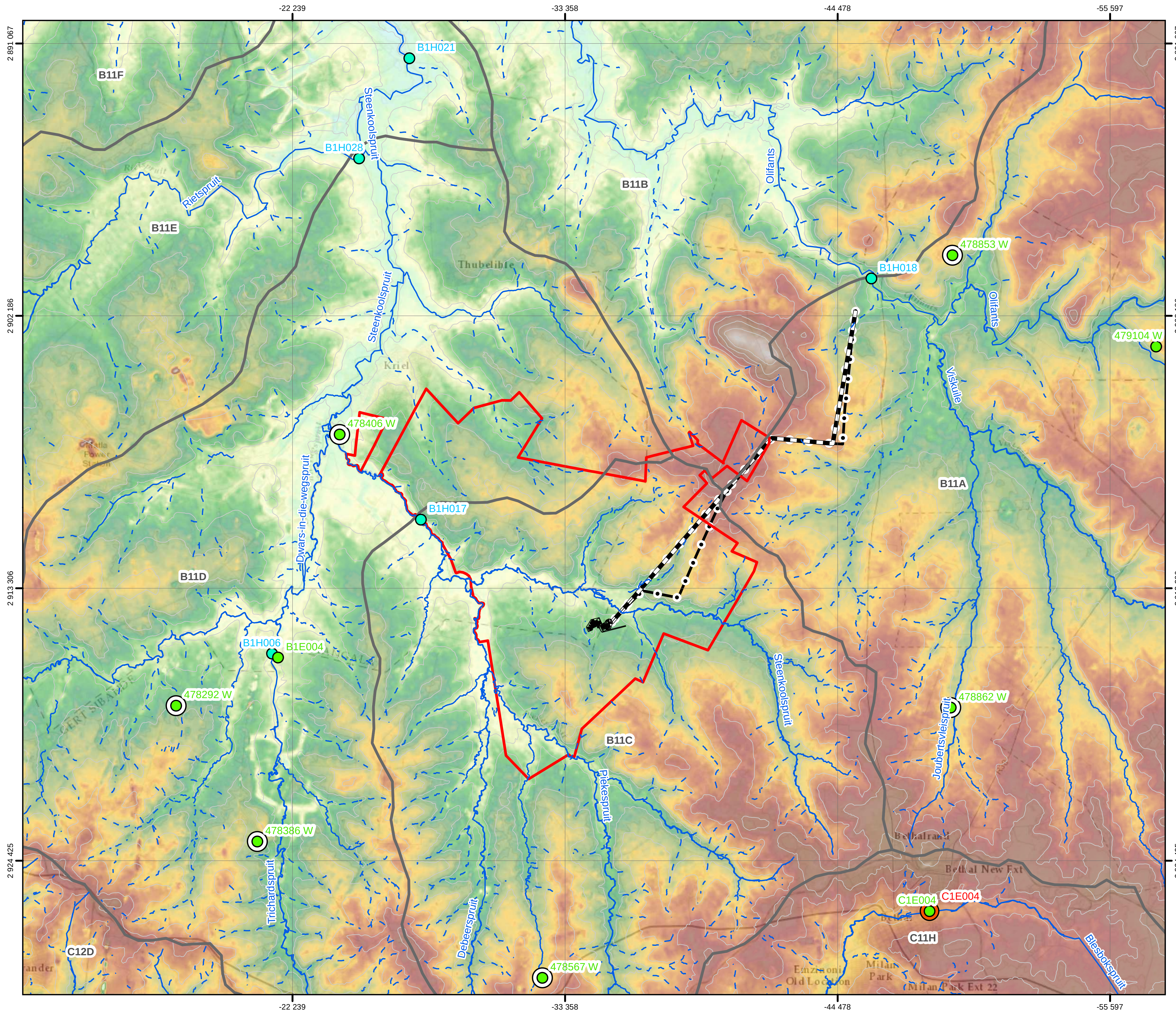
The Steenkoolspruit flows to a confluence with the Olifants approximately 33km north of the shaft complex area, and the Olifants river continues north through Witbank dam (approximately 43km of the shaft complex), through Loskop dam (approximately 100km north of the shaft complex) before flowing in an easterly direction through Limpopo and into Mozambique.

3.3 TOPOGRAPHY

Various sources of topographical data for the project area and surroundings were reviewed including:

- Site Topography Data – topographical data provided by AAIC included 1m contours, and survey points XYZ file, with elevation values on a 15m grid.
- ASTER GDEM – the Advanced Spaceborne Thermal Emmission and Reflection Radiometer Global Digital Elevation Model features an elevation level taken on a 30m grid.
- 20m contours from the 1:50 000 topographical maps of South Africa.

The Project Area is located in an area of undulating topography between 1560 – 1630mAMSL, which generally slopes to the north-west.



Legend

- Rain Gauges
- Evaporation Pans
- Project Rain Gauges
- Flow Gauges
- Rivers - Non-Perennial
- Rivers - Perennial
- Quaternary Catchments
- Project Area
- Shaft Complex
- Conveyor Route
- Alternative Conveyor
- 20m Contours

ASTER Digital Elevation Model

Value

High : 1851

Low : 1352

0 1 2 4 6 8 10

Kilometers

Projection: Transverse Mercator
Datum: Cape, LO29

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Figure 3-1

Regional Hydrology

SLR Consulting (Africa) (Pty) Ltd
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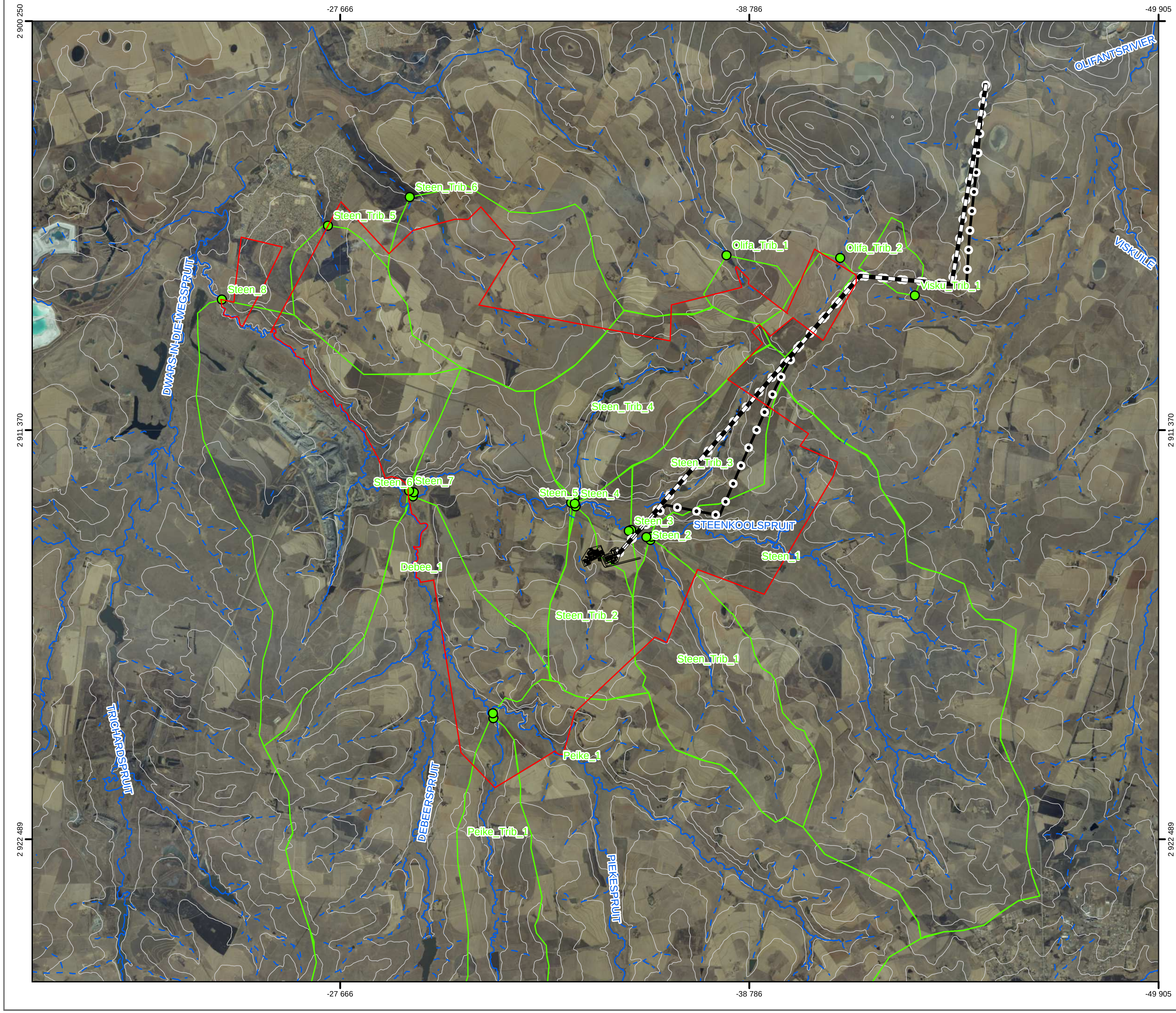

Legend

- Project Area
- Shaft Complex
- Conveyor Route
- Alternative Conveyor
- Catchments Outfalls
- Rivers - NonPerennial
- Rivers - Perennial
- Catchments
- 20m Contours

0 0.5 1 2 3 4

Kilometers

Projection: Transverse Mercator
Datum: Cape, LO29

Anglo American Inyosi Coal (Pty) Ltd

Figure 3-2

Local Hydrology

SLR

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3.4 LOCAL WATERCOURSES NETWORK AND CATCHMENTS

The local hydrology is presented in Figure 3-2. The Steenkoolspruit flows through the centre of the site from east to west, and then along the western site boundary. The Piekespruit flows through the southern part of the site, past a confluence with the Debeerspruit, along the western site boundary to a confluence with the Steenkoolspruit. West of the site the Trichardspruit flows in a northerly direction to a confluence with the Steenkoolspruit approximately 1.5km north west of the project area. All of these mentioned watercourses are shown to be perennial on the 1:50 000 topographic maps.

97% of the project area falls within the Steenkoolspruit catchment, with the remaining 3% within the Olifants river catchment. Runoff from 66% of the project area will flow into the Steenkoolspruit upstream of the confluence with the Trichardspruit, 19% will flow into the Steenkoolspruit downstream of this confluence and 12% will flow into the Debeerspruit catchment (which flows into the Steenkoolspruit on the western site boundary).

The project area is 125km^2, of which 92.5km^2 falls within quaternary catchment B11C, and the project area accounts for 24% of the total area of B11C.

The shaft complex is situated south of the Steenkoolspruit between two non-perennial unnamed tributaries of the Steenkoolspruit, both of which flow north into the Steenkoolspruit. The conveyor route passes over the Steenkoolspruit and another non-perennial tributary which flows from the north-east to south-west and features several farm dams. Although, the alternative conveyor route avoids this tributary.

Many of the smaller non-perennial watercourses within the project area feature dams, and a total of 34 dams were identified from aerial photography of the site.

Photos of the main watercourses within the vicinity of the Shaft Complex are presented in Figure 3-3 to Figure 3-5.

FIGURE 3-3: TRIBUTARY 1 OF THE STEENKOOLSPRUIT (STEEN_TRIB_1) FACING DOWNSTREAM APPROXIMATELY 1KM NORTH-WEST OF PROPOSED SHAFT COMPLEX

FIGURE 3-4: STEENKOOLSPRUIT FACING UPSTREAM APPROXIMATELY 1KM NORTH-WEST OF PROPOSED SHAFT COMPLEX

FIGURE 3-5: STEENKOOLSPRUIT FACING UPSTREAM APPROXIMATELY 1.5KM NORTH-EAST OF PROPOSED SHAFT COMPLEX

3.5 BASELINE FLOWS

3.5.1 GAUGING STATIONS

A review of the Department of Water and Sanitation's (DWS) network of flow gauging stations indicates that 3 stations are located downstream of the project area, a summary of which is presented in Table 3-2. Time series of monthly flow volumes for each station are presented in Figure 3-6, Figure 3-7 and Figure 3-8.

TABLE 3-2: FLOW GAUGING STATIONS

Watercourse	Location	DWS No.	Quaternary Catchment	Catchment Area (km^2)	Record
Steenkoolspruit	Aangewys	B1H017	B11C	387	Nov 1989 onwards
Steenkoolspruit	Middeldrift	B1H021	B11E	1356	Oct 1990 onwards
Olifants	Middelkraal	B1H018	B11A	985	Nov 1989 onwards

