Surface Water Assessment for the Proposed Twyfelaar Coal Mine

Surface Water Assessment

Project Number:

DAG5603

Prepared for:

Dagsoom Coal

October 2019

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Report Type:	**Surface Water Assessment**
Project Name:	**Surface Water Assessment for the Proposed Twyfelaar Coal Mine**
Project Code:	**DAG5603**

Name	**Responsibility**	**Signature**	**Date**
Daniel Fundisi	Baseline and Floodlines Modelling		August 2019
Lungile Lembede	Storm Water Management Plan		September 2019
Mashudu Rafundisani	Water Balance, Impact Assessment and Technical Review		October 2019
Andre van Coller	OpsCo Review		October 2019

EXECUTIVE SUMMARY

The study area is located within the W53A quaternary catchment of the Inkomati-Usuthu Water Management Area (WMA 3). The Project Area is characterised by a temperate climate with dry winters and warm summers, while it generally receives moderate to high rainfall during the rainy season. The MAP and MAE of this region is 825 mm and 1400 mm respectively. The MAR depth for the area was calculated to be 91.25 mm. This runoff accounts for approximately 11% of the MAP for the area.

Water quality samples were collected on the streams within and around the Project Area determine the baseline water quality conditions prior to commencement of mining activities and enable monitoring of any potential water quality impact that could emanate from the mine. It is therefore recommended that water quality monitoring should continue as advised in this report, for all baseline parameters, at the sampled & proposed monitoring points, and in all mine water storage facilities (surface dams) at the mine site.

Generally, the water quality as compared to the DWS irrigational and domestic standards did not show any significant contamination. All major cations and Anions were within the set standards, except for Iron which exceeded the domestic use standards at monitoring point SW3, SW4 and SW5 while Lead so exceeded the domestic use standard at SW1 monitoring point. All other trace analysed elements were within the set DWS water quality standards

To ensure separation of clean and dirty water (as stipulated in regulation 704 of on the National Water Act), a conceptual storm water management plan was developed for this project. Separation of clean and dirty water will be done through the recommended storm water management infrastructures which include storm water drains or channels, clean water diversion berms, silt traps and PCDs. A conservative approach was used to size all channels to accommodate 1:50 year storm event with a maximum flow rate of 2.771 m3/s and a maximum velocity of 5.58 m/s.

It is recommended that the proposed PCD location at the Western Underground Access area be relocated to the northern boundary of western block, this is mainly because the currently proposed location is at a higher elevation and would not allow gravitational flow of dirty water runoff into the PCD. Lastly, it is recommended that the dirty water channels be lined to prevent contamination of groundwater resources through seepage.

The 1:50 and 1:100 year floodlines were calculated for the streams within and around the mining right boundaries and It was found that the floodlines will not encroach on the proposed mine infrastructures.

An impact assessment was conducted, and a number of potential surface water/hydrological impacts that could emanate from the project and its associated activities were identified, these include:

- Siltation of surface water resources leading to a poor water quality as a result of eroded material reporting into the streams;

- Contamination of surface water resources when dirty water runoff from the mine reports into the nearby streams; and
- Reduction in runoff to the natural streams when all the dirty water runoff is contained within the proposed pollution control dams

This study also provided the appropriate mitigation/management measures to prevent, and/or minimise the identified potential surface water impacts. With all the mitigation and management measures in place, this project is unlikely to pose a significant threat to the natural water courses and the hydrological features within and around the project area

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ALOS	Advanced Land Observing Satellite
AMD	Acid Mine Drainage
CSIR	Council for Scientific and Industrial Research
DEM	Digital Elevation Model
DTM	Digital Terrain Model
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
DTM	Digital Terrain Model
BPG	Best Practice Guidelines
EIA	Environmental Impact Assessment
EMP	Environmental Management Programme
HDPE	High-Density Polyethylene
HEC-RAS	Hydrologic Environmental Centre River Analysis System
NEMWA	National Environmental Management Waste Act
NWA	National Water Act
MAE	Mean Annual Evaporation
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
PCD	Pollution Control Dam
PCSWMM	Personal Computer Storm Water Management Model
PFD	Process Flow Diagram
SANAS	South African National Accreditation System
SAWG	South African Water Quality Guidelines
SDF	Standard Design Flood
SW1	Surface Water Monitoring Point Number 1
SWMP	Storm Water Management Plan
WHO	World Health Organisation
WMA	Water Management Area
WRC	Water Resources Commission
WRD	Waste Rock Dump

1 Introduction

Digby Wells Environmental (hereafter Digby Wells) was appointed by Dagsoom Coal to undertake a surface water assessment study for the proposed Twyfelaar Greenfields Coal Mine Project (Project Area). The Project Area is located off the N2 National Road, approximately 6 km from Sheepmoor in Mpumalanga Province, South Africa.

The proposed development includes the following infrastructure:

- Underground Mine accessed by adit. Boxcut which will produce limited rock dump.
- Access and haulage road – Maximum 9.6m wide, maximum 6km long;
- Adit – Grassland no other vegetation
- Two ventilation fans
- Processing plant
- Pollution control dam (volumetric capacity of approximately 5 500 m^3 and measures 40 x 35 x 4 m
- Raw water pump station and process water pump station
- Pipelines
  - Both pipelines are 2-inch HPDE. Maximum requirement 22.1 m^3/h
  - Raw water pipeline = 1.49 km (traverses two watercourses and road)
  - Process water pipeline
- Electricity supply servitude – 22kV line which is 2.3 km long
- Potable water treatment plant and associated tanks
- Sewage treatment plant
- Reverse Osmosis plant
- 2 x change houses
- Offices and ablutions
- Workshops and cable workshop
- Re-fuel bay
- Weighbridge and weighbridge control room
- Access control office.