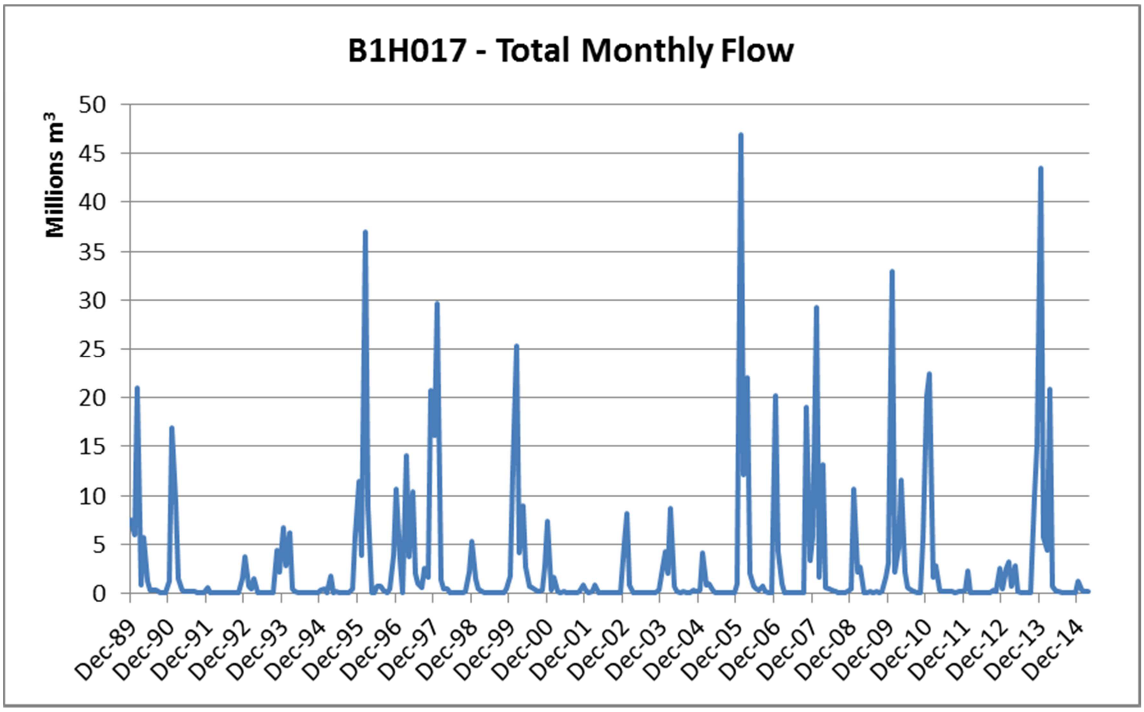


FIGURE 3-6: MONTHLY FLOW VOLUMES RECORDED AT GAUGING STATION B1H017

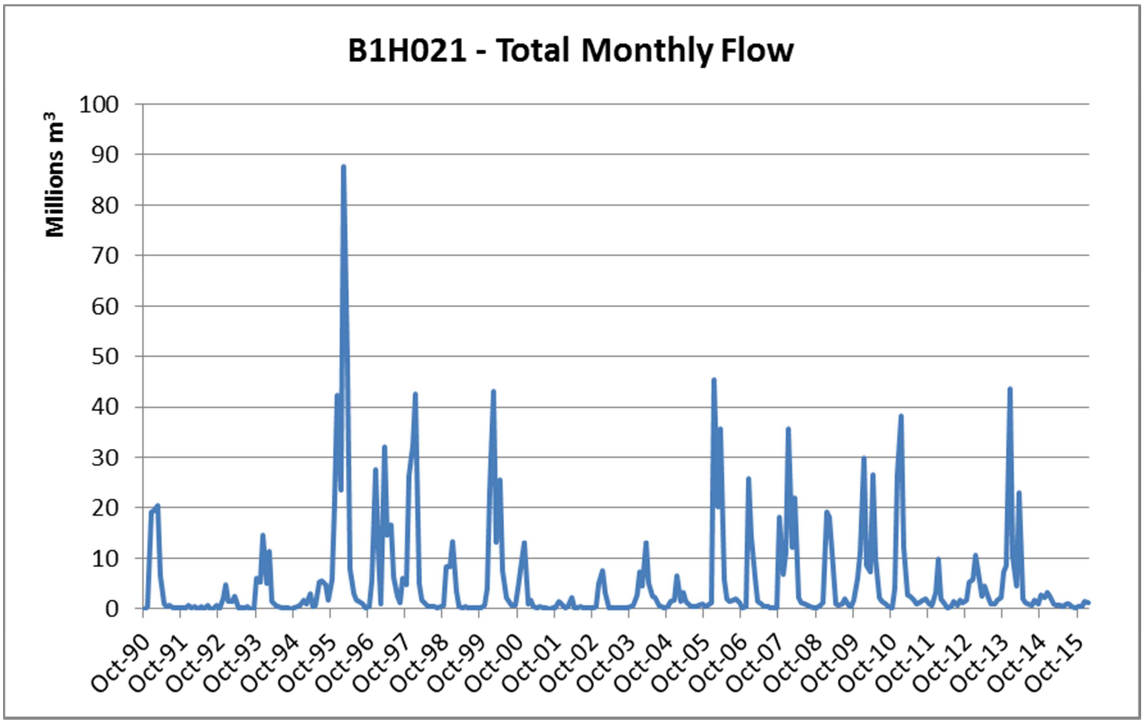


FIGURE 3-7: MONTHLY FLOW VOLUMES RECORDED AT GAUGING STATION B1H021

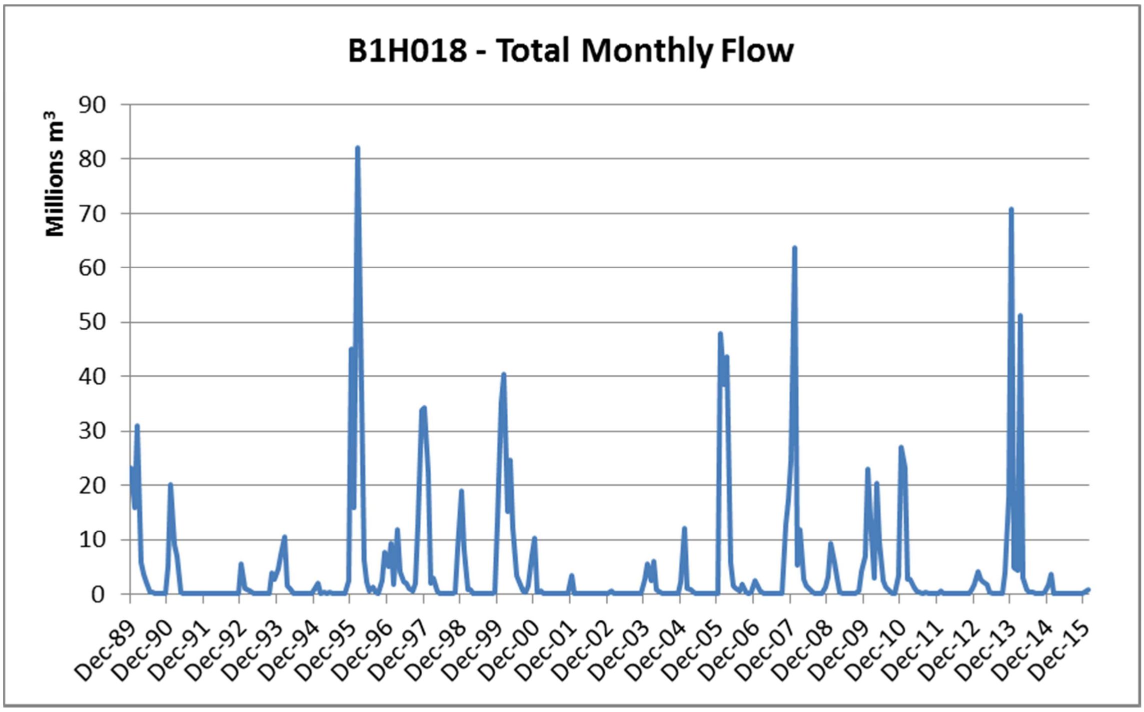


FIGURE 3-8: MONTHLY FLOW VOLUMES RECORDED AT GAUGING STATION B1H018

3.5.2 MODELLED FLOWS - WRSM/PITMAN

The Surface Water Resources of South Africa, 2012 Study (WR2012) is the latest water resources appraisal and updates and expands upon previous studies, most recent of which was WR2005, which was pre-dated by WR90. The WR2005 study focused on assessing resources through rainfall, observed streamflow and land/water use using records up to September 2006, generating information at a quaternary catchment level for the whole of South Africa, Lesotho and Swaziland.

Compared to the WR2005 study, the WR2012 includes, amongst other items, an improved level of detail over previous studies on farm dams and reservoirs, updated rainfall and streamflow data up to September 2012.

The WR2012 study presents analysis of the water resources of South Africa, Lesotho and Swaziland undertaken using the WRSM2000/Pitman rainfall-runoff model. The WRSM/Pitman model considers the role of rainfall, evaporation, runoff and groundwater alongside the impacts of water users in the form of reservoirs, irrigation, and mines to estimate the flows within quaternary watercourses at a monthly timestep.

The WRSM/Pitman model was calibrated against flow in gauging stations B1H017, B1H021, and B1H0018 as part of the WR2012 Study. The calibrated model was run with an extended rainfall series to estimate the flow in each quaternary catchment between 1920 – 2009, as presented in Figure 3-9, Figure 3-10 and Figure 3-11.

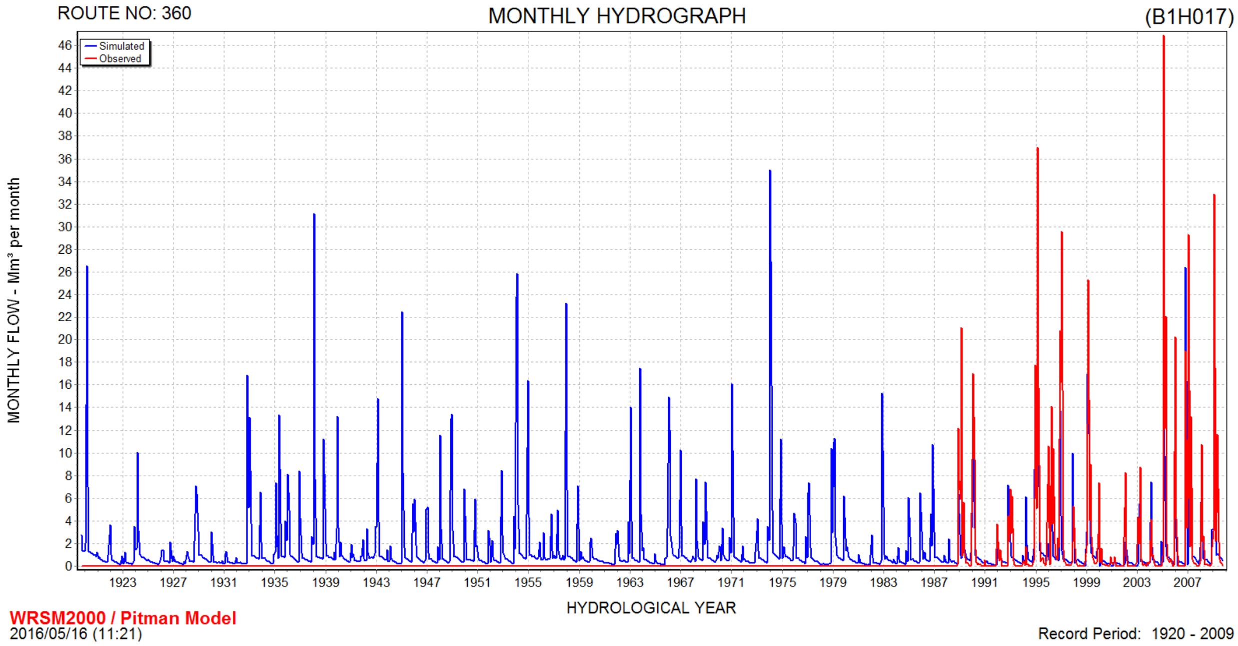


FIGURE 3-9: SIMULATED FLOWS AT GAUGING STATION B1H017 (STEENKOOLSPRUIT)

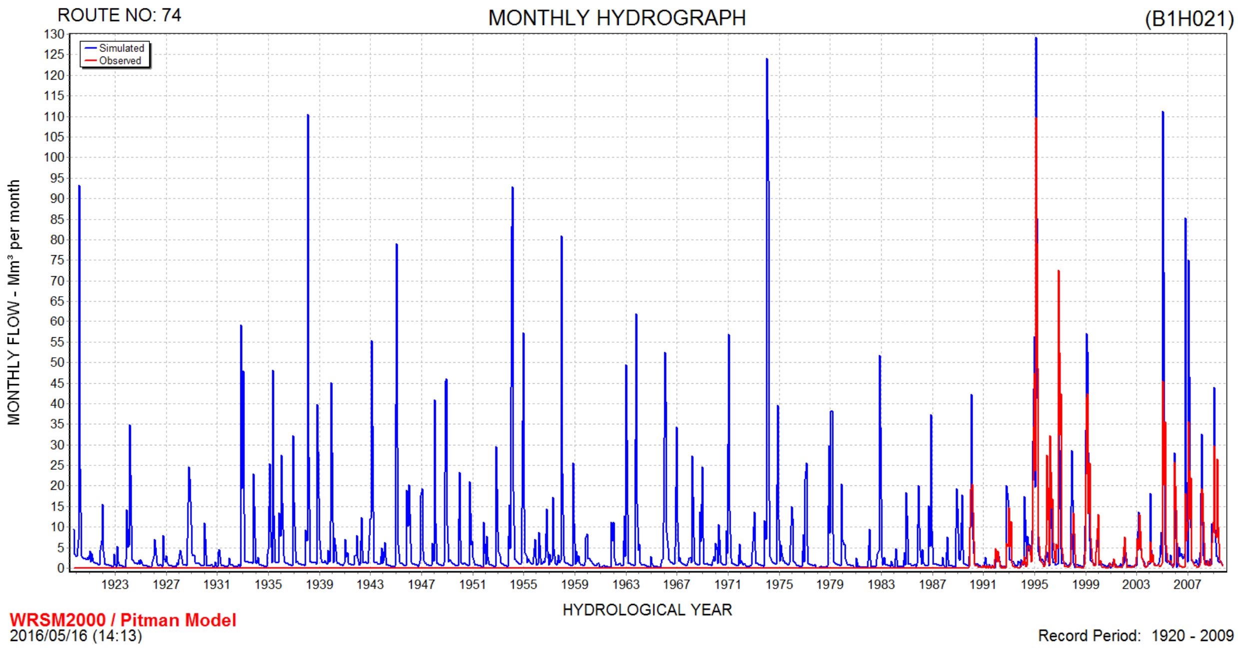


FIGURE 3-10: SIMULATED FLOWS AT GAUGING STATION B1H021 (STEENKOOLSPRUIT)

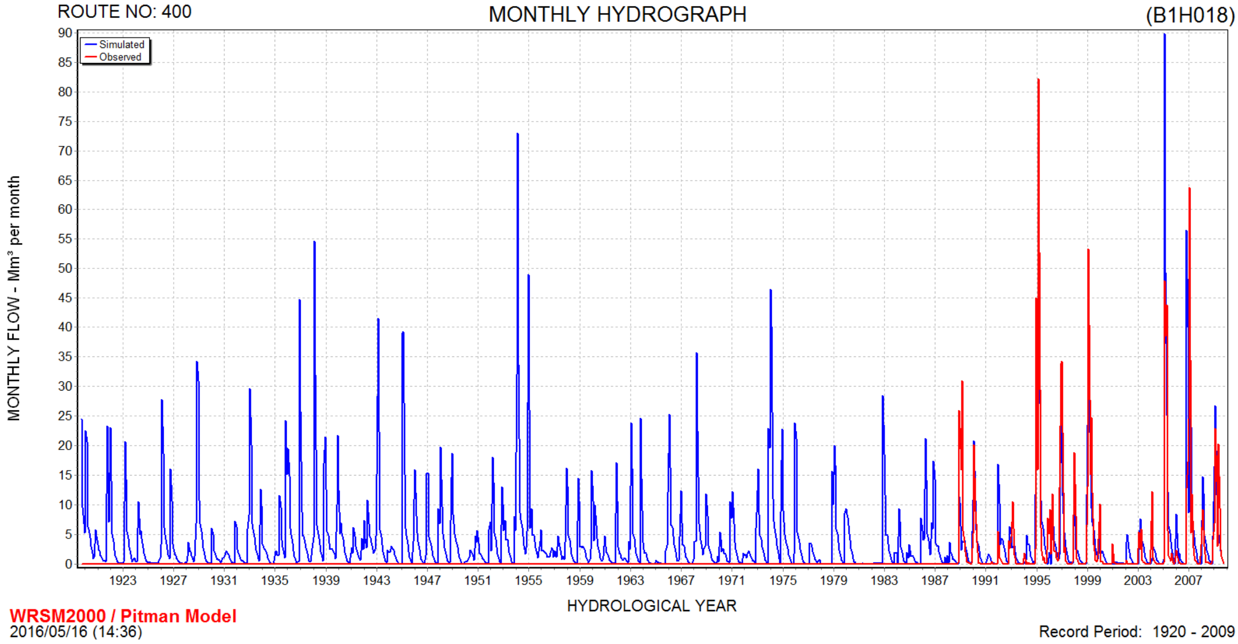


FIGURE 3-11: SIMULATED FLOWS AT GAUGING STATION B1H018 (UPPER OLIFANTS RIVER)

The time series were analyzed to understand the average, high and low flows for each month, as presented in Table 3-3 and Figure 3-12 to Figure 3-14. Low flows are expressed as Q_{90} which is the flow which is exceeded 90% of the time during a given month, and high flows are expressed as Q_{10} which is the flow which is exceeded only 10% of the time during a given month.

TABLE 3-3: AVERAGES AND EXTREMES OF MODELLED FLOWS (MILLION M3/MONTH) 1920-2009

Month	B1H017			B1H021			B1H018		
	Low Flow	Ave. Flow	High Flow	Low Flow	Ave. Flow	High Flow	Low Flow	Ave. Flow	High Flow
October	0.15	1.24	1.80	0.27	3.87	8.08	0.00	2.29	2.90
November	0.18	3.00	8.65	0.34	10.05	29.58	0.00	6.31	17.04
December	0.26	3.06	6.89	0.61	10.10	23.49	0.00	8.40	19.83
January	0.31	4.60	13.88	0.97	15.54	48.06	0.33	10.46	25.84
February	0.34	3.40	8.43	0.75	11.55	29.81	0.41	9.54	23.66
March	0.36	1.96	5.00	0.73	6.17	16.50	1.38	6.76	18.94
April	0.33	0.98	1.92	0.57	2.63	6.40	1.08	4.12	7.43
May	0.30	0.77	1.09	0.48	1.78	2.37	0.61	2.88	5.86
June	0.28	0.59	0.85	0.47	1.21	1.68	0.36	2.08	4.49
July	0.24	0.50	0.76	0.43	0.93	1.45	0.19	1.37	3.12
August	0.21	0.44	0.70	0.39	0.86	1.29	0.08	0.83	1.99
September	0.16	0.46	0.73	0.35	1.12	2.21	0.05	0.56	1.57