The local setting of the proposed Twyfelaar Greenfields Coal Mine Project is indicated in Figure 1-1.

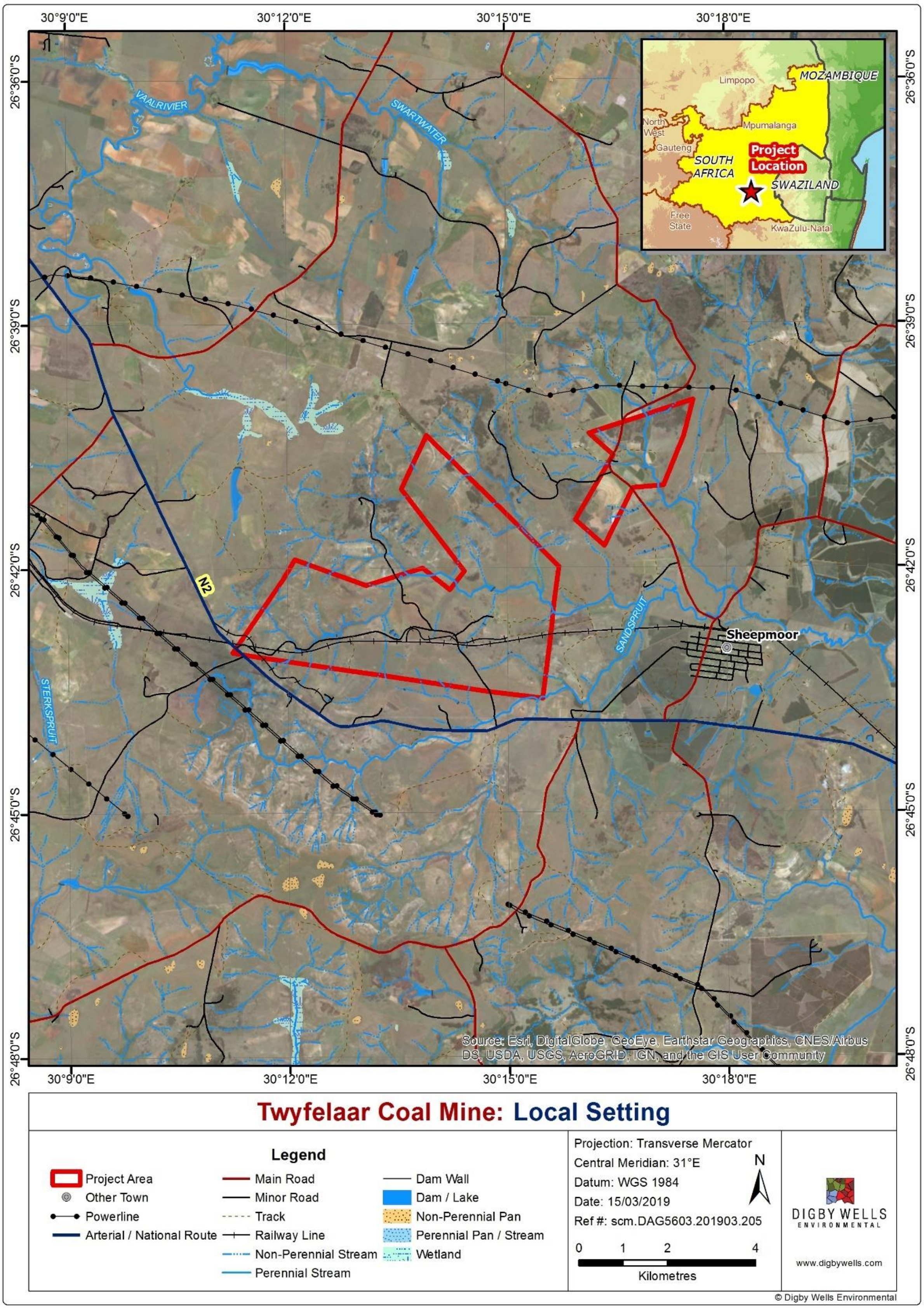


Figure 1-1: Local Setting of the Twyfelaar Project Area

2 Legal and Administrative Framework

This specialist surface water assessment was compiled in support of the EIA/ EMP to be utilised in environmental authorisations legislated under the;

- The Constitution Act (Act 108 of 1996) , Section 24 on environmental rights;
- National Environmental Management Act (Act 107 of 1998), (NEMA) as amended;
- Environmental Impact Assessment Regulations of 2010;
- National Environmental Management Waste Act (Act 59 of 2008), (NEMWA); and
- National Water Act (Act 36 of 1998) (NWA);
- NWA amendment as per Regulation 704 (GN R 704, (1999)) on use of water for mining and related activities aimed at the protection of water resources and
- Government Notice 718 of 2009, for identified listed activities relevant to the backfilling project and the construction and operation of the required infrastructure.

In compilation of the surface water specialist report the following water related legislation and guidelines are also applied DWA Best Practice Guidelines (BPGs) series (2008).