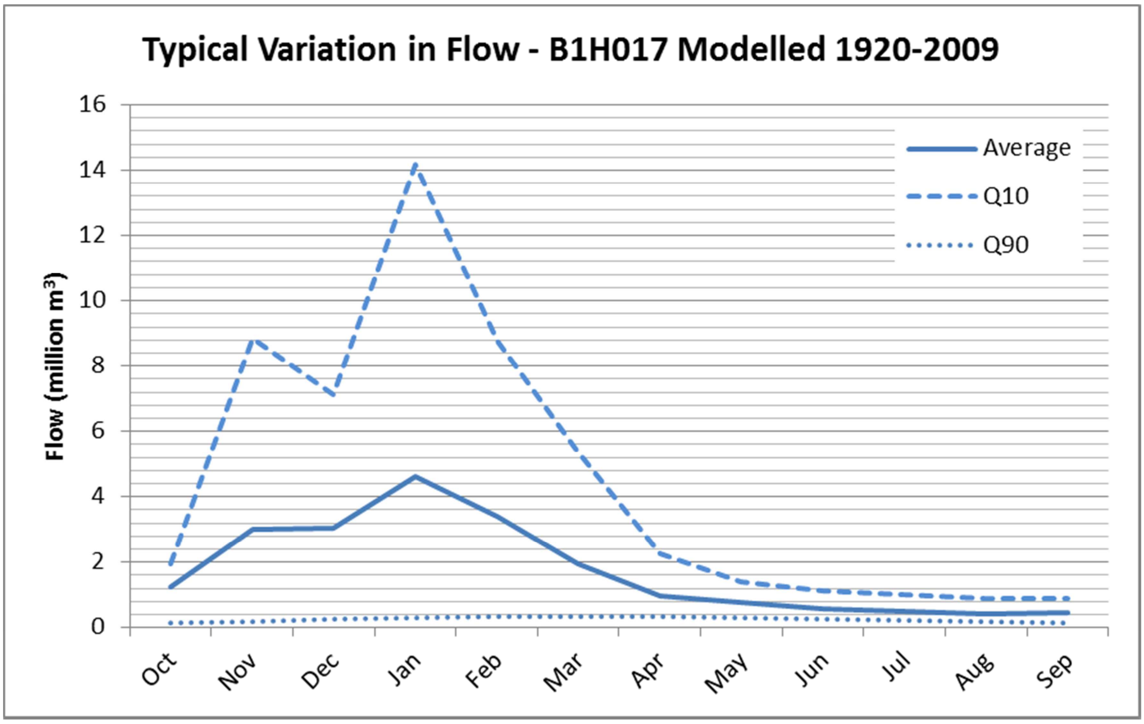


FIGURE 3-12: AVERAGES AND EXTREME OF MODELLED FLOWS AT GAUGING STATION B1H017

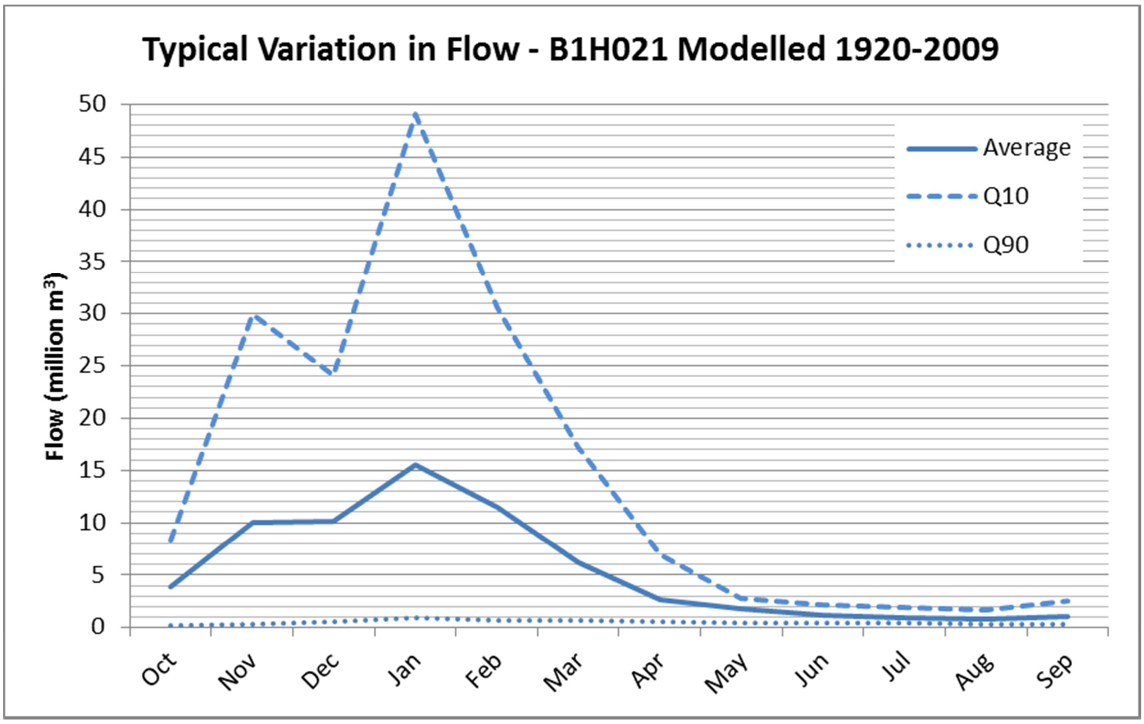


FIGURE 3-13: AVERAGES AND EXTREME OF MODELLED FLOWS AT GAUGING STATION B1H021

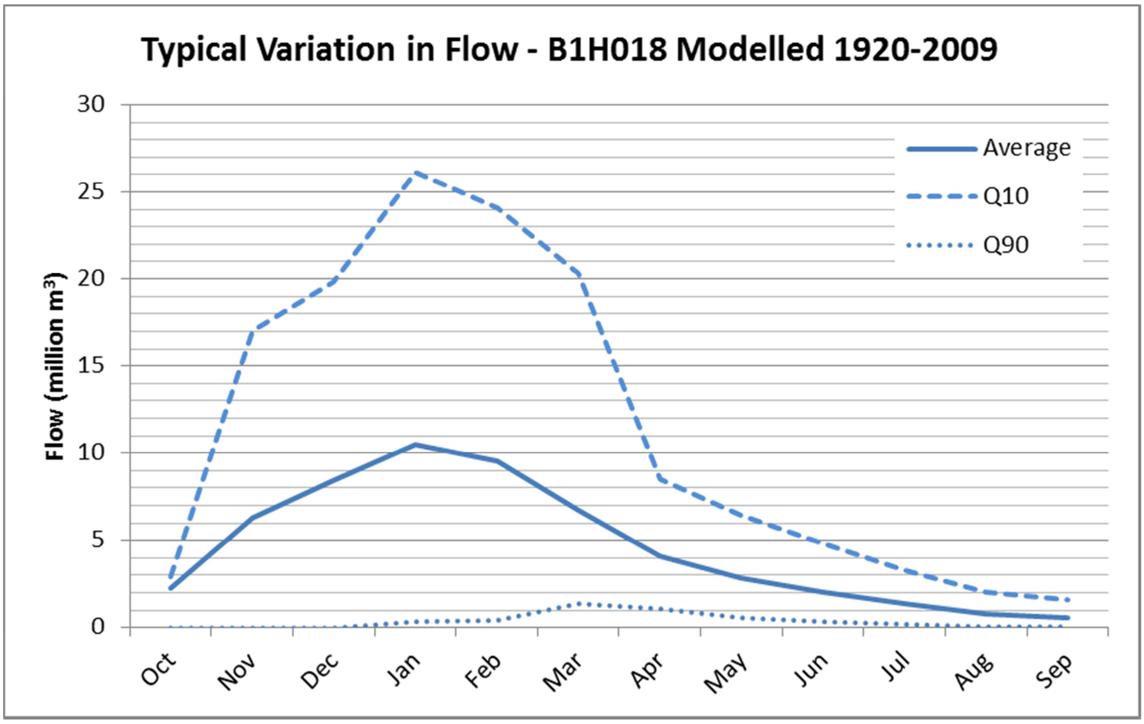


FIGURE 3-14: AVERAGES AND EXTREME OF MODELLED FLOWS AT GAUGING STATION B1H018

The above analysis shows that the Steenkoolspruit at BH1017 sustains a significant baseflow throughout the dry season of 0.46 million m^3/month (0.175m^3/s) on average, and a low flow of approximately 0.16 million m^3/month (0.060m^3/s). This is likely to be attributable to groundwater inflows throughout the dry season, indicating that there is some degree of hydraulic connection with underlying aquifers within the catchment.

3.6 WATER USERS

A Water Users Survey was undertaken to gain an understanding of the typical water usages within the Project area.

3.6.1 METHODOLOGY

The survey involved liaison with local landowners, who were identified from the stakeholders database, or encountered during the hydrocensus fieldwork. A standard questionnaire was developed to allow a consistent approach to data collection, and the questionnaire was either completed in person or telephonically, using contact details from the stakeholders database.

3.6.2 Results and Conclusions

A review of the available cadastral data and the stakeholders database shows that a total of 96 farm portions, across 11 parent farms fall within the Project Area.

A total of 10 landowners completed the questionnaire, many of whom owned many portions within the project area. The survey concluded:

- All of the surveyed water users were reliant on borehole water for domestic uses and relied on septic tanks for disposal of sewage water.
- Most of the surveyed water users frequently used borehole water for irrigation and livestock watering.
- Livestock use several of the small dams across the Project Area.
- None of the surveyed water users used water from the dams for irrigation.
- None of the surveyed water users abstracted water from the local watercourses.

3.6.3 Limitations

The details within the stakeholder database for each farm portions often lacked a phone number, the phone number was not working, or the phone went unanswered and in each case several messages were left but no calls were returned.

The survey only captured information on water users within the project area, and does not extend downstream where water users may abstract from the Steenkoolspruit.

The survey results are considered to be a useful indication of water usage within the project area, although does not represent a complete and absolute catalogue of all water users within the project area.

3.7 Water Quality

The quality of stormwater from coal mines in the Upper Olifants catchment typically has elevated concentrations of sulphates and high salinity, and several rounds of surface water quality sampling have been undertaken to document the baseline surface water quality of the Project Area.

3.7.1 Methodology

SLR undertook a surface water and groundwater hydrocensus between 13 – 21 April 2016, which is presented in full within the Alexander Project - Hydrocensus Report (SLR, 2016).

Surface water was collected from 16 locations, as presented in Figure 3-15. Monitoring points were located upstream and downstream of the Project Area, and monitoring points from J&W study were revisited where possible.

The water users survey concludes that groundwater is the predominant water supply source for domestic uses (including drinking), livestock watering and irrigation within the project area. However, it is considered likely that surface water may be used for irrigation and livestock watering within the project area or downstream of project area, and the possibility of surface water being used for drinking water cannot be ruled out. Therefore the surface water quality results were compared against the following guidelines:

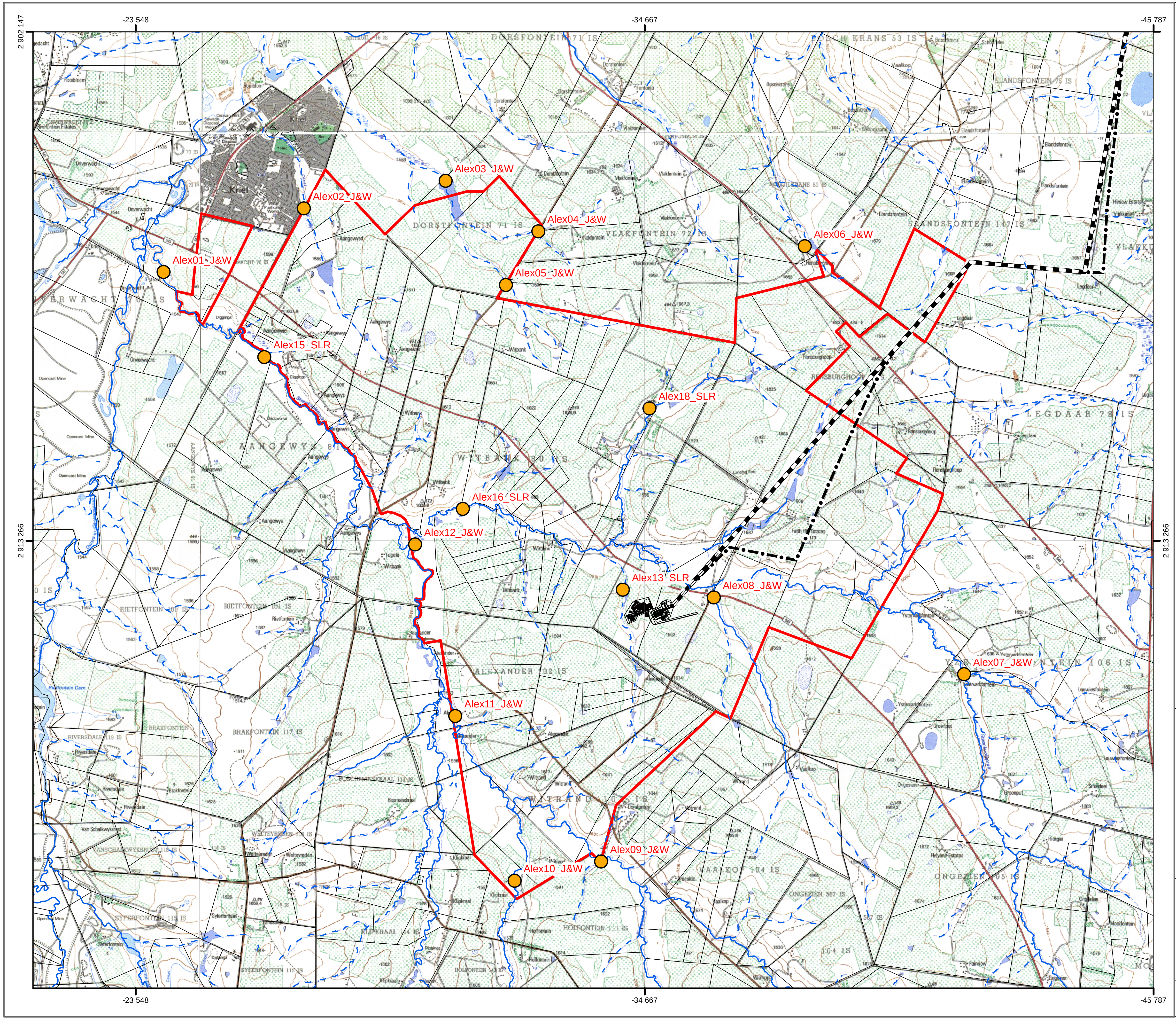
- South African National Standards (SANS) 241 (2011) water quality standards (SANS 241 (2011);
- Department of Water Affairs (DWAF) (now Department of Water and Sanitation) Target Water Quality Range Livestock watering (2009).
- Department of Water Affairs (DWAF) (now Department of Water and Sanitation) Target Water Quality Range for Irrigation (2009).

The results collected as part of the Baseline Surface Water Assessment (Jones and Wagner, 2014) were compared to Interim Resource Water Quality Objectives (RWQO) for Catchment Management Unit 7 (MU7), developed by the Directorate National Water Resource Planning (DNWRP) of the (then) Department of Water Affairs and Forestry (DWAF) for the Upper and Middle Olifants River catchment (DNWRP, 2009). SLR has been unsuccessful in sourcing the document in which the RWQO were published, however the surface water results collected during the hydrocensus results have also be compared to the MU7 limits.

3.7.2 RESULTS AND CONCLUSIONS

Based on the surface water hydrocensus results, the following is concluded:

- Surface water is not fit for irrigation due to elevated **manganese and electrical conductivity** concentrations in all samples, along with elevated concentration of **selenium, sodium, chloride and TSS** in selected samples.
- Surface water is fit for livestock watering.
- Surface water at monitoring points Alex 01_J&W, Alex 05_J&W and Alex 14_SLR is not fit for human consumption due to elevated concentrations of **manganese** above the SANS 241:2015 limit for Chronic Health which indicates an unacceptable health risk if ingested over an extended period.
- **Iron** concentrations at Alex 05_J&W and Alex 14_SLR were also elevated above the SANS 241:2015 Aesthetic limit. Although the concentrations do not pose an unacceptable health risk, water will be tainted with respect to taste, odour or colour.



Legend

- Rivers: Perennial
- Rivers: Non Perennial
- Shaft Complex
- Conveyor Route
- Alternative Conveyor
- Project Area
- Monitoring Points

0 0.5 1 2 3 4 5

Kilometers

Projection: Transverse Mercator
Datum: Cape, LO29

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Figure 3-15

Surface Water Monitoring Locations

SLR

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- Surface water at Alex 11_J&W and Alex 15_SLR does not pose an unacceptable health risk, however water will be tainted with respect to taste, odour or colour due to **manganese** concentrations (both boreholes) and **sulphate** (Alex 15_SLR) concentrations elevated above the SANS 241:2015 Aesthetic limit.

When compared to the interim RWQO for MU7, the hydrocensus data show that elevated concentrations of Al, Fe, Mn, P, Na, EC, TDS, Cl and F were recorded.

The elements Al, Fe, Mn, Na, EC, TDS and Cl were recorded at concentration in excess of the MU7 limits during J&W's 2014 Baseline Surface Water Assessment.

3.7.3 LIMITATIONS

The Hydrocensus Report (SLR, 2016) presents surface water quality results from January, March and May 2014, and April 2016 which are all during the wet season or towards the end of the wet season, however no sampling rounds were undertaken during the dry season (typically July – August). Given the low flows observed during the April 2016 sampling round, there would not be expected to be significant flow at most of the sampling locations, and therefore the lack of dry season water quality is not considered to detrimentally effect the characterisation of the baseline surface water quality.

3.8 WETLANDS

The Project Area features numerous wetlands, predominantly associated with the network of watercourses which pass through the site. The Wetland Assessment report[2] concluded that 37.6% of the Project Area comprised wetlands, of which most were hillslope seepages or floodplains.

3.9 VEGETATION

The WR2005 shows the natural vegetation of the project area to be grassveld both pure and false types. The Vegetation Map of South Africa (SANBI, 2006) classifies the natural vegetation type of the Steenkoolspruit catchment as highveld grassland. During the site visit in May 2016, it was noted that large parts of the Project Area are used for agriculture including maize farming and grazing of livestock.

[2] *Wetland Delineation and Impact Assessment for the Proposed Alexander Project (Wetland Consulting Services (Pty) Ltd, May 2016)*

3.10 SOILS AND GEOLOGY

WR2005 shows the project area to be situated in an area of "intercalated arenaceous and argillaceous strata", with soils described as "moderate to deep, clayey loam". The project area is underlain by the Vryheid formation (Ecca), which is essentially an interbedded succession of sandstone with lesser gritstone, siltstone and mudstone, which contains five coal seams of the Highveld coalfield.[3]

The Soil and Terrain Database (SOTER v1.0) for South Africa shows that the soils throughout the majority of the project area are Acrisols which are defined in the Harmonized World Soil Database (FAO, 2008) as "soils with subsurface accumulation of low activity clays and low base saturation", whilst smaller areas in the east and far south feature Vertisols "dark coloured cracking and swelling clays".

Based on the soils and geology, it is likely that infiltration rates are moderate to low across the project area and runoff is likely to be readily generated during storm events.

3.11 GROUNDWATER

The groundwater environment is discussed in full in the Groundwater Specialist Study (SLR, 2016), a brief summary of the relevant details is presented below.

The upper Ecca formation, which underlies the project area, comprises a moderate (in some places high) hydraulic conductivity aquifer, which sustains groundwater supplies to numerous water users via boreholes (21 boreholes were identified and inspected during the Hydrocensus). Groundwater levels are expected to be 10 – 20m below ground level (bgl) according to the National Groundwater Maps, and water levels in boreholes measured during the Hydrocensus were typically observed to be between 5 – 30m bgl.

The lower Ecca formation has poor hydraulic conductivities and is considered an aquitard. The S4 coal seam, from which coal will be mined, sits below the Ecca formation.

[3] *Alexander Coal Project: Groundwater Specialist Study. Project No. 750.01080.0006 (SLR, 2016)*

4 FLOOD HYDROLOGY

4.1 INTRODUCTION

Jones & Wagener (J&W) estimated peak flows as part of the Baseline Surface Water Study[1] using various methods including the Rational method, Standard Design Flood method, the Synthetic Hydrograph method, the Regional Maximum Flood (RMF) method and the Direct Run-off Hydrograph method. J&W estimated flood volumes based on a simplified hydrograph method and the relationship between RMF and MAR which Department of Water Affairs derived from measurements of various extreme flood events across South Africa.

4.2 METHODOLOGY

This study assumed that J&W's peak flow and flood volumes estimates are valid and suitable to adopt for informing hydraulic flood modelling discussed in Section 5. Slight differences in catchment areas exist between SLR's and J&W's catchment analysis and the flows and volumes were scaled up or down according to area for consistency with SLR's catchments areas.

J&W's analysis does not present flow or volume estimates for a small catchment (2km^2) located 11km north-east of the shaft complex (Visku_Trib_1), which flows in a south-easterly direction beneath the proposed conveyor route. For the Visku_Trib_1 catchment, peak flows for the 1:50 year, 1:100 year and 1:200 year events were estimated by the Rational method. The RMF was estimated by applying a growth factor to the 1:200 year peak flow, which was estimated by taking the average of the RMF divided by 1:200 year peak flows presented by J&W.

4.3 RESULTS

The estimated peak flows and flood volumes based on J&W's analysis are presented in Table 4-1 and the peak flows for Visku_Trib_1 catchment are presented in Table 4-2.

TABLE 4-1: PEAK FLOWS AND FLOOD VOLUMES (BASED ON J&W'S BASELINE SURFACE WATER REPORT)

Catchment	Area (km^2)	J&W Ref	1:50yr		1:100yr		1:200yr		RMF	
			Flood peak (m^3/s)	Volume (million m^3)	Flood peak (m^3/s)	Volume (million m^3)	Flood peak (m^3/s)	Volume (million m^3)	Flood peak (m^3/s)	Volume (million m^3)
Debee_1	200.80	A_11	364.3	16.2	464.8	20.7	546.0	24.3	844.3	37.5
Olifa_Trib_1	3.06	A_06	54.6	3.6	68.0	4.5	80.6	5.4	137.7	9.2
Olifa_Trib_2	3.07	A_14	16.8	0.2	21.1	0.2	26.2	0.3	51.8	0.6
Pieke_1	104.11	A_09	242.6	8.1	305.5	10.2	362.5	12.1	583.5	19.4
Pieke_Trib_1	20.32	A_10	76.2	2.1	96.7	2.6	118.2	3.2	309.7	8.4
Steen_1	73.74	A_07	220.6	5.1	279.6	6.4	347.5	8.0	597.6	13.8
Steen_2	93.60	A_12	186.4	6.9	238.8	8.9	284.9	10.6	471.3	17.5
Steen_3	104.67	A_13	208.5	7.7	267.0	9.9	318.6	11.8	527.1	19.6
Steen_4	116.27	A_13	231.6	8.6	296.6	11.0	353.9	13.1	585.5	21.8
Steen_5	134.56	A_13	268.0	10.0	343.3	12.8	409.6	15.2	677.6	25.2
Steen_6	153.96	A_13	306.7	11.4	392.8	14.6	468.6	17.4	775.3	28.8
Steen_7	354.48	A_12	518.3	30.3	654.3	38.3	764.7	44.7	1133.3	66.3
Steen_8	398.83	A_01	471.1	28.9	595.8	36.6	707.6	43.5	1214.6	74.6
Steen_Trib_1	20.03	A_18	104.0	1.3	131.2	1.6	162.3	2.0	307.1	3.7
Steen_Trib_2	9.22	A_19	69.2	0.5	87.7	0.7	107.2	0.8	228.9	1.7
Steen_Trib_3	9.46	A_16	63.1	0.5	80.9	0.6	96.0	0.8	218.7	1.7
Steen_Trib_4	20.11	A_17	109.2	1.2	137.0	1.5	170.4	1.9	334.1	3.8
Steen_Trib_5	10.08	A_02	72.0	0.6	91.2	0.8	108.5	0.9	227.0	1.9
Steen_Trib_6	24.71	A_03	153.8	2.2	192.2	2.8	229.8	3.4	315.6	4.6

TABLE 4-2: RATIONAL METHOD INPUT PARAMETERS – VISKU_TRIB_1 CATCHMENT

Flood Event	Area (km^2)	Runoff Coefficient	Time of Concentration (hours)	Rainfall Intensity (mm/hr)	Flow (m^3/s)
1:50 year	2.0	0.305	1.004	57.58	9.76
1:100 year	2.0	0.368	1.004	64.87	13.24
1:200 year	2.0	0.368	1.004	72.65	14.83
RMF	N/A				26.80

4.4 CONCLUSIONS AND RECOMMENDATIONS

Whilst no independent checks have been undertaken of J&W's analysis, the peak flows presented above appear reasonable for the watercourses of interest and are considered suitable to inform the hydraulic modelling of flood-lines.

4.5 LIMITATIONS AND FURTHER WORK

The peak flows are considered fit for purpose and no further work is considered necessary.

5 HYDRAULIC FLOOD MODELLING

5.1 INTRODUCTION

In order to inform the infrastructure layout of the mining operation, understand and manage the risks of flooding to the operation and assess compliance with Condition 4 of GN704, modelling of the 1:50 year and the 1:100 year flood-lines is required for the watercourses within the vicinity of the surface infrastructure. It is not considered necessary to model flood-lines for all watercourses within the Project area, only those which flow close to any surface infrastructure.

The following section details the approach and the methods used in the development of a hydraulic model for the purpose of delineating the flood-lines.

5.2 METHODOLOGY

5.2.1 CHOICE OF SOFTWARE

HEC-RAS 4.1 was used for the purposes of modelling the flooding resulting from a 1:50 year, 1:100 year, 1:200 year and RMF flood events. HEC-RAS is a hydraulic programme used to perform one-dimensional hydraulic calculations for a range of applications, from a single watercourse to a full network of natural or constructed channels. The software is used worldwide and has consequently been thoroughly tested through numerous case studies.

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

5.2.2 TOPOGRAPHICAL DATA

As discussed in Section 2, topographical data was provided by AAIC which included 1m contours, and survey points XYZ file, with elevation values on a 15m grid. The survey points and contours were combined and used to generate a digital elevation model (DEM), of the project area.

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

5.2.3 MODEL EXTENTS

The flood model setup is shown in Figure 5-1. In total 10 reaches of watercourse were modelling including 5 reaches of the Steenkoolspruit, 4 of it's tributaries and a separate tributary of the Viskule. The Steenkoolspruit model extends from 1.4km upstream of the shaft complex, 1.7km upstream of the conveyor route to the east and 0.8km upstream of the conveyor route to the north, to 3.2km downstream of the shaft complex. The Viskule model extends from 0.8km upstream to 0.4km downstream of the conveyor route. A total length of approximately 21.0km of watercourses are modelled.

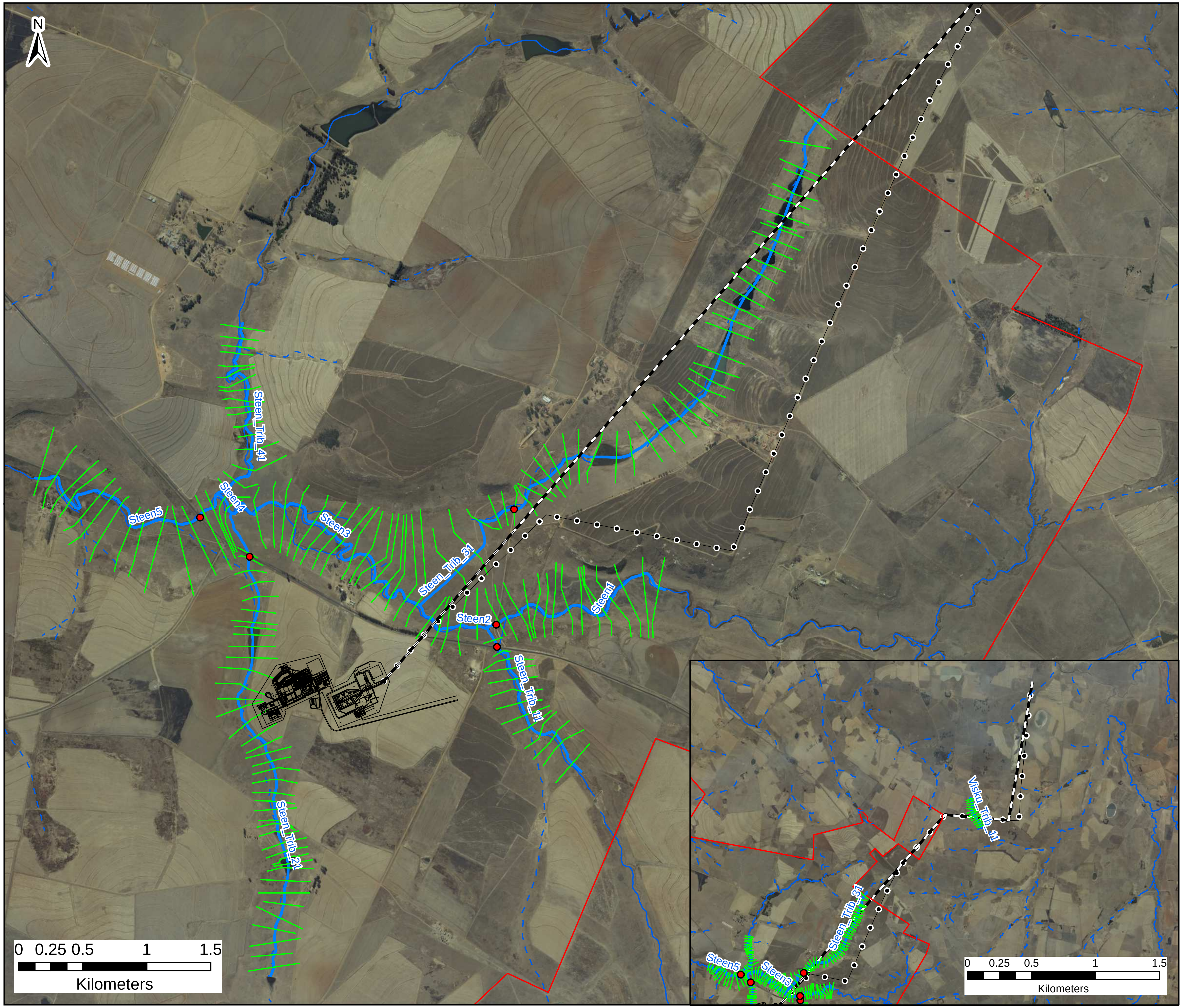
5.2.4 HYDRAULIC STRUCTURES

One of the key objectives of the site visit undertaken was to determine the existence of any hydraulic structures within the modelled reaches of the Steenkoolspruit. In total 5 watercourse crossings were identified, details of which are presented in Table 5-1 and photos are presented in Figure 5-2 to Figure 5-6.

TABLE 5-1: DETAILS OF WATERCOURSE CROSSINGS

Watercourse Reference	Description	Figure No.
Steen_Trib_1	Concrete beam bridge, with 2 support pillars. Deck = 0.5m thick. Pillars = 0.5m wide. Height of deck above stream bed: Left = 3.5m, Middle = 3.2m, Right = 2.8m. Width between pillars = 3.5m (perpendicular to flow). Bridge is aligned 30º to flow direction.	5-2
Steen_1	Crossing across main Steenkoolspruit channel comprises 23 x 1300mm internal diameter (ID) culverts with 400mm of cover above. Culverts are placed onto an exposed flat sandstone outcrop, which comprises the river bed in this location.	5-3
Steen_Trib_3	Road crossing runs along the top of a dam wall, impounding flow to the east. Outflow from the dam comprises 2 x 1300mm ID culverts placed beneath the road surface at the northern end.	5-4
Steen_Trib_2	Concrete beam bridge, with 1 support pillar. Deck = 0.5m thick. Pillar = 0.5m wide. Height of deck above stream bed: Left = 3.5m, Right = 3.5m. Width between pillars = 3.5m (perpendicular to flow). Bridge is aligned 30º to flow direction.	5-5
Steen_5	Crossing across main Steenkoolspruit channel concrete beam with 1 support pillar. Deck = 0.5m thick. Pillar = 0.5m wide. Height of deck above stream bed: Left = 4.5m, Right = 3.5m. Width between pillars = 6m (perpendicular to flow). Bridge is aligned 30º to flow direction.	5-6

In total 9 dams were identified within the modelled extents. These were input into the model by generating a cross-sections through the dam wall, which picked up the dimensions of the dam spillway / outflow control for each dam. Steady state modelling was undertaken which ignores the effects of storage and flood routing through the dams, and it is assumed that each dam is full (up to the spillway) at the start of a flood event.



Legend

- Project Area
- Shaft Complex
- Conveyor Route
- Alternative Conveyor
- Bridges
- Cross Sections
- Modelled Rivers
- Rivers - Non Perennial
- Rivers - Perennial

Projection: Transverse Mercator
Datum: Cape, LO29

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Figure 5-1

Flood Model

SLR

SLR Consulting (Africa) (Pty) Ltd
P O Box 1596, Cramerview, 2060, South Africa
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FIGURE 5-2: BRIDGE OVER STEENKOOLSPRUIT TRIBUTARY 1 - FACING DOWNSTREAM (NORTH)

FIGURE 5-3: RIVER CROSSING OVER STEENKOOLSPRUIT MAIN CHANNEL NORTH-EAST OF SHAFT COMPLEX - FACING UPSTREAM (EAST)

FIGURE 5-4: OUTFALL FROM LOWEST DAM ON STEENKOOLSPRUIT TRIBUTARY 3 - FACING UPSTREAM (EAST)

FIGURE 5-5: BRIDGE OVER STEENKOOLSPRUIT TRIBUTARY 2 - FACING DOWNSTREAM (NORTH)

FIGURE 5-6: RIVER CROSSING OVER STEENKOOLSPRUIT MAIN CHANNEL NORTH-WEST OF SHAFT COMPLEX - FACING UPSTREAM (EAST)

5.2.5 ROUGHNESS COEFFICIENTS

The Manning's roughness factor n is used to describe the flow resistance / frictional characteristics of a specific surface. Based on the site visit undertaken, it was observed that the modelled reaches feature clean winding channels with some pools or shoals, whilst the floodplains feature high grasses or mature field crops and Manning's n value of 0.04 was used to represent these conditions in both the channel and floodplain.

5.2.6 BOUNDARY CONDITIONS

The peak flows and boundary conditions for the flood modelling are presented in Table 5-2. The methodology for estimating peak flows are discussed in Section 4, and the gradients for the normal flow conditions were measured from the DEM.

TABLE 5-2: PEAK FLOWS AND BOUNDARY CONDITIONS

Reach	Peak Flow (m^3/s)				Upstream Boundary	Downstream Boundary
	1:50yr	1:100yr	1:200yr	RMF		
Steen_1	220.6	279.6	347.5	597.6	Normal Depth (gradient = 0.006)	Steen_2
Steen_2	186.4	238.8	284.9	471.3	Steen_1	Steen_3
Steen_3	208.5	267.0	318.6	527.1	Steen_1	Steen_4
Steen_4	231.6	296.6	353.9	585.5	Steen_1	Steen_5
Steen_5	268.0	343.3	409.6	677.6	Steen_1	Normal Depth (gradient = 0.001)
Steen_Trib_1	104.0	131.2	162.3	307.1	Normal Depth (gradient = 0.011)	Steen_2
Steen_Trib_2	69.2	87.7	107.2	228.9	Normal Depth (gradient = 0.009)	Steen_4
Steen_Trib_3	63.1	80.9	96.0	218.7	Normal Depth (gradient = 0.065)	Steen_3
Steen_Trib_4	109.2	137.0	170.4	334.1	Normal Depth (gradient = 0.002)	Steen_5
Visku_Trib_1	9.8	13.2	14.8	26.8	Normal Depth (gradient = 0.030)	Normal Depth (gradient = 0.025)

5.3 KEY ASSUMPTIONS

The following assumptions are made:

- Steady state hydraulic modelling was undertaken, which assumes the flow is continuous at the peak rate, which ignores the effects of storage within the watercourses and is considered a conservative approach;
- The topographic data provided was of a sufficient accuracy to enable hydraulic modelling at a suitable level of detail;
- The peak flow estimates adopted from Section 4 for the modelled events are realistic;
- The Manning's 'n' values used is considered suitable for use in the 1:50 year, 1:100 year, 1:200 year and RMF events modelled, as well as in representing both the channel and floodplain;
- A mixed flow regime which is tailored to both subcritical and supercritical flows was selected for running of the steady state model;
- No flood protection infrastructure was modelled;
- The modelling of the adopted flow through the respective hydraulic structures was undertaken, whilst assuming no blockages were present; and
- No abstractions from the river section or discharges into the river section were taken into account during the modelling.

5.4 RESULTS

Figure 5-7 presents the flood-lines and 100m buffers for the watercourses. Within the Steenkoolspruit tributaries and Viskule tributary, the flood-lines are generally narrow and well constrained by the valleys through which they flow. However the main Steenkoolspruit channel meanders through a wide flat floodplain, and the flood-lines in this area are wide, and in the larger flood events floodwater would be expected to spill across the entire floodplain area, although depths of inundation are typically relatively shallow and flood flows will have low velocities.

5.5 CONCLUSIONS AND RECOMMENDATIONS

The shaft complex is situated outside of the 1:100 year flood-lines, is not considered to be at risk of flooding. Whilst outside of the flood-lines, a short section of the fence around the complex is within 100m of the centreline of the Steenkoolpsruit tributary, this is not considered to have any impact upon the watercourse and nor are fences considered to be significant infrastructure in the context of GN 704. Therefore, the shaft complex is in compliance with Condition 4 of GN 704.