3 Details of the Author

The following specialists were involved in this hydrological assessment study:

Responsibility	**Technical Review**
Full Name of Specialist	Mashudu Rafundisani
Highest Qualification	BSc Honours
Years of experience in specialist field	7
	Cert.Sci.Nat. (SACNASP) ; Reg. Number: 115066
Responsibility	**Final Review**
Full Name of Specialist	Andre van Coller
Highest Qualification	MSc Geohydrology
Years of experience in specialist field	11

3.1 Declaration of Specialist

I, Mashudu Rafundisani, as the appointed specialist, hereby declare/affirm the correctness of the information provided or to be provided as part of the application, and that I:

- in terms of the general requirement to be independent, other than fair remuneration for work performed/to be performed in terms of this application, have no business, financial, personal or other interest in the activity or application and that there are no circumstances that may compromise my objectivity;
- in terms of the remainder of the general requirements for a specialist, am fully aware of and meet all of the requirements and that failure to comply with any the requirements may result in disqualification;
- have disclosed/will disclose, to the applicant, the Department and interested and affected parties, all material information that have or may have the potential to influence the decision of the Department or the objectivity of any report, plan or document prepared or to be prepared as part of the application; and
- am aware that a false declaration is an offence in terms of regulation 48 of the 2014 NEMA EIA Regulations.

Signature of the specialist

Mashudu Rafundisani

Full Name and Surname of the specialist

Digby Wells Environmental

Name of company

October 2019

Date

4 Methodology

4.1 Baseline Hydrology

Rainfall and runoff data obtained from the database of the Water Resources Commission of South Africa 2012 study (WRC, 2015) was analysed to determine the Mean Annual Precipitation (MAP), Mean Annual Evaporation (MAE) and the Mean Annual Runoff (MAR) for the Twyfelaar Greenfields Coal Mine (Twyfelaar) region and site. Historical rainfall-runoff data from 1920 to 2009 (89 years) was adequate to determine mean hydro-meteorological parameters for the Project Area. These analyses were useful to provide insight into the general rainfall-runoff and evaporation dynamics at the site, which informed the surface water impact assessment study.

4.2 Water Quality

Chemistry results of water samples collected at the upstream and downstream of the nearby natural water bodies and analysed at a South African National Standards (SANAS) accredited laboratory was assessed and interpreted to provide baseline conditions prior to commencement of mining activities.

The Department of Water and Sanitation (DWS) water quality guidelines for Livestock watering, irrigation and aquatic ecosystems were used as benchmarks against the laboratory results (DWA, 1996). These guidelines were selected based on dominant water uses in the area.

4.3 Peak Flows

Catchment delineation was undertaken in Global Mapper using Advanced Land Observing Satellite (ALOS) World 3D – 30m (AW3D30) global digital surface model (DSM) data (JAXA, 2015). This dataset is stored in a raster GeoTIFF format referenced to the Hartebeesthoek 94 Datum (WGS84 ellipsoid). The ALOS data showed a higher resolution than a Digital Elevation Model (DEM) generated from 5 m contours (National Geospational Institute, 2013) of the area.

Widely used and recommended methods including the Rational Method Alternative 3 (RM3), Standard Design Flood (SDF) and the Midgley & Pitman (MIPI) were used to calculate the 1:50-year and 1:100-year peak flows for delineated subcatchments at the Project Area (SANRAL, 2013). Design rainfall depths were determined using the Design Rainfall Programme for South Africa and the modified Hershfield equation as input to the RM3 and SDF methods, respectively.

4.4 Floodlines Determination

Hydraulic modelling was conducted in HEC-RAS 5.07 which allows pre-processing within the in-built RAS Mapper module. A Digital Terrain Model (DTM) was generated from the ALOS DSM for the area to make the topographic data compatible with RAS Mapper. The pre-processing involved generation of the channel geometry, including the river network, banks, flow paths and cross sections.

The HEC-RAS model simulates total energy of water by applying basic principles of mass, continuity and momentum as well as roughness factors between all cross sections (US Army Corps of Engineers, 1995). A height is calculated at each cross-section, which represents the level to which water will rise at that section, given the calculated initial peak flows for the 1:50-year and 1:100-year events on all river sections.

Analyses are performed by modelling flows at the sub-catchment outlet of stream or channel sections first, moving upstream. Manning's Roughness Coefficients (n) for the channels were set at 0.08, and those for river banks were determined to be 0.1 representing natural channels with weeds, reeds and brush on the banks (Chow, 1959).

It must be noted that the study only determined indicative floodlines, hence can only be used for environmental purposes and not for detailed engineering design purposes.

4.5 Water Balance

The Water Balance was based on the water Process Flow Diagram (PFD) that was developed for Scorpion Mineral Processing (SMP) South Africa LTD for Twyfelaar Greenfields Coal Mine in September 2014. The PFD describes a concept water balance indicating, sources and the transfer of water within the site, abstraction, water storage and discharges. The static water balance compilation utilised results of the hydrological assessment to provide hydrological inputs such as rainfall, runoff and evaporation into modelling calculations. Other water uses and required processing & consumption volumes used were either calculated or provided in the SMP processing report. Where information gaps were identified, assumptions have been made and are presented in Section 9 of the report.

4.6 Conceptual Stormwater Management Plan

The conceptual SWMP was undertaken with adherence to the guidelines for Human Settlement Planning and Design as stipulated by the Council for Scientific and Industrial Research (CSIR, 2005). Clean and dirty water catchments were delineated based on the functions of proposed infrastructure on site. Stormwater drains and berms were determined and sized in the Personal Computer Storm Water Management Model (PCSWMM). PCSWMM is a dynamic rainfall-runoff simulation model used for single event or long-term simulation of runoff quantity (James, 2010). The PCSWMM programme derived site elevation details from a Digital Elevation Model (DEM) generated using 30 m contours for the site.

The storage capacity of an outfall/storage structure was determined as a function of the simulated stormflow, incident rainfall and outfall depth for an optimised model to ensure zero flooding or surcharge. The drains were sized not to spill, on average, when a 1:50-year flood event occurs. The model uses the catchment area, average slope, catchment permeability and the design rainfall depth to simulate storm flows which are channelled to containment structures or discharged through low-point outlets. The influence of paved areas such as rooftops, roads and concrete slabs was incorporated in PCSWMM by specifying the proportionate percentages of impervious areas within the demarcated sub-catchments.

4.7 Surface Water Impact Assessment

Potential surface water impacts (quality and quantity) that may result from the proposed mining activities, based on the established baseline conditions, were identified. The detailed impact assessment methodology is appended in Appendix A.

4.8 Assumptions and Limitations

The following assumptions and limitations are applicable to this study:

- Only a five (5) water quality samples were collected on the streams within and around the Project Area, sampling points which could not be sampled due to access issues or which were dry at the sampling moment have been included on the proposed monitoring programme for the mine to continue monitoring;

- Water balance process flow was obtained from SMP process report and this was adopted for the current excel based static water balance model developed for this project;
- The ALOS 3D 30m DEM used for floodlines modelling was of low resolution, hence some topographical detail was missed. It should, however, be noted that this data is sufficient for the intended purpose of environmental indicative floodlines.

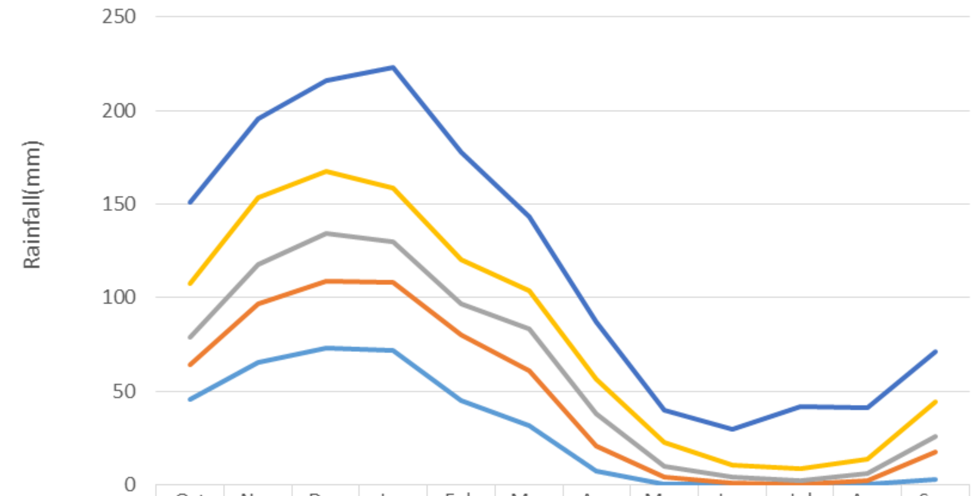
5 Baseline Hydrology

South Africa is divided into 9 Water Management Areas (WMA) (Revised National Water Resource Strategy, 2012), managed by their own water boards. Each of the WMAs is made up of quaternary catchments which relate to the drainage regions of South Africa, ranging from A to X (excluding O). These drainage regions are subdivided into four known divisions based on size. For example, the letter A represents the primary drainage catchment; A2 for example will represent the secondary catchment; A21 represents the tertiary catchment and A21D would represent the quaternary catchment which is the lowest subdivision in the Water Resources of South Africa, 2012 manual. Each of the quaternary catchments has associated hydrological parameters.

The study area is located within the W53A quaternary catchment of the Inkomati-Usuthu Water Management Area (WMA 3) as revised in the 2012 water management area boundary descriptions (Government Gazette No. 35517). For the relevant quaternary catchment refer to Figure 5-4.

5.1 Climate

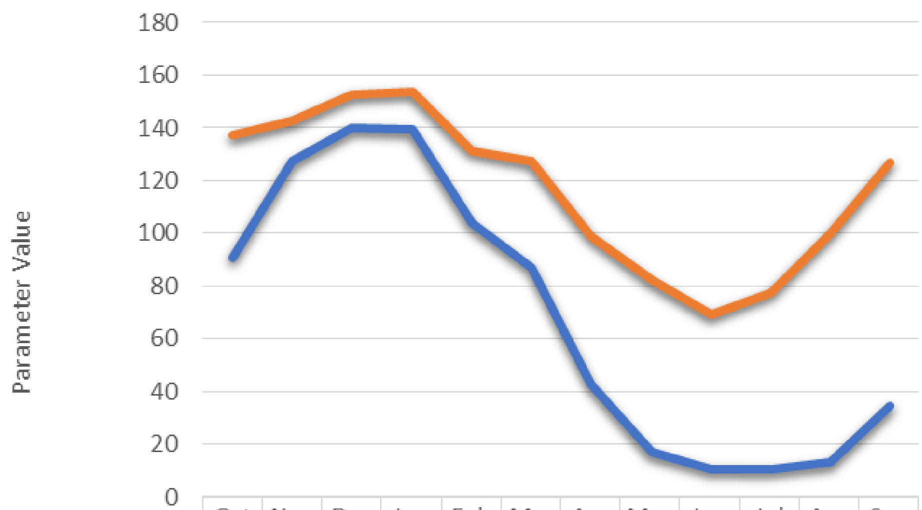
The Project Area is characteristic of a temperate climate with dry winters and warm summers. The precipitation of the driest month in winter is less than 1 tenth of the wettest month precipitation in summer (Cannon, 2011). The Mean Annual Precipitation (MAP) of region is 825 mm which is likely to be distributed as indicated in Figure 5-1 (WRC, 2015). The 90th percentile of the wettest month (December) is 73 mm while the 10th percentile is indicated to be 216 mm. This implies that this region generally receives moderate to high rainfall during the rainy season.