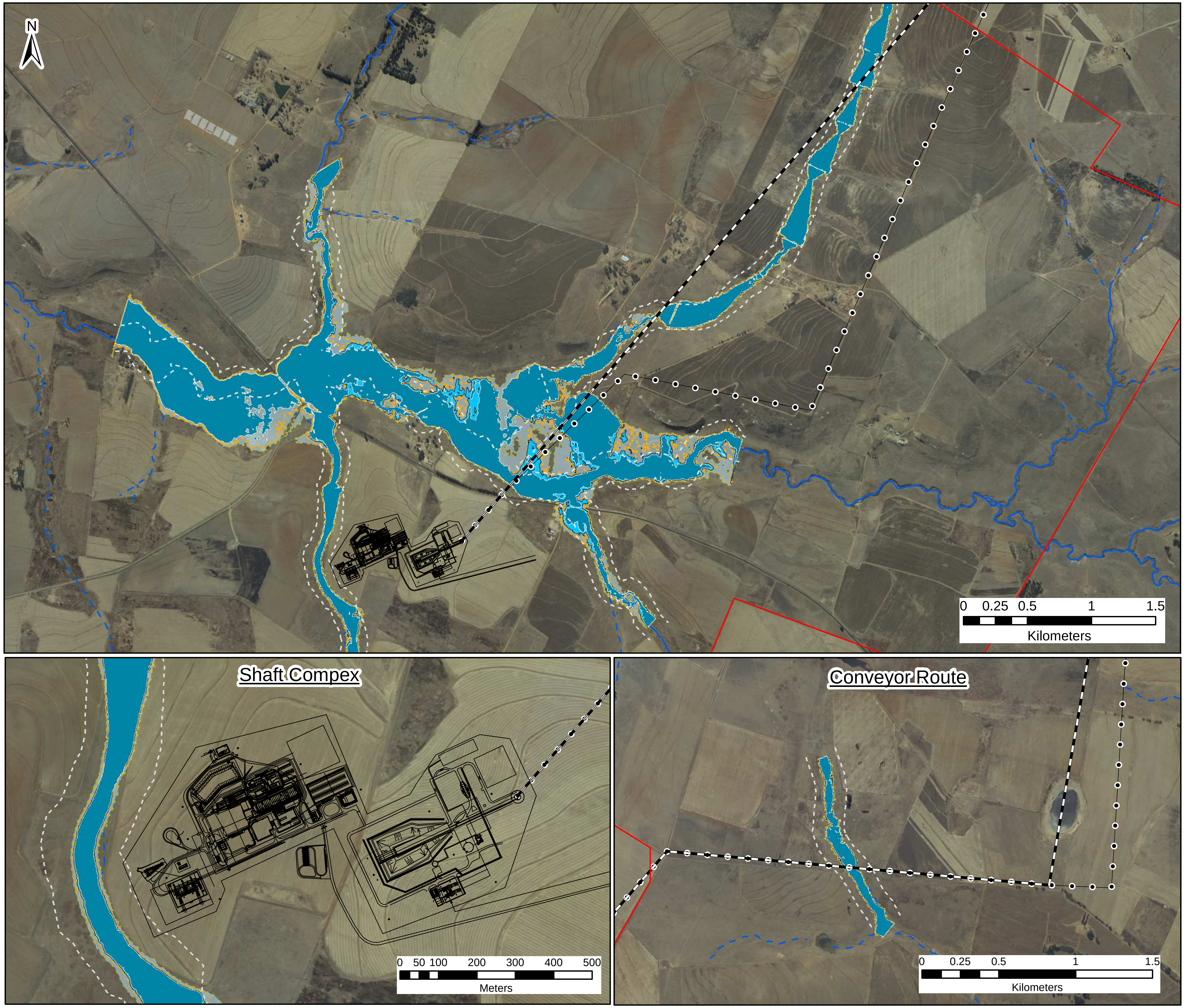
Both the proposed conveyor route and alternative conveyor route cross the main Steenkoolspruit channel at the widest point of the floodplain. After crossing the Steenkoolspruit, the proposed conveyor route crosses the northern tributary (Steen_Trib_3) and associated dams twice before leaving the project area, whereas the alternative conveyor route will minimise the amount of the conveyor that crosses the floodplain, and therefore the alternative conveyor route is preferable in terms of flood risk and ease of maintenance.

5.6 LIMITATIONS AND FURTHER WORK

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

Given the shaft complex infrastructure is shown to be located outside of the conservative estimate of flood-lines, no further flood modelling work is considered necessary.

It is recommended that detailed design of the conveyor ensures that any supporting structures located within the flood-lines are designed to withstand the flow velocities and ensure that the conveyor and any other vulnerable aspects of this infrastructure above modelled flood levels whilst ensuring the conveyance of flood flows is not impacted.



Legend

- Project Area
- Shaft Complex
- Conveyor Route
- Alternative Conveyor
- 100m Buffers
- Flood-Lines 50yr
- Flood-Lines 100yr
- Flood-Lines 200yr
- Flood-Lines RMF
- Rivers - Non Perennial
- Rivers - Perennial

Projection: Transverse Mercator
Datum: Cape, LO29

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Figure 5-7

Flood-Lines

SLR

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6 CONCEPTUAL STORMWATER MANAGEMENT PLAN

6.1 INTRODUCTION

Coal mining operations have the potential to impact upon the baseline water quality of an area in the following ways:

- Bulk earthworks which will strip vegetation and expose top soils and subsoils to erosion by stormwater thereby increasing levels of suspended solids within local watercourses and water features;
- Earthworks and minerals processing operations may expose elements naturally occurring within soils and geology to stormwater, mobilising elements into local watercourses and water features;
- Storage and usage of process specific chemicals and vehicular related pollutants which, if not properly managed properly, may be washed by stormwater into local watercourses and water features;
- Discharge of polluted or improperly treated stormwater, process water and sewage water into local watercourses or water features; and
- Transport of coal via conveyors across various watercourses which may spill coal or release coal dust which may be washed into local watercourses during storm events.

Any impact upon the baseline water quality caused by mining operations may impact upon the local aquatic ecosystems, and/or local human populations who use the water for drinking, washing, irrigating or livestock watering.

In addition to the above, if not managed correctly, stormwater may pose a risk of flooding to a proposed development.

The aim of this conceptual stormwater management plan is to mitigate the above impacts by fulfilling the requirements of the National Water Act (Act 36 of 1998) and more particularly GN 704 (as discussed in Section 1).

The following definitions from GN 704 are appropriate to the classification of catchments and design of stormwater management measures at the Alexander project:

- **Clean water system:** includes any dam, other forms of impoundment, canal, works, pipeline and any other structure or facility constructed for the retention or conveyance of unpolluted (clean) water;

- **Dam:** includes any settling dam, slurry dam, evaporation dam, catchment or barrier dam and any other form of impoundment used for the storage of unpolluted water or water containing waste (i.e. dirty water);

- **Dirty area:** means any area at a mine or ***activity*** which causes, has caused or is likely to cause pollution of a water resource;

- **Dirty water system:** This includes any dirty water diversion bunds, channels, pipelines, dirty water dams or other forms of impoundment, and any other structure or facility constructed for the retention or conveyance of water containing waste (i.e. dirty water); and

- **Activity:** means any mining related process on the mine including the operation of washing plants, mineral processing facilities, mineral refineries and extraction plants; the operation and the use of mineral loading and off-loading zones, transport facilities and mineral storage yards, whether situated at the mine or not; in which any substance is stockpiled, stored, accumulated, dumped, disposed of or transported.

6.2 DESIGN PRINCIPLES FOR STORMWATER MANAGEMENT PLAN

Informed by the baseline hydrology of the site and surroundings, a review of the proposed surface infrastructure has been undertaken, and a series of design principles for stormwater management developed to ensure compliance with the requirements of GN 704.

The surface infrastructure proposed as part of the Alexander projects includes:

- Shaft Complex which includes: decline shaft, ventilation shaft, waste rock dump, offices, changehouse and lamp room, workshops, stores, Eskom yard, pollution control dams, evaporation dam, water treatment plant, car parking, bus shelter, and various access roads.
- Conveyor Belt which stretches north-east of the shaft and conveys coal to the Elders site for processing.

6.2.1 STORMWATER QUALITY CLASSIFICATION

The design of stormwater management measures for each aspect of the surface infrastructure is based on classification of the expected quality of stormwater that will be generated during the operational phase of the project. The water quality classification is presented in Table 6-1.

TABLE 6-1: STORMWATER QUALITY CLASSIFICATION

Classification	Areas	Management Techniques
Dirty Stormwater	• Decline shaft • Waste rock dump • Workshops • Salvage yard • Stores • Transfer stations • Surge silo	Convey stormwater to a Pollution Control Dam, to be re-used or evaporated.
Slightly Dirty	• Car parking • Bus stop	Stormwater passed through a silt trap prior to discharge to the environment.
Clean	• Ventilation shaft • Eskom yard • Conveyor (roof and sidewalls) • Access roads • Natural catchments	Stormwater discharged directly to the environment.

6.2.2 SHAFT COMPLEX

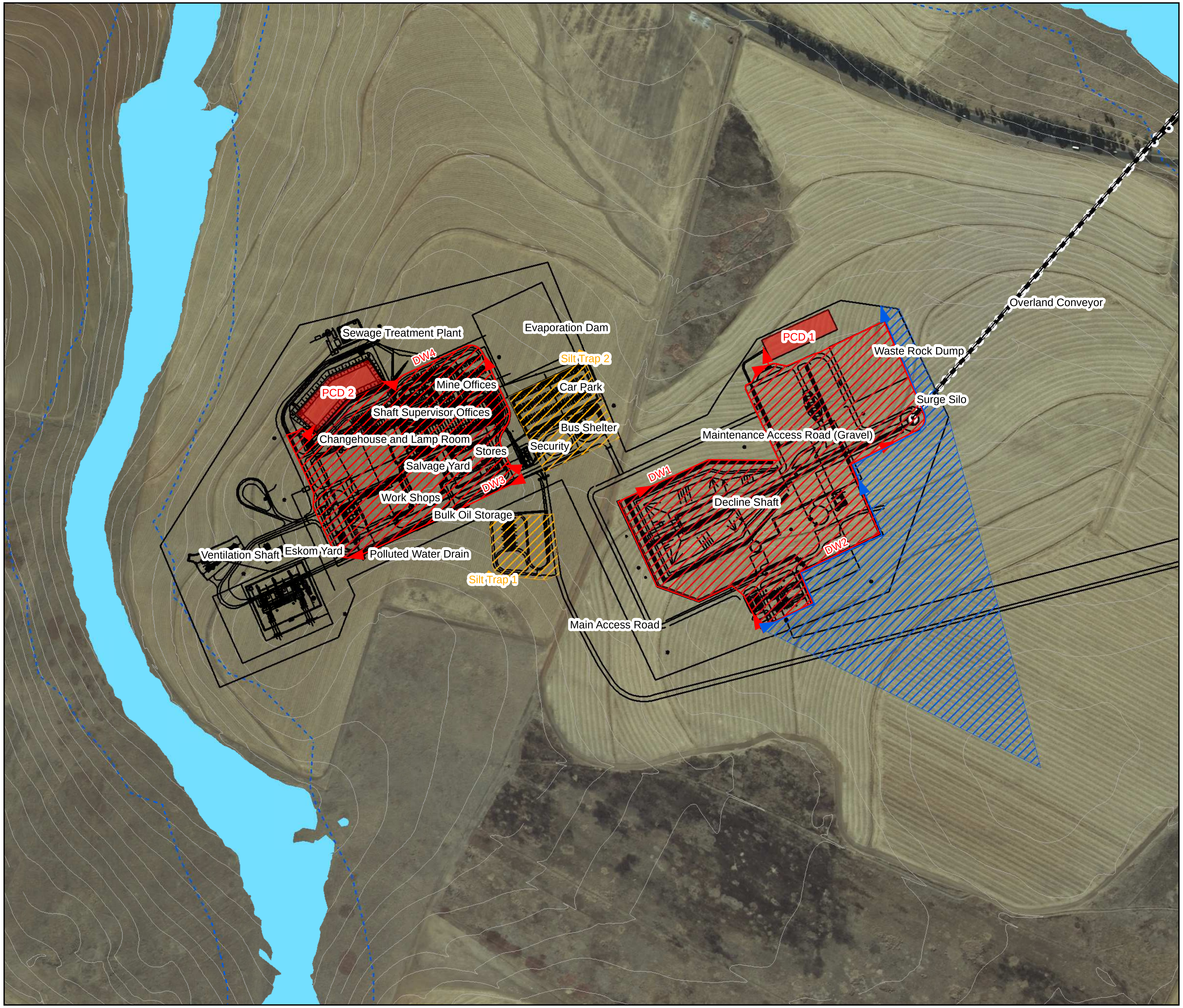
The proposed conceptual stormwater management plan for the Shaft Complex is presented on Figure 6-1, the key features include:

- Clean stormwater from a small catchment to the south of the decline shaft will be diverted around the decline shaft, Waste Rock Dump (WRD) and surge silo.
- Slightly dirty stormwater from the car parking and bus shelter areas will be collected and conveyed to silt traps, the outfall from which will be discharged to the environment.
- Dirty stormwater from the decline shaft, waste rock dump and surge silo will be collected and conveyed to Pollution Control Dam (PCD) 1 and re-used at the mine or pumped to the water treatment plant and then discharged into the environment.
- Dirty stormwater from the workshops, stores, changehouse, stores and salvage yard will be collected, conveyed to PCD 2 and re-used at the mine or pumped to the water treatment plant and then discharged the environment.

6.2.3 CONVEYOR ROUTE

The conveyor will include the following mitigation by design features:

- As it crosses surface water receptors including watercourses, dams and wetlands, the conveyor will feature a roof and sidewalls preventing rain from contacting the coal and generating dirty runoff. Runoff from the roof and sidewalls is considered clean and will not impact upon the quality of surface water receptors.
- Away from surface water receptors, the conveyor will feature a roof and single sidewall along the side of the prevailing wind to reduce the amount of rain which contacts the coal. Any runoff from the coal (expected to be minimal) will collect on the ground surface beneath the conveyor and infiltrate to ground and is therefore unlikely to reach surface water receptors.



Legend

- Conveyor Route
- Alternative Conveyor
- Clean Catchment
- Slightly Dirty Catchments
- Dirty Catchment
- Dirty Stormwater Channels
- Shaft Complex
- Clean Stormwater Channels
- Silt Trap
- PCD
- 100m Buffers
- Flood-Lines 100yr
- 1m Contours

0 50 100 200 300

Meters

Projection: Transverse Mercator
Datum: Cape, LO29

Anglo American Inyosi Coal (Pty) Ltd

Figure 6-1

Conceptual Stormwater Management Plan

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- Dust suppression along the length of the conveyor will be achieved through sprinklers along the length of the conveyor to minimise coal dust being transported by wind or rainfall into nearby watercourses.
- Dirty runoff from transfer stations (which will be required at bends in the conveyor) will be separated from clean runoff from the surrounding areas by perimeter berms, and collected in evaporation dams.

6.3 DAMS AND SILT TRAPS

6.3.1 HYDRAULIC DESIGN STANDARDS – PCDS

GN 704 requires that dirty water containment facilities are designed, constructed, maintained and operated so that they are not likely to spill into a clean water environment more than once in 50 years, which equates to an annual probability of spillage of 2% or less. A critical component in sizing the containment pond is the rate at which water is pumped from the pond for re-use at the site, which forms part of the site wide water balance. GN 704 also requires that a 0.8m freeboard allowance should always be available above the maximum design water level of the facility.

This report has sized PCDs for dirty stormwater to accommodate runoff from a 1:50 year 24 hour rainfall event **and** the highest monthly rainfall (February) falling over the catchment, **less** the corresponding monthly evaporation (February) taking place over the surface area of the proposed containment facility.

As part of the detailed design of the containment facilities the containment volumes proposed within this report will need to be assessed by a daily timestep water balance model to ensure compliance with GN 704. Modelling must consider the predicted inflows to, and outflows from, each facility and estimate the capacity required to prevent spillages with an annual probability of 2% of less.

6.3.2 HYDRAULIC DESIGN STANDARDS – TRANSFER STATION EVAPORATION DAMS

No design details are available for the transfer stations, and this report has sized dams using an assumed area of 10 000m^2, which should be revisited when further details are available.

This report has sized evaporation dams, to the same standards outlined above for the PCDs. As above, it is recommended that, to ensure compliance with GN 704, the detailed design of the evaporation dams should be assessed by a daily timestep water balance model considering inflows, outflows and

6.3.3 HYDRAULIC DESIGN STANDARDS – SILT TRAPS

The silt traps are designed to accommodate runoff generated during a 1:5 year 24 hour rainfall event, and the overflow from the silt trap will be discharged to the environment.

6.3.4 DESIGN METHODOLOGY

The PCD, Silt Trap and Evaporation Dam design parameters are presented in Table 6-2. The runoff coefficients for the various catchment areas during a 1:100yr storm event were estimated using the SANRAL Drainage Manual[4] and adjusted for the design events as follows:

- 1:50 year storm = 1:100 year runoff coefficient * 0.83
- 1:5 year storm = 1:100 year runoff coefficient * 0.55
- Average Wet Month = 1:100 year runoff coefficient * 0.40

The runoff coefficient for hardstanding areas was 0.9 for all scenarios.