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
90 Percentile	45	65	73	72	45	31	8	0	0	0	0	3
70 Percentile	64	97	109	108	80	61	20	4	1	0	2	17
50 Percentile	79	118	135	130	97	83	38	10	4	2	6	26
30 Percentile	107	153	168	158	120	104	57	23	10	8	13	44
10 Percentile	151	196	216	223	178	143	87	40	30	42	41	71

Figure 5-1: Monthly rainfall distribution for quaternary W53A

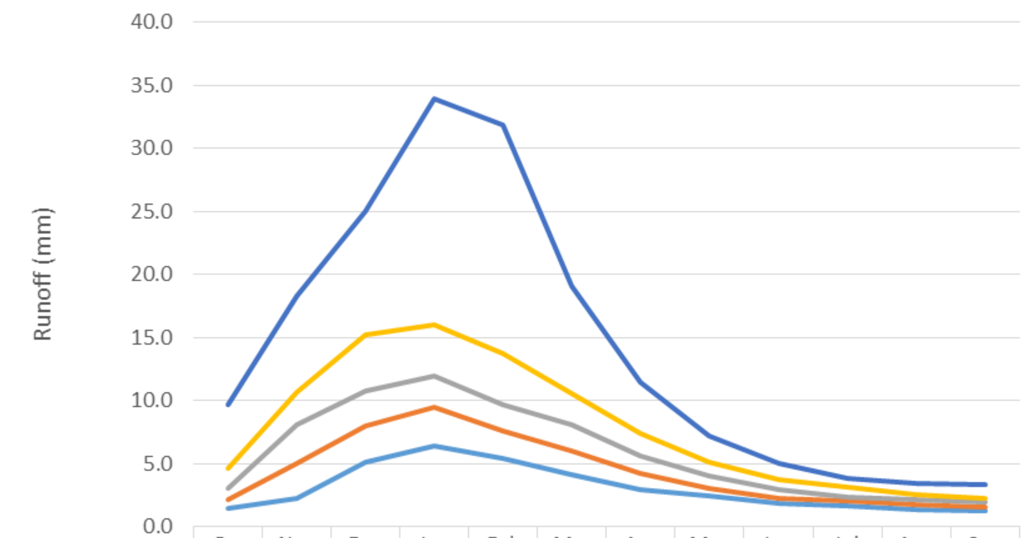
The Mean Annual Evaporation (MAE) (1400 mm) is almost twice as much as the MAP (817 mm) for the area which indicates a region characterised by distinct dry and wet seasons (WRC, 2015) with a negative natural water balance. The monthly distribution of potential evaporation and rainfall can be seen in Figure 5-2.



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Evaporation(mm)	137	143	153	154	131	127	99	82	69	78	100	127
Rainfall(mm)	91	128	140	140	104	87	43	17	10	10	13	34

Figure 5-2: Monthly evaporation and rainfall for quaternary W53A

The Mean Annual Runoff (MAR) depth for the area was calculated to be 91.25 mm. This runoff accounts for approximately 11% of the MAP for the area. The 90th and 10th percentiles of runoff during the wettest month of December are 5.1 mm and 25 mm, respectively. Owing to considerable antecedent soil moisture conditions in the following month of January, these values increase to 6.4 mm and 33.9 mm, respectively (See Figure 5-3).



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
90 Percentile	1.4	2.2	5.1	6.4	5.5	4.1	3.0	2.4	1.8	1.6	1.4	1.3
70 Percentile	2.1	5.0	8.0	9.5	7.6	6.0	4.2	3.0	2.3	2.0	1.8	1.6
50 Percentile	3.0	8.1	10.8	12.0	9.6	8.1	5.6	4.0	3.0	2.4	2.1	1.9
30 Percentile	4.6	10.7	15.2	16.0	13.8	10.6	7.4	5.1	3.8	3.2	2.5	2.3
10 Percentile	9.7	18.3	25.0	33.9	31.8	19.1	11.5	7.2	5.0	3.9	3.4	3.4

Figure 5-3: Monthly runoff distribution for quaternary W53A

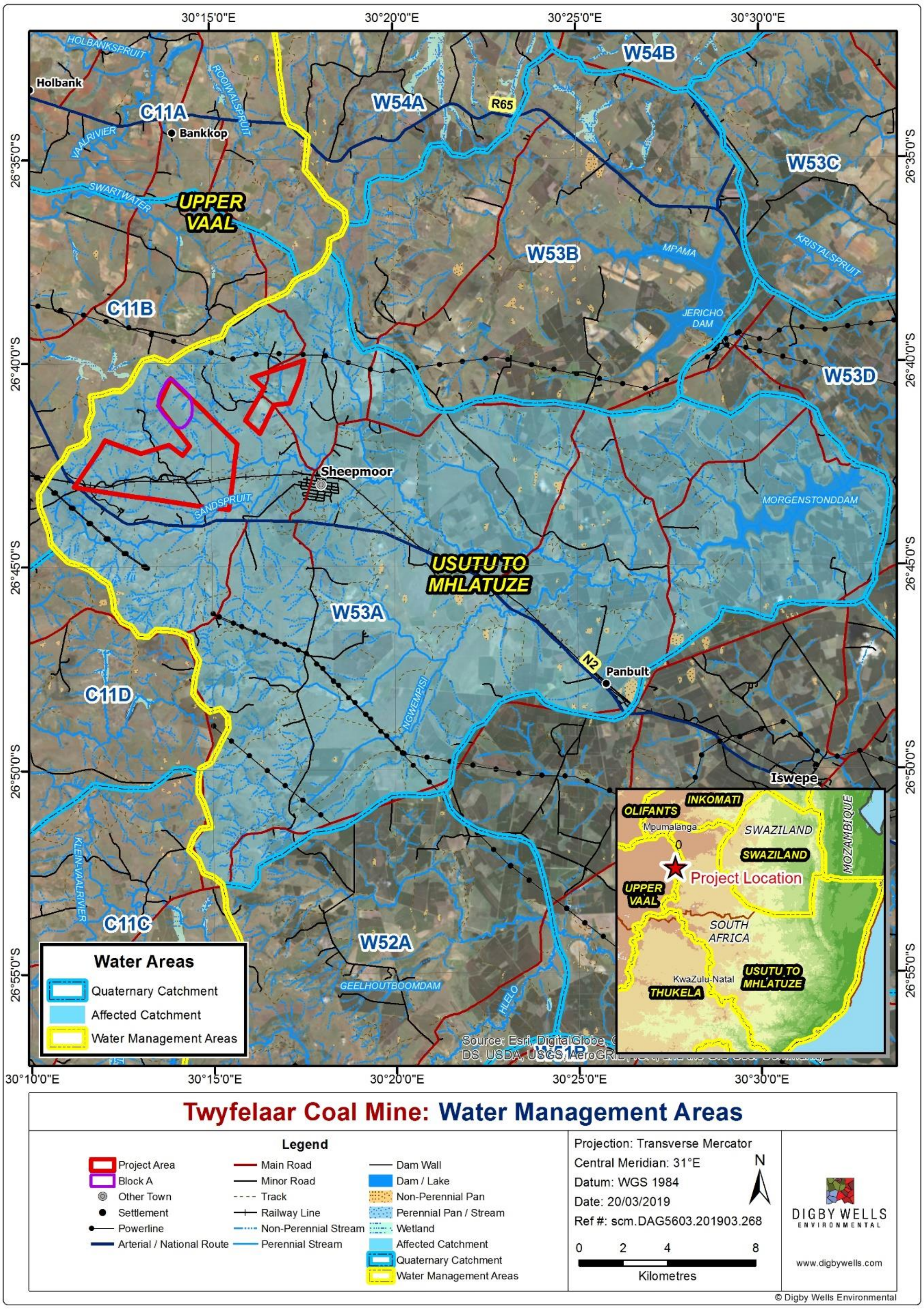


Figure 5-4: Hydrological Setting

6 Water Quality Assessment

Baseline water quality for streams within and around the proposed Twyfelaar Coal Mine was assessed and interpreted to provide baseline conditions prior to commencement of mining activities. Digby Wells undertook a site visit August 2019 to collect water samples on the streams within and around the project area, five (5) samples were collected on the Sandspruit and other unnamed streams around the Project Area, sampling points which could not be sampled due to access issues or were dry at the moment, would be included on the proposed monitoring program for the mine to continue monitoring. The samples were submitted to Waterlab Laboratory (Pty) Ltd, a SANAS accredited laboratory, in Pretoria for analyses of physical and chemical water quality parameters. The results of the surface water quality analysis are presented in Table 6-2.

The predominant water use around the project area is agriculture (irrigation) and for that reason the results were benchmarked against the South African Water Quality Guidelines for Agricultural Use: Irrigation (DWAF, 1996).

The location and description of the monitoring localities for the proposed Twyfelaar Coal Mine site are presented in Table 6-1 and Figure 6-1.

Table 6-1: Location and description of surface water quality sampling points at the proposed Twyfelaar Coal Mine site

Monitoring Localities	Description	Coordinates	
		Latitude	Longitude
SW1	Upstream of Western Block of the Project Area	26°42'59.62"S	30°12'12.40"E
SW2	Upstream of the North Block of the Project Area (unnamed tributary of Sandspruit)	26°40'17.68"S	30°13'17.14"E
SW3	Sandspruit adjacent (south) of the Project Area	26°43'52.47"S	30°15'58.88"E
SW4	Sandspruit, downstream of the Project Area	26°42'20.14"S	30°18'9.61"E
SW5	Upstream of North Block of the Project Area (unnamed tributary of Sandspruit)	26°40'4.49"S	30°15'5.32"E
SW6*	Upstream of north of the Project Area (unnamed tributary of Sandspruit)	26°39'59.96"S	30°16'59.04"E
SW7*	Downstream of Western Block of the Project Area	26°42'6.82"S	30°14'3.12"E
SW8*	Downstream of North Block of the Project Area	26°42'17.61"S	30°15'0.69"E
SW9*	Downstream of North Block and Eastern Block of the Project Area	26°42'27.91"S	30°16'47.58"E