TABLE 6-2: PCD, SILT TRAP AND EVAPORATION DAM CATCHMENT PARAMETERS

Description	Catchment Area (m^2)	Natural		Hardstanding		Dam Footprint (m^2)
		Area (m^2)	Runoff Coeff.	Area (m^2)	Runoff Coeff.	
PCD1	40 884*	18 565	0.41	18 565	0.90	3 000
PCD2	54 913	38 439	0.41	38 439	0.90	4 500
Silt Trap 1	13 000	9 100	0.41	3 900	0.90	200
Silt Trap 2	7 400	3 700	0.41	3 700	0.90	180
Transfer Station Dams	10 000	7 000	0.41	3 000	0.90	600

** It is assumed that an area of 21 000m^2 of the total catchment (61 884m^2) will drain internally into the Shaft Decline i.e. not generate runoff into the PCD*

6.3.5 RECOMMENDATIONS

The recommended capacity requirements for the PCDs, silt traps, and evaporation dams at the transfer stations are presented in Table 6-3.

It is recommended that operation of the PCDs and Transfer Station Evaporation Dams ensure a 0.8m freeboard is provided above the maximum design water level and an engineered spillway is included in the design to convey design exceedance events through the PCD without risk of eroding the dam walls.

[4] SANRAL, 2013, "Drainage Manual-Sixth Edition". The South African National Roads Agency Limited, Pretoria.

TABLE 6-3: PCD, SILT TRAP AND EVAPORATION DAM CAPACITY REQUIREMENTS

Dam	Storm			February				Containment Required (m^3)
	Event	Rainfall (mm)	Runoff (m^3)	Rainfall (mm)	Runoff (m^3)	Evaporation (mm)	Evaporation (m^3)	
PCD1	1:50yr 24hr	142.4	3 896	119	2 778	170	509	6 165
PCD2	1:50yr 24hr	142.4	6 356	119	4 959	170	763	10 552
Silt Trap 1	1:5yr 24hr	87.7	505	N/A				
Silt Trap 2	1:5yr 24hr	87.7	381	N/A				
Transfer Station Dam	1:50yr 24hr	142.4	809	119	528	170	102	1 236

6.4 DRAINAGE CHANNELS

The clean and dirty stormwater catchments and route of drainage channels are presented in Figure 6-1.

6.4.1 DESIGN METHODOLOGY

A spreadsheet calculation using the Rational Method (as presented in the SANRAL Drainage Manual) was used to estimate peak flows and inform the design of each of the diversion channels.

The Rational Method equation is:

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

Where:

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

C = Runoff Coefficient (%);

I = Rainfall Intensity (mm/hr); and

A = Area (km^2).

The runoff coefficients for each catchment were estimated using the SANRAL Drainage Manual.

The worst case rainfall event for each catchment (i.e. duration = time of concentration) was taken from the Storm DDF estimates presented in Table 2-6.

The channels have been sized using the Manning's Equation to ensure that the flow capacity of the channel is sufficient to convey the 1:50 year rainfall event.

The Mannings equation is:

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

Where:

A = Area of Channel

R = Hydraulic Radius (area / wetted perimeter);

S = Longitudinal Slope of Channel; and

n = Mannings Roughness Coefficient

6.4.2 PEAK FLOW ESTIMATES

The rainfall intensities and peak flow estimates for each of the stormwater diversion channels are presented in Table 6-4.

TABLE 6-4: RATIONAL METHOD INPUT PARAMETERS

Catchment	Area (km^2)	Runoff Coefficient	Time of Concentration (hours)	Rainfall Intensity (mm/hr)	Flow (m^3/s)
Clean Water 1	0.086	0.307	0.809	66.6	0.49
Shaft & WRD	0.062	0.510	0.337	123.0	1.08
Workshops	0.055	0.731	0.333	123.7	1.38

6.4.3 RECOMMENDED CHANNEL SIZING

The peak flows for the slightly dirty catchments were not estimated, due to the small area of each catchment, instead a nominal channel sizing was recommended. In order to accommodate the design flows for the remaining channels, the recommended dimensions are presented in Table 6-5, whilst Figure 6-2 presents a typical cross-section through the channel.

The following assumptions were made during the design of the flow diversion channels:

- The channels are sized to take the maximum flow calculated for the downstream end of the contributing catchment and the channel sizing will be uniform along their entire length.
- The longitudinal gradients are based on 1m contours provided by AAIC.
- Some cut and fill maybe required along the length of the channels to achieve the required gradient to ensure that water flows freely within the channels.
- Clean water will be kept out of the dirty water channels by constructing a linear bund on the outside of the channel with the material excavated from the channel (as shown on Figure 6-2).

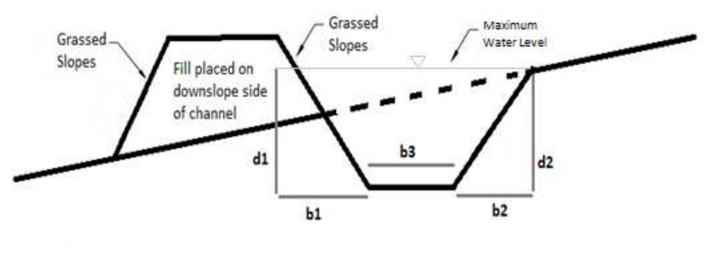

FIGURE 6-2: STORMWATER DIVERSION CHANNEL SIZING

TABLE 6-5: STORMWATER DIVERSION CHANNEL SIZING

Catchment	Total Flow	Drainage Channel	Design Flow		Channel dimension (refer to Fig 6.2)					S	n	A	P	R	V	Q
					b1	d1	b2	d2	b3							
	m^3/s		%	m^3/s	m	m	m	m	m	m/m		m^2	m	m	m/s	m^3/s
CW1	0.49	100%	0.49	0.49	0.5	0.3	0.5	0.3	1.0	0.010	0.025	0.4	2.1	0.2	1.4	0.61
DW1	1.08	50%	0.54	1.08	0.5	0.3	0.5	0.3	1.0	0.010	0.025	0.4	2.1	0.2	1.4	0.61
DW2	1.08	50%	0.54	1.08	0.5	0.3	0.5	0.3	1.0	0.010	0.025	0.4	2.1	0.2	1.4	0.61
DW3	1.38	65%	0.90	1.38	0.6	0.4	0.6	0.4	1.0	0.005	0.025	0.6	2.4	0.3	1.2	0.74
DW4	1.38	35%	0.48	1.38	0.5	0.3	0.5	0.3	1.0	0.004	0.025	0.4	2.1	0.2	0.9	0.39
Slightly Dirty	N/A	N/A	N/A	N/A	0.5	0.3	0.5	0.3	0.3	0.005	0.025	0.2	1.4	0.2	0.8	0.19

The dirty water channels should be lined to prevent dirty water from infiltrating through the base of the channels which may impact upon the quality of the underlying groundwater.

6.5 IMPACT ON MEAN ANNUAL RUNOFF

The shaft complex is located within quaternary catchment B11C which (as presented in Section 3.2) has a catchment area of 385km^2 and a mean annual runoff (MAR) of 21.55mcm, which equates to 55 974m^3/km^2. It is proposed that stormwater from a total area of 0.11km^2 is diverted away from the watercourses and into PCDs or evaporation dams.

The impact of the stormwater management measures outlined above on the MAR of quaternary catchment B11C is negligible.

However, the baseline flows within the watercourses may be impacted by dewatering of the underground workings, and by discharge of excess mine water and the impacts of these aspects of the mine are discussed in more detail in Section 7.

6.6 LIMITATIONS AND FURTHER WORK

The following recommendations should be addressed during the detailed design phase:

- The capacity of the containment facilities are reviewed by a daily timestep water balance model to ensure compliance with GN 704 and BPG A1 (DWAF, 2007);
- The recommended stormwater drainage for the transfer station be revisited when designs for these stations become available;
- A Maintenance Program for the stormwater infrastructure should be developed to regularly inspect dams, channels and silt traps, empty silt and ensure the design capacities are maintained throughout the life of the mine.

7 SITE WIDE WATER BALANCE

7.1 INTRODUCTION

A site wide water balance model has been prepared to understand flows within the Alexander Project water circuit during average dry season and average wet season conditions for the following years of the mine:

- Year 0 – Construction Phase
- Year 3 – Start of Operational Phase
- Year 23 – Maximum Groundwater Inflows

The water balance reviews all relevant design work by the wider project team, estimates the typical flows, and volumetric requirements of make-up water or discharge of surplus water.

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

- Underground Workings;
- Shaft complex;
- Waste Rock Dump (WRD);
- Mining Services (Offices, Workshops etc); and
- Water Treatment Plant (to supply potable water, process water and treat any discharge if required).

This water balance aims to ensure that dirty water is recycled and re-used within the mining operations in preference to abstracting and dirtying clean water resources. As such recycled water will be treated at the Water Treatment Plant and pumped to the Raw Water Tank which is used to supply process water to various activities at the site. Only where recycled process water is insufficient to meet the mine's water demand, will makeup water be abstracted from either on-site boreholes or piped from Elders Colliery.

7.2 METHODOLOGY

A spreadsheet model was used to represent the flows within the operational water circuit using information taken from the following studies:

- Project Alexander – Project Description (AAIC, 09 January 2016); and
- Alexander Project – Groundwater Assessment (SLR, June 2016).

Water sources (inflows) were taken as:

- Groundwater ingress into the underground workings;
- Stormwater collected from dirty catchments and conveyed to the PCD;

- Direct rainfall into any dams;
- Makeup water from on-site boreholes or piped from Elders Colliery.

Water sinks (losses) were taken as:

- Evaporation from any dams;
- Losses of process water during activities on site;
- Dust suppression; and
- Consumption of potable water not returned to sewage treatment plant or raw water tank.

The footprint of the Evaporation Dam (used to evaporate brine generated by the water treatment plant) was estimated based on the evaporation rate and considering direct inflow of rainfall. The dam was sized to manage brine associated with treatment of water to supply process water and potable water (25% of 90 000l/day during construction and 102 350l/day during operation), and does not account for treatment of excess mine water from underground workings, the treatment technology for which has yet to be confirmed.

7.3 ASSUMPTIONS AND INPUT PARAMETERS

The water balance assumes the following:

- The water balance is steady state and no consideration is given to changes in flows associated with varying rainfall, production rates, or storage (e.g. start up water);
- Rainfall related inflows and evaporation related losses for the wet and dry season scenarios were estimated based on: i) average values during the three driest months of the year; and ii) average values during the three wettest months of the year;
- Runoff and evaporation coefficients for each surface were fixed and not influenced by antecedent climatic conditions;
- All catchment areas are constant; and
- Evaporation from the PCDs and Evaporation Dam would only occur if there was water in the dam.

The input parameters used for the water balance are presented in Table 7-1 and the modelled groundwater inflows to the underground workings (adopted from SLR's June 2016 Groundwater Study) are presented in Figure 7-1.

TABLE 7-1: WATER BALANCE INPUT PARAMETERS

Parameter	Description	Source
Climate Data	• Average wet month rainfall = 110.0mm/month • Average wet month evaporation = 162.8mm/month • Average dry month rainfall = 7.6mm/month • Average dry month evaporation = 90.1mm/month	• Baseline Hydrology – Section 2
Water Requirements	• Potable Water Requirements: o Construction Phase: 90 000l/day o Operational Phase: 62 350l/day • Potable Water Losses: 20% • Process Water Requirements (Operational Phase only): 40 000l/day • Process Water Losses: 50% is assumed to be lost i.e. not collected, returned and re-used).	• Alexander Project Description 2016 (AAIC, Jan 2016)
Dust Suppression	• Estimated 1 x 4500 litre water truck at 12 trips per day for surface roads • Total = 1 642 m^3/month	• Client email 21 April 2016
Brine	• Brine generated by the Reverse Osmosis treatment plant = 25% of the supply rate (90 000l/day during construction and 102 350l/day during operation) • Evaporation Dam footprint: 14 000m^2	• Assumed • Estimated to evaporate brine
Underground Workings	• Groundwater Inflows: o Year 0 = 8.6 m^3/hr (6 275 m^3/month) o Year 3 = 161.3 m^3/hr (118 998m^3/month) o Year 23 = 643.5m^3/hr (469 498m^3/month) • Water exported with coal: assumed 5% of coal by weight at 6 million tonnes/year	• Alexander Project – Groundwater Study (SLR, 2016) • Assumed
Stormwater Inflows	• PCD1: o Catchment = 61 884 m^2 o Runoff Coefficient = Wet: 0.39, Dry: 0.27 • PCD2: o Catchment = 54 913 m^2 o Runoff Coefficient = Wet: 0.68, Dry: 0.63	• Section 6 - Stormwater Management

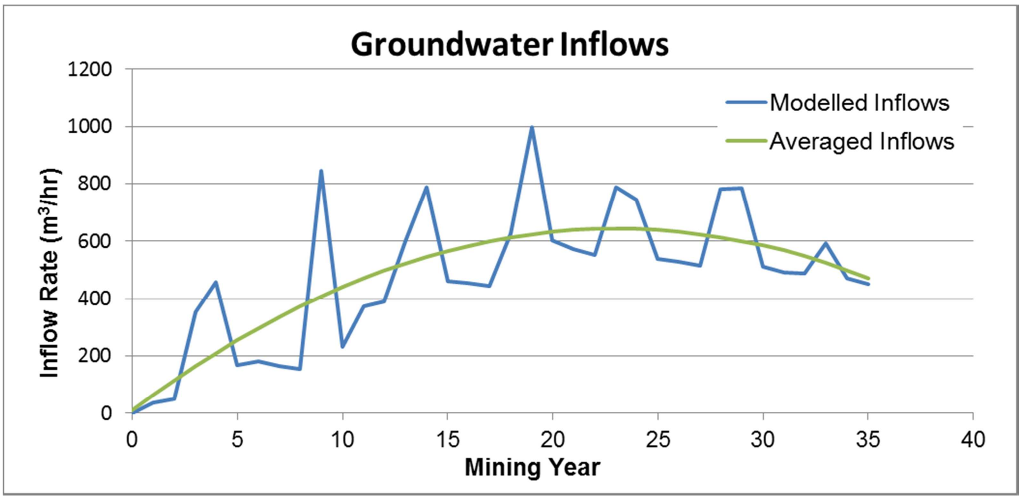

FIGURE 7-1: MODELLED GROUNDWATER INFLOWS TO UNDERGROUND WORKINGS (SOURCE: SLR GROUNDWATER STUDY, JUNE 2016)

7.4 RESULTS

The water balances for the wet and dry seasons, for year 0, year 3 and year 23 are presented in Figure 7-2 to Figure 7-7.