*** - Proposed monitoring points**

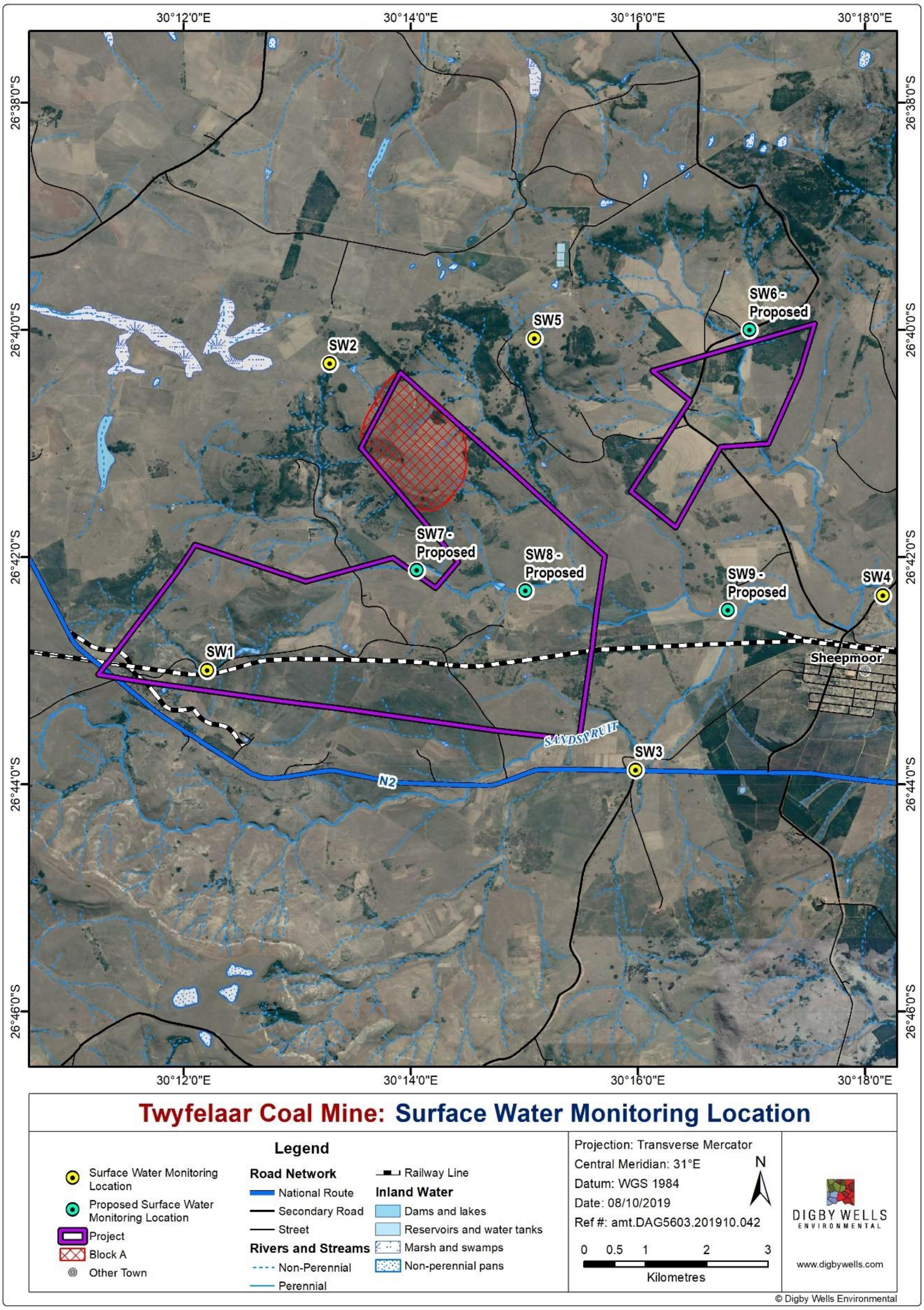


Figure 6-1: Surface Water Sampling Localities at the Proposed Twyfelaar Coal Mine site

6.1.1 Eastern Underground Access Water Management

A diversion berm is proposed to divert clean water from entering the mine footprint area. A lined dirty water channel surrounding the mine footprint area and diverting the contaminated runoff into the PCD is recommended.

6.2 Results Interpretation

The water quality results represent baseline conditions prior to commencement of any mining activities which should thus provide a necessary benchmark for any future water quality changes. pH at monitoring point SW1 was above the DWS Irrigational standards but was still within the DWA Domestic use standard.

Electrical Conductivity (EC) and Total Dissolved Solids (TDS) are within the DWS water quality guidelines as indicated in Table 6-2. All major cations (K, Na, Ca and Mg) are also within the DWS guidelines.

Anions which include Sulphate (SO4), Chloride (Cl), Fluoride (F), Nitrate (NO3) and Phosphate (PO4) were also within the DWS water quality guidelines as indicated in Table 6-2.

Iron (Fe) exceeded DWS water quality guidelines for domestic use at monitoring point SW3, SW4 and SW5 while Lead (Pb) had also exceeded the domestic use standard at SW1 monitoring point. All other trace analysed elements were within the set DWS water quality standards (Table 6-2).

Table 6-2: Surface water quality for streams within and around the proposed Twyfelaar Coal Mine