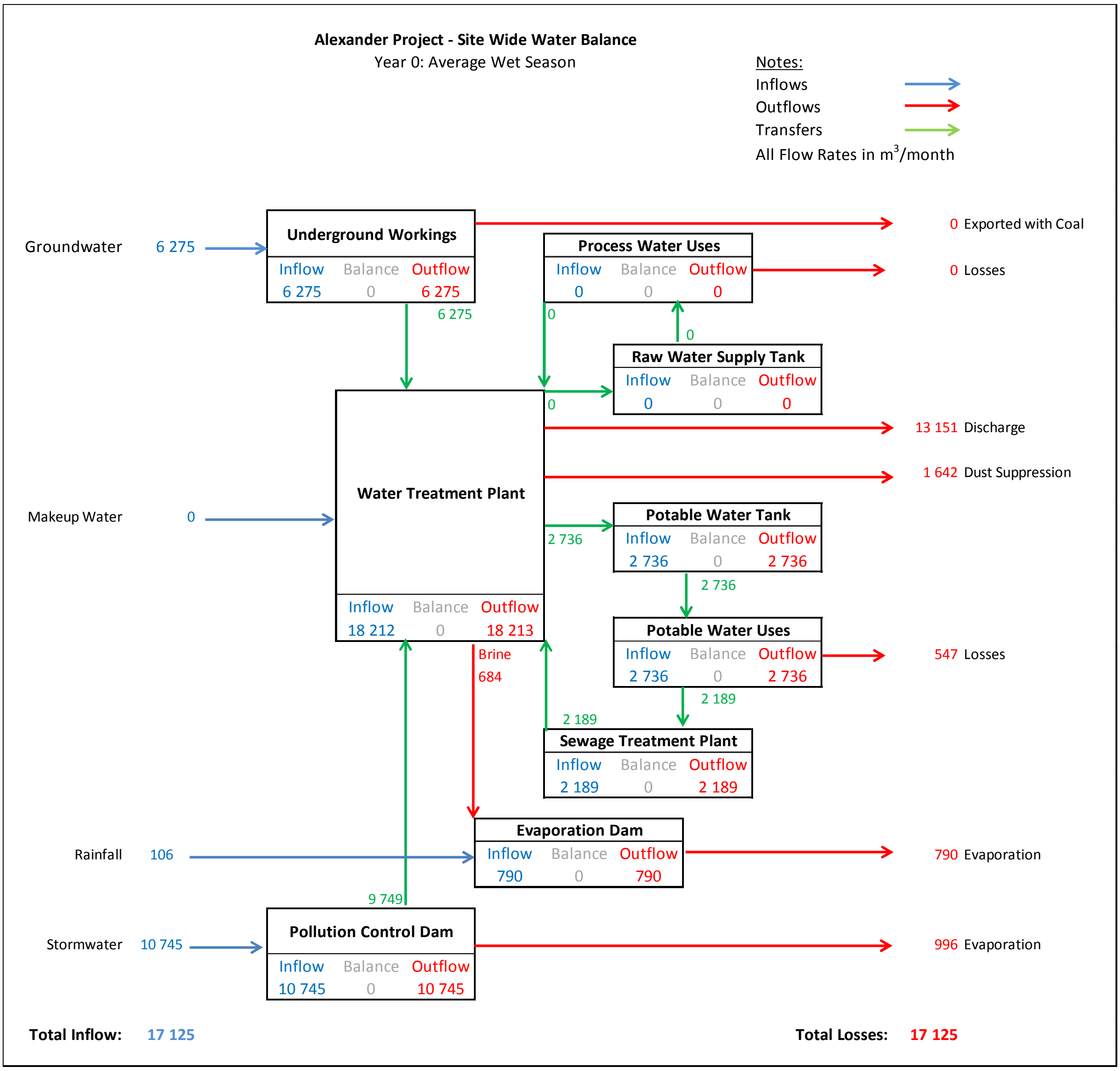

FIGURE 7-2: WATER BALANCE - YEAR 0 WET SEASON

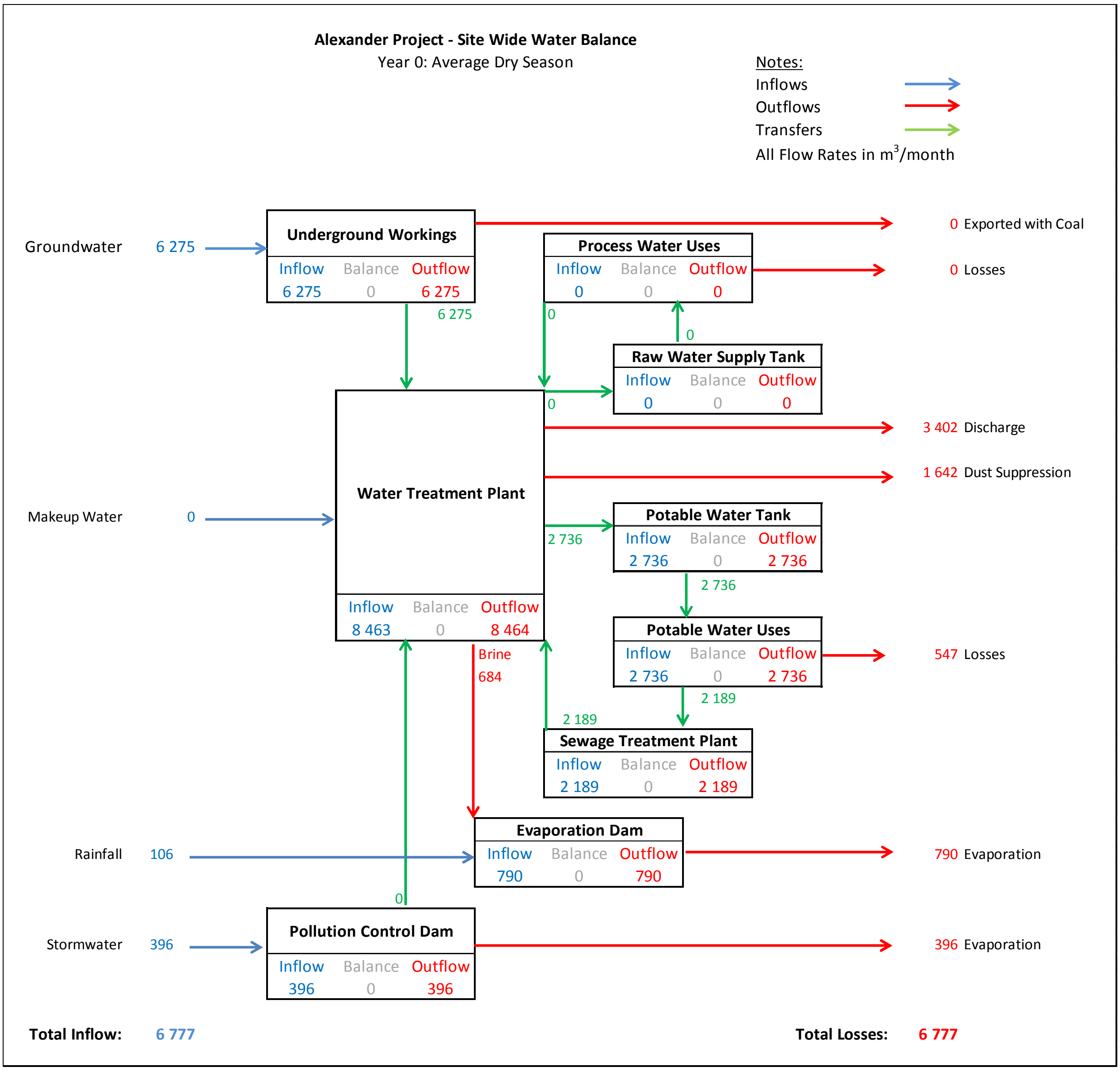

FIGURE 7-3: WATER BALANCE - YEAR 0 DRY SEASON

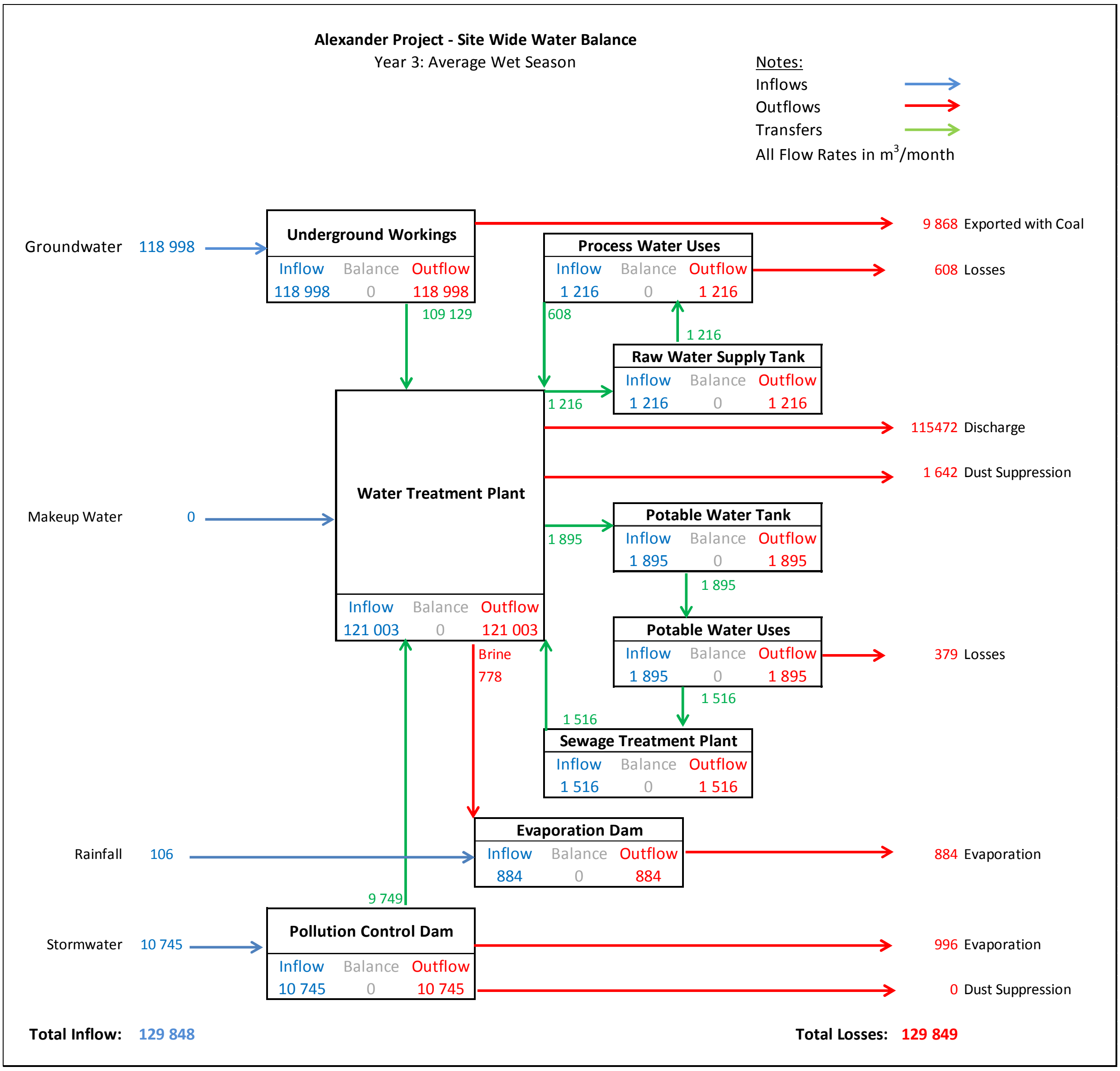

FIGURE 7-4: WATER BALANCE – YEAR 3 WET SEASON

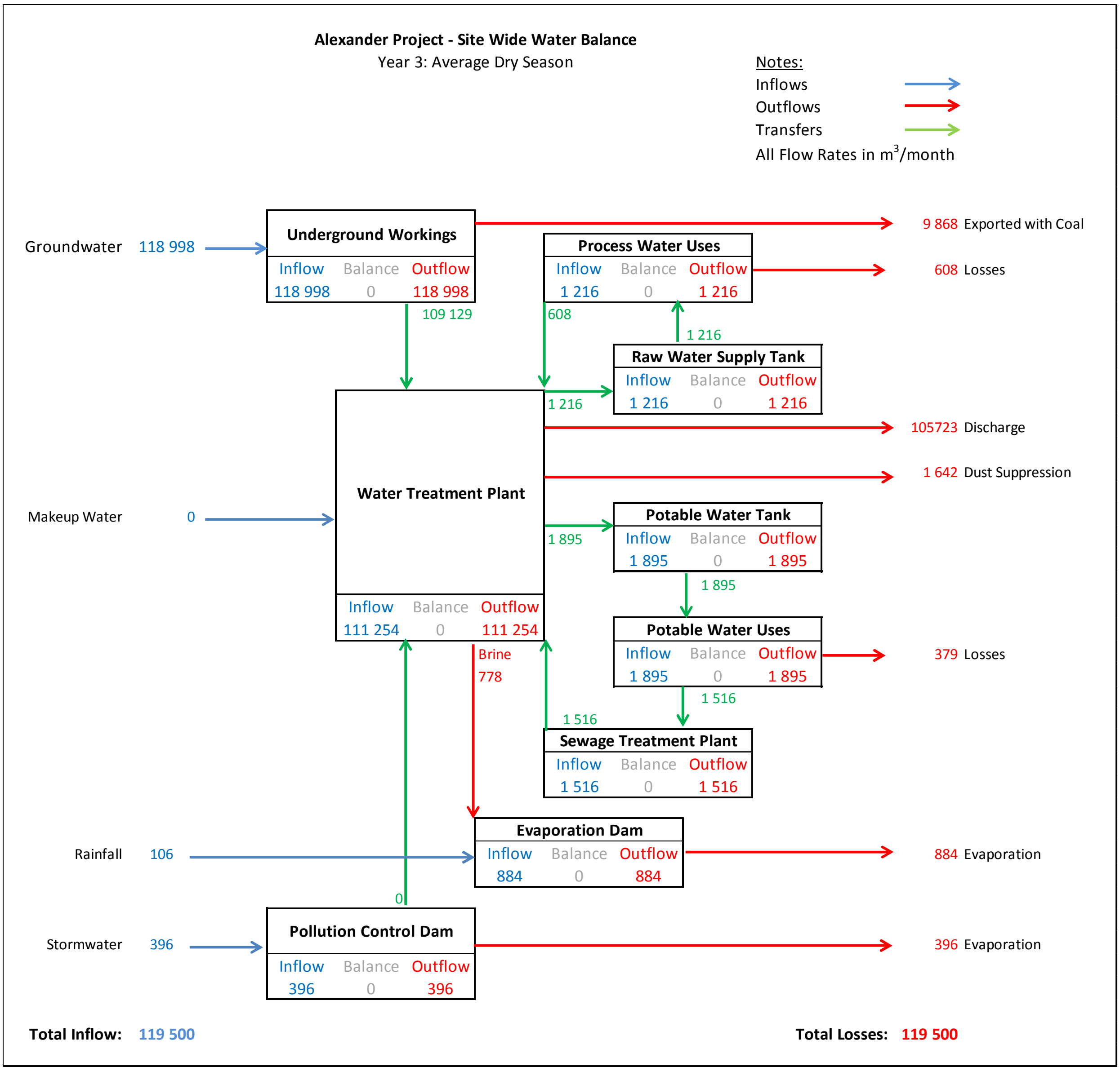

FIGURE 7-5: WATER BALANCE – YEAR 3 DRY SEASON

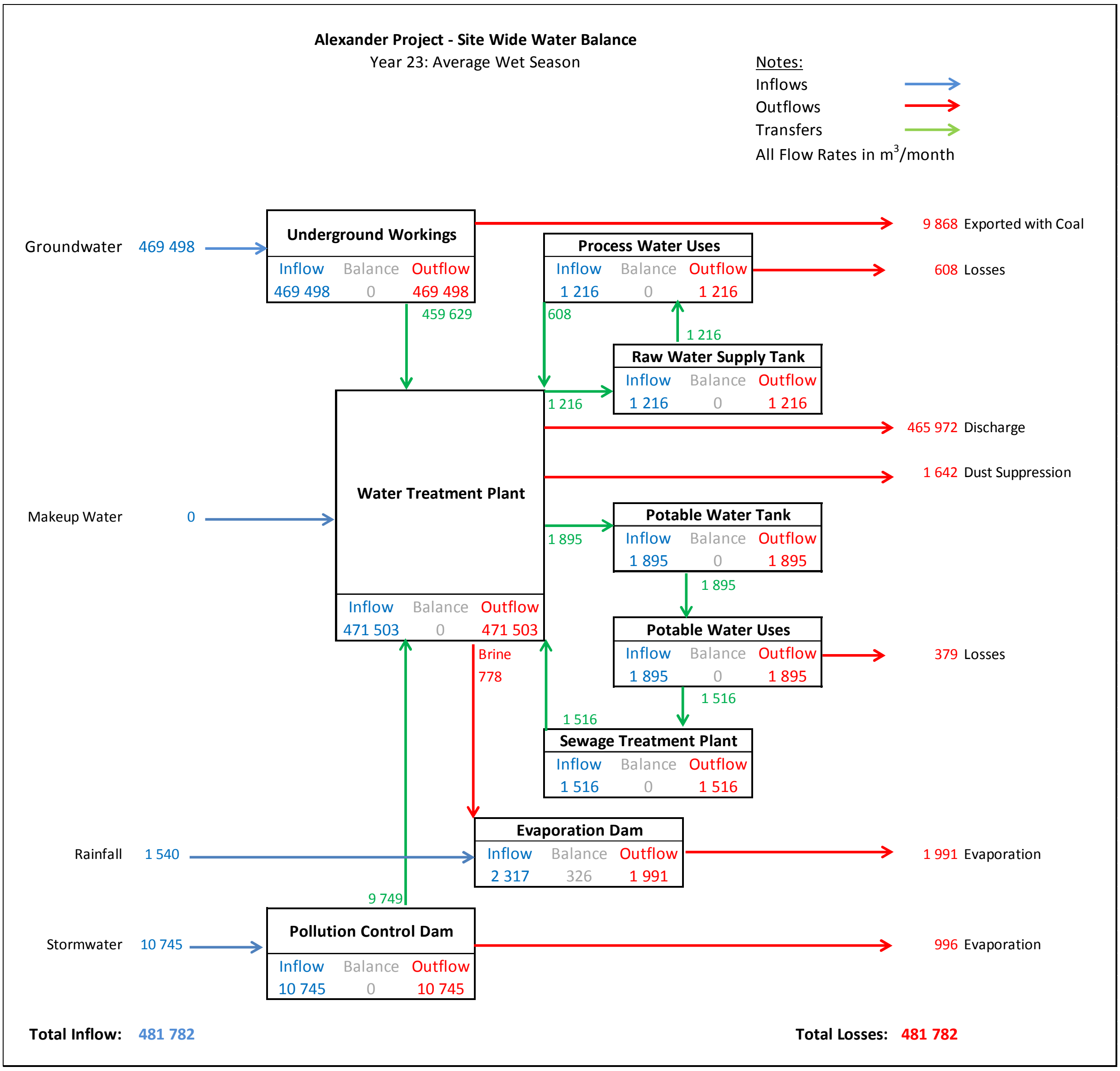

FIGURE 7-6: WATER BALANCE – YEAR 23 WET SEASON

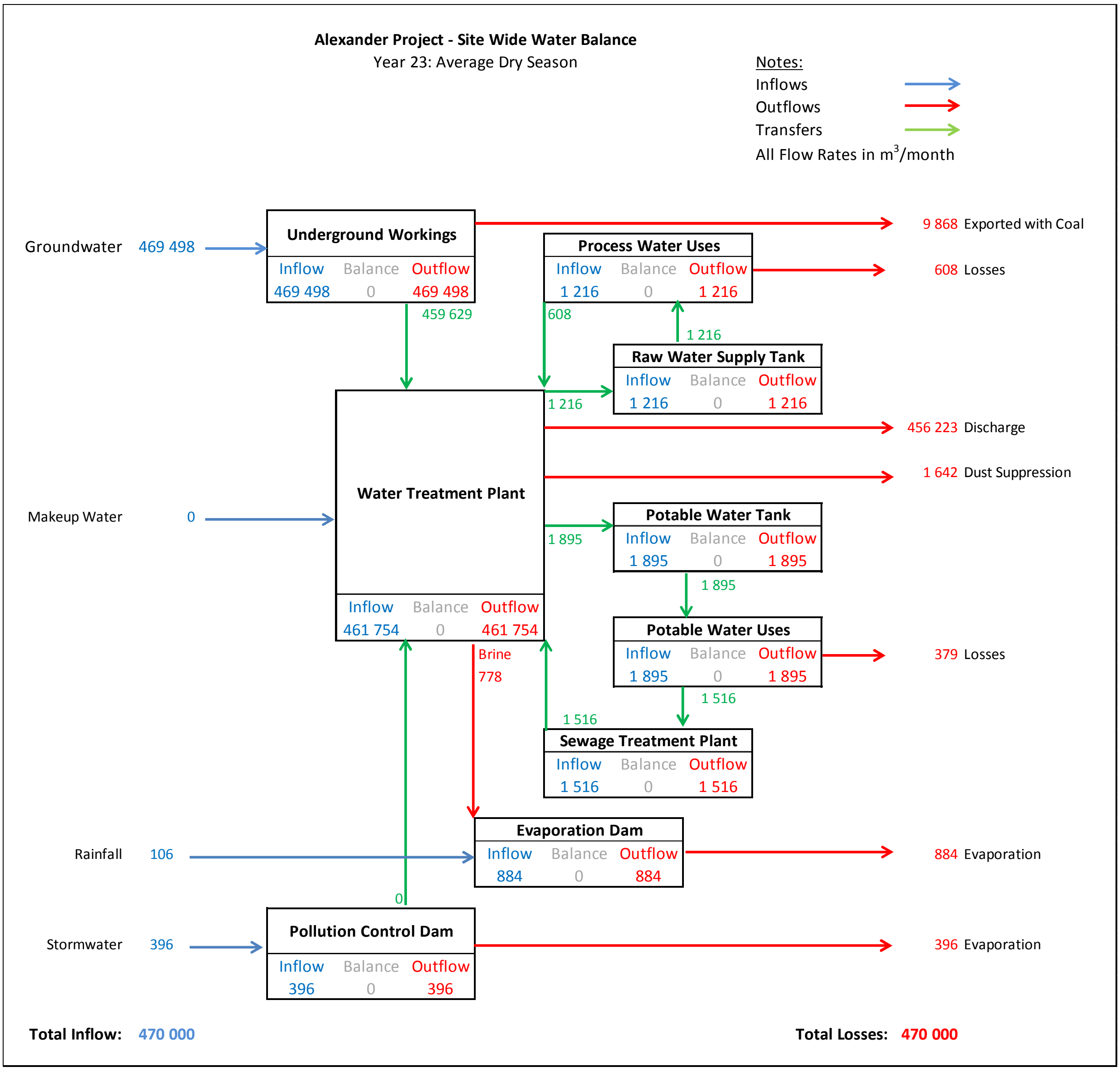

FIGURE 7-7: WATER BALANCE – YEAR 23 DRY SEASON

7.5 CONCLUSIONS AND RECOMMENDATIONS

During the construction phase of the mine (year 0), there is minimal demand for water at the surface, and even though the groundwater inflows to the shaft are fairly low, the mine is water positive through both the wet season and the dry season, there is no requirement for makeup water from on-site boreholes or piped from Elders Colliery, and excess water will need to be discharged to the surface water environment.

When the operational phase of the mine commences (year 3), there is a slight increase in water demand at the surface, however the groundwater inflows to the underground mine workings are considerable and the mine remains water positive during both wet and dry seasons. As the underground mine works increase in area, the groundwater inflows also increase, peaking at 644m^3/hr in year 23.

The losses of water are very minor compared to the groundwater inflows, and the maximum discharge from the mine is estimated to be up to 465 972m^3/month, which equates to 639m^3/hr or 177l/s (only slightly less than the groundwater inflows). Any discharge would be subject to water quality and it is expected that produced water will need to be passed through the treatment plant prior to discharge.

The discharge of excess groundwater pumped from the underground mine workings will quickly become significant, and is similar in quantity to the average flow during September (dry season) for catchment B11C (gauging station B1H017) presented in Table 3-3. The estimated discharge rate of 5.6million m^3/year equates to 26% of the MAR of catchment B11C.

7.6 Limitations and Further Work

This study makes use of various assumed and estimated parameters, and should be updated whenever better information becomes available.

Groundwater inflow to the underground mine workings form critical parts of the mine's water circuit and is the main source of water. It is recommended that pump rates and dam levels are recorded on a regular basis to allow the water balance to be calibrated for further use during the operational phase of the mine.

The evaporation dam is sized to cater for brine generated during treatment of water to supply process water and potable water requirements, and no consideration is given to treatment of excess mine water from underground workings, the treatment technology for which has yet to be confirmed but the generation and management of brine during treatment of excess mine water should be considered in more detail during the detailed design of the treatment plant.

Given the high flow rates, it is recommended that the design of the outfall for the discharge includes suitable erosion protection measures to safeguard against erosion in the receiving watercourse.

Routine water quality monitoring of the discharge will be required to demonstrate compliance with the relevant water quality standards, and where exceedances of guidelines are identified contingency plans should be implemented including a review of the mining practices and treatment plant performance.

The large volume of excess water generated by the project may be a useful water source for local water users, and it is recommended that the feasibility of establishing a local water supply network for interested parties be investigated.

8 CONCLUSIONS AND IMPACT ASSESSMENT

This surface water study report presents a comprehensive description of the baseline hydrology of the site and surroundings which may be impacted by the proposed mining operation. A series of mitigation measures are recommended, and the impacts of the project are discussed below.

8.1 SUMMARY OF MITIGATION MEASURES

The project infrastructure has been designed with an understanding of the baseline hydrology of the site and surroundings, and includes various mitigation measures to minimise impacts on the surface water environment and ensure compliance with GN 704, including:

- Flood-Lines: mapping of the flood-lines has demonstrated that the shaft complex is outside of the flood-lines, whilst the modelled flood-lines and flood levels can be used to inform the detailed design of the conveyor which crosses various watercourses, thereby reducing the probability of impacts from the project infrastructure on the baseline flow and quality of the local watercourses during flood events.
- Stormwater Management: the project infrastructure was reviewed and clean and dirty water catchments identified, and measures are proposed to collect and/or treat stormwater from dirty areas, thereby reducing the probability of impacts from the project infrastructure on the baseline water quality of the local watercourses.
- Water Balance: the projects water circuit has been defined, and collection / re-use of dirty water is prioritised above abstraction of clean water from local water resources, thereby reducing the probability of impacts from the project on the baseline flow regime of the local watercourses, whilst the rates of makeup water abstraction and discharge of excess mine water are estimated and can be used to inform the detailed design of associated treatment infrastructure, thereby reducing the probability of impacts from the project on the baseline flow and quality of the local watercourses.

In addition to the mitigation measures presented throughout this report, several recommendations are identified which should be addressed during the detailed design phase of the project.

8.2 IMPACT ASSESSMENT

The proposed mining project includes various mitigation by design measures, theoretically without these measures the impacts on the environment would be much higher, although the mine would almost certainly not be allowed to proceed as it would not comply with current best practice and relevant guidelines. The potential unmitigated impacts (unrealistic worse-case scenario), and residual impacts of the project after considering the mitigation measures proposed within this report are qualitatively assessed and presented in Table 8-1.

TABLE 8-1: QUALITATIVE IMPACT ASSESSMENT

Issue	Description	Severity	Duration	Extent	Consequence	Probability	Significance
Impact on Baseline Flows – Unmitigated	Without considering the mine's water balance, the project could impact on the baseline flows within the local watercourses either through increasing or decreasing the flows by an unquantified and uncontrolled abstraction or discharge.	The potential impact could be moderate.	Impacts could be long-term, extending for the life of the mine.	Impacts could stretch far downstream.	Medium	Mining projects often have a significant impact on baseline flows in local watercourses, consequently a medium probability of an impact could be expected.	Medium
Impact on Baseline Flows – Mitigated	The proposed water balance presents recommendations for collecting and re-using water wherever possible, and concludes that the due to the large groundwater inflows to the underground workings, the project will be water positive and need to discharge up to 177l/s.	The proposed discharge will have a moderate positive impact on the baseline flows in the local watercourses.	Impacts will be long term, extending for the life of the mine.	Impacts will be high locally, diminishing further downstream.	Medium	Based on the water balance the probability of a significant increase in baseline flows in the local watercourses is high.	Medium positive
Impact on River Channels - Unmitigated	Without considering the flood-lines associated with local watercourses, the project could locate infrastructure within areas, which may encounter deep and fast flowing water, or infrastructure could reduce conveyance of flood flows within the river channels thereby increasing flood levels upstream of the project and flood risk to nearby receptors.	The potential impact could be moderate.	Impacts could be short term, during and immediately following flood events.	Impacts could be local.	Minor	The Project Area features numerous watercourses, and without considering flood-lines, there would be a medium probability of impacting channels by inappropriate location of infrastructure.	Medium
Impact on River Channels – Mitigated	The location of surface infrastructure is informed by the flood-line mapping, and detailed design of the conveyor should mitigate impacts upon the river channels by using modelled flood levels and velocities at watercourse crossings.	After mitigation, the impact will be minor.	Impacts will be short term, during and immediately following flood events.	Impacts will be local.	Minor	Any residual risk of infrastructure impacting upon the channels will be during design exceedance events with a very low probability of occurrence.	Very Low
Impact on Baseline Water Quality - Unmitigated	Without considering flood risk and stormwater management, the project could cause pollution of local watercourses through various means including: locating pollution sources in the flood-lines, silt from earthworks, spillage of coal and emission of coal dust from conveyors, and mobilisation of hydrocarbons or other vehicular related pollutants stored at the site.	Without mitigation, the project could have a severe impact on the quality of surface water resources.	Impacts could be long term for the lifetime of the project.	Impacts could stretch far downstream.	High	Without mitigation, there could be a high probability of impacting the quality of surface water resources.	High

Issue	Description	Severity	Duration	Extent	Consequence	Probability	Significance
Impact on Baseline Water Quality - Mitigated	The location of surface infrastructure is informed by flood-line mapping, and a stormwater management plan is developed in accordance with GN 704 to ensure that dirty water does not spill into clean water more frequently than once in 50 years.	After mitigation, the impact will be minor.	Any residual impacts will be both short term during and immediately following storm events.	Impacts will be highest locally, diminishing further downstream.	Minor	Any residual risk of impact on the baseline water quality will be during design exceedance events with a very low probability of occurrence.	Very Low

Subject to implementing the mitigation measures and recommendations proposed herewith, it is concluded that the activities should be authorised.

Paul Klimczak PrSciNat	**Paul Klimczak PrSciNat**	**Steve Van Niekerk PrEng**
(Report Author)	**(Project Manager)**	**(Project Reviewer)**

9 REFERENCES

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APPENDIX A: NEMA REGULATION (2014) APPENDIX 6 SUMMARY

NEMA Regs (2014) - Appendix 6	Relevant section in report
Details of the specialist who prepared the report	Section 1.1.
The expertise of that person to compile a specialist report including a curriculum vitae	Appendix A.
A declaration that the person is independent in a form as may be specified by the competent authority	Appendix B.
An indication of the scope of, and the purpose for which, the report was prepared	Section 1.4.
The date and season of the site investigation and the relevance of the season to the outcome of the assessment	May 2016.
A description of the methodology adopted in preparing the report or carrying out the specialised process	Numerous methodologies discussed throughout the report to document baseline conditions and management measures.
The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure	Baseline hydrological conditions are discussed in Section 3.
An identification of any areas to be avoided, including buffers	Flood-lines presented in Figure 5-7.
A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Figure 5-7.
A description of any assumptions made and any uncertainties or gaps in knowledge;	Numerous assumptions are made as discussed in Sections 4.2, 5.2.4, 5.3, 6.2.1, 6.3.2, 6.3.4, 6.4.3, and 7.3.
A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment	Discussed within the EIA.
Any mitigation measures for inclusion in the EMPr	Stormwater management plan presented in Section 6 and water balance is presented in Section 7.
Any conditions for inclusion in the environmental authorisation	N/A
Any monitoring requirements for inclusion in the EMPr or environmental authorisation	N/A
A reasoned opinion as to whether the proposed activity or portions thereof should be authorised and	See Section 8.
If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan	Various recommendations are made throughout the report, most notably Sections 5, 6 and 7.
A description of any consultation process that was undertaken during the course of carrying out the study	N/A
A summary and copies if any comments that were received during any consultation process	N/A
Any other information requested by the competent authority.	N/A

APPENDIX B: TECHNICAL SPECIALIST'S CV

Position: Senior Hydrologist

Name: Paul Klimczak

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Curriculum Vitae

Qualifications and Education

2000	Batchelor of Science (BSc) with Honours (Hons): Geology
2002	Master of Science (MSc): Hydrology for Environmental Management
2002	Diploma Imperial College (DIC)

Employment Record

2011 - Present	SLR Consulting Ltd, Johannesburg, South Africa
2008 - 2011	SLR Consulting Ltd, Bristol, United Kingdom
2005 - 2007	RPS Bowman Bishaw Gorham, Perth, Western Australia
2002 - 2005	RPS Group Ltd, Chepstow, United Kingdom

Professional Affiliations and Registrations

C.WEM – Chartered Water and Environmental Manager and Member of the Chartered Institution of Water and Environmental Management (CIWEM)

Cenv – Chartered Environmentalist

PrSciNat – Professional Natural Scientist in the field of Water Resource Science

Summary of Experience and Capability

Paul is a Senior Hydrologist based in Johannesburg, and has thirteen years of consultancy experience on variety of mining, energy, infrastructure, waste and urban development projects across the UK, Australia and Africa.

With a broad understanding of environmental issues in Africa, Australia and the UK, Paul works closely with clients, regulators and other technical specialists (e.g. hydrogeologists, engineers, ecologists, town planners and architects) to seek cost effective and sustainable strategies for minimising a projects impacts on the water environment.

Paul is professionally registered / chartered through CIWEM, SocEnv, and SACNASP. He is an approved technical reviewer under SLR's ISO9001 Quality Management Systems and responsible for undertaking and reviewing specialist various studies climate characterisation, flood hydrology, water balances and stormwater management plans.

Paul's input is provided across various stages of a project from initial constraints appraisal and risk identification at scoping stages, to layout / design optimisation during pre-feasibility studies, through environmental impact assessment and management plans, to working with engineers during detailed feasibility studies and construction phases, ultimately to compliance monitoring in operational stages.

African Project Experience

Date	Location	Client	Deliverable	Services Provided
2015	Panda Hill Project, SW Tanzania	Cradle Resources Ltd	Site Water Management for Pre-Feasibility Study and Feasibility Study	• Climate Characterisation • Flood-Line Mapping • River Diversion • Stormwater Management Plan • Water Balance • Flood-Lines Mapping
2015	Jeanette Project, Free State, RSA	Taung Gold	Surface Water Study for EIA	• Climate Characterisation • Baseline Hydrology • Flood-Line Mapping • Stormwater Management Plan • Water Balance
2015	Lake Albert Infrastructure Project, Uganda	EleQtra	Water Resources Specialist Study for EIS	• Baseline Hydrology • Hydrocensus • Water Quality Monitoring • Impact Assessment
2014	Kudumane Project, Northern Cape, RSA	Kudumane Manganese Resources	Surface Water Study for EIA	• Climate Characterisation • Baseline Hydrology • Flood-Line Mapping • River Diversion • Stormwater Management Plan • Water Balance
2014	Letlhakane Project, Botswana	A-Cap Resources	Surface Water Study for EIA	• Climate Characterisation • Baseline Hydrology • Flood-Line Mapping • River Diversion • Stormwater Management Plan • Water Balance
2013	Hinda Phosphate Project, Congo-Brazzaville	Cominco Resources	Site Water Management for Pre-feasibility Study	• Climate Characterisation • Baseline Hydrology • Flow Monitoring • Water Quality Monitoring • Flood-Line Mapping • River Diversion • Stormwater Management Plan • Water Balance
2013	Magazynskraal, North-West Province, RSA	Pilanesburg Platinum Mines	Surface Water Study for EIA	• Climate Characterisation • Baseline Hydrology • Flood-Line Mapping • Stormwater Management Plan • Water Balance
2013	Leeuwkop Project, North-West Province, RSA	Impala Platinum	Surface Water Study for EIA	• Climate Characterisation • Stormwater Management Plan • Water Balance • North-West Province, RSA
2012	Sedibelo West, North-West Province, RSA	Pilanesburg Platinum Mines	Surface Water Study for EIA	• Baseline Hydrology • Stormwater Management Plan • Water Balance

APPENDIX C: DECLARATION OF INDEPENDENCE

DECLARATION OF INDEPENDENCE

The independent Environment Assessment Practitioner I, ***Paul Klimczak***, declare that I:
• Act as an independent Environmental Practitioner for the Alexander Coal Project. • Do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the Environmental Impact Assessment Regulations, 2014. • Have no and will not have any vested interest in the proposed activity proceeding. • Have no and will not engage in conflicting interests in the undertaking of the activity. • Undertake to disclose, to the competent authority, any material information that has or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the Environmental Impact Assessment Regulations, 2014. • Will ensure that information containing all relevant facts in respect of the application are distributed or made available to interested and affected parties and the public.
Signature of Specialist:
Date: 22 JULY 2016

SLR Consulting (Africa) (Pty) Ltd

RECORD OF REPORT DISTRIBUTION

SLR Reference:	750.01080.00005
Title:	Surface Water Study for the EIA
Site name:	Alexander Project
Report Number:	1
Client:	Anglo American Inyosi Coal (Pty) Ltd

Name	Entity	No. of copes	Date issued	Issuer

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