Parameter	SW1	SW2	SW3	SW4	SW5	DWS Domestic Use	DWS Aquatic Ecosystem	DWS Livestock Watering	DWS Irrigation
	(mg/L, unless otherwise stated)								
pH, at 25˚C *(pH meter units)*	8.6	7.2	7.7	7.8	7.6	6 - 9	NS	NS	6.5 - 8.4
Electrical Conductivity, *(mS/m)*	43.1	9.1	16	18.6	18.9	<70	NS	NS	NS or <40
Total Dissolved solids (TDS)	274	46	98	108	118	<450	NS	<1000	NS
Aluminium	< 0.100	< 0.100	< 0.10	< 0.100	< 0.100	<0.15	<0.01	<5	<5
Ammonia	Na	Na	Na	Na	Na	NS	NS	NS	NS
Arsenic	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	≤200	0.01	≤1	0.1
Barium	0.035	0.011	0.048	0.046	0.238	NS	NS	NS	NS
Beryllium	< 0.010	< 0.010	< 0.01	< 0.010	< 0.010	NS	NS	NS	0.10
Bismuth	< 0.010	< 0.010	< 0.01	< 0.010	< 0.010	NS	NS	NS	NS
Boron	0.087	0.065	< 0.01	< 0.010	< 0.010	NS	NS	<5	<0.5
Cadmium	< 0.010	< 0.010	< 0.01	< 0.010	< 0.010	<0.005	<0.00015	<0.01	<0.01
Calcium	22	10	14	13	13	<32	NS	<1000	NS
Cerium	< 0.010	< 0.010	< 0.01	< 0.010	< 0.010	NS	NS	<5	NS
Caesium	< 0.010	< 0.010	< 0.01	< 0.010	< 0.010	NS	NS	<5	NS
Chloride	10	7	5	9	8	<100	NS	<1500	<100
Chromium	< 0.010	< 0.010	< 0.01	< 0.010	< 0.010	<0.05	0.007	<1	<0.1
Cobalt	< 0.010	< 0.010	< 0.01	< 0.010	< 0.010	NS	NS	<1	<0.05
Copper	< 0.010	0.020	< 0.010	< 0.010	< 0.010	<1	<0.0003	<0.5	<0.2
Fluoride	0.6	<0.2	<0.2	<0.2	<0.2	<1	<0.75	<2	<2
Iron	0.045	0.029	0.408	0.293	1.21	<0.1	NS	<10	<5
Lead	< 0.010	0.020	< 0.01	< 0.010	< 0.010	<0.01	<0.0002	<0.1	<0.2
Lithium	< 0.010	0.020	< 0.01	< 0.010	< 0.010	NS	NS	NS	NS
Magnesium	5	2	8	9	11	<30	NS	<500	NS
Manganese	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	<0.05	<0.18	<10	<0.02
Mercury	< 0.010	< 0.010	< 0.01	< 0.010	< 0.010	<1	0.04	<1	NS
Molybdenum	< 0.010	0.020	< 0.01	< 0.010	< 0.010	NS	0.04	0.01	0.01
Nickel	Na	Na	Na	Na	Na	NS	NS	<1	<0.2
Nitrate	0.5	0.1	0.1	0.1	1.5	≤6	NS	<200	100
Total Phosphate, as P	0.330	0.013	0.011	< 0.010	< 0.010	NS	NS	NS	NS
Potassium	2.6	3.1	2.4	2.5	3.9	<50	NS	NS	NS
Selenium	< 0.010	0.020	< 0.01	< 0.010	< 0.010	<0.02	<0.002	<0.05	<0.02
Silicon	12.7	0.4	8.5	5.7	6.7	NS	NS	NS	NS
Silver	< 0.010	< 0.010	< 0.01	< 0.010	< 0.010	NS	NS	NS	NS
Sodium	66	3	7	9	6	<100	NS	<2000	<70
Strontium	0.137	0.021	0.045	0.056	0.074	NS	NS	NS	NS
Sulphate	48	4	<2	5	2	<200	NS	<1000	NS
Suspended Solids at 105°	2.7	16	11.3	2.7	5.3	NS	NS	NS	<50
Tin	< 0.010	0.020	< 0.01	< 0.010	< 0.010	NS	NS	NS	NS
Titanium	0.018	< 0.010	< 0.01	< 0.010	< 0.010	NS	NS	NS	NS
Uranium *(in Bq)*	< 0.010	0.020	< 0.01	< 0.010	< 0.010	0.070 - 0.284	NS	NS	0.01
Vanadium	< 0.010	0.020	< 0.01	< 0.010	< 0.010	<0.1	NS	<1	<0.1
Zinc	< 0.010	0.064	< 0.01	< 0.010	0.010	<3	<0.002	<20	<1

KEY:

Exceeds least stringent standard or only available standard	(green)
Exceeds most stringent standard	(orange)
No Standard	NS
Not Analysed	Na

7 Floodlines

The 1:50-year and 1:100-year floodlines on the river sections were analysed to evaluate the risks associated with the potential flooding or inundation of infrastructure and for the protection of water resources. In this study floodlines were modelled for the streams within and in proximity to the Project Area.

7.1 Peak Flows

7.1.1 Design rainfall depths

Design Rainfall Depths for the 1:2-year to 1:100-year return periods were calculated using the Design Rainfall Software for South Africa (Smithers and Schulze, 2000). The rainfall depths are presented in Table 7-1. The rainfall depths with durations equal to the time of concentration (Tc) of assessed catchments were used to calculate peak flows using the RM3 method. The recalibrated modified Hershfield equation was used to determine precipitation depths used in the SDF method (Alexander, 2002).

Table 7-1: 24-Hour Design rainfall depths for Twyfelaar region

Return Period						
Duration	**2year**	**5year**	**10year**	**20year**	**50year**	**100year**
5 m	9.4	12.4	14.6	16.7	19.7	22.1
10 m	13.4	17.7	20.8	24	28.3	31.7
15 m	16.5	21.9	25.7	29.6	34.8	39
30 m	21.2	28.2	33.1	38	44.9	50.2
45 m	24.6	32.7	38.3	44.1	52	58.2
1 h	27.3	36.3	42.6	49	57.7	64.7
1.5 h	31.7	42	49.4	56.7	66.9	74.9
2 h	35.2	46.7	54.8	63	74.3	83.2
4 h	42.6	56.4	66.3	76.2	89.8	100.6
6 h	47.6	63.1	74.1	85.1	100.4	112.5
8 h	51.5	68.2	80.1	92.1	108.6	121.7
10 h	54.7	72.5	85.2	97.9	115.5	129.4
12 h	57.5	76.2	89.5	103	121.4	136
16 h	62.2	82.5	96.9	111.4	131.3	147.1
20 h	66.1	87.7	103	118.4	139.6	156.4
24 h	69.5	92.2	108.3	124.5	146.8	164.4

7.1.2 Delineated subcatchments and peak flows

A total of 8 subcatchments (C1 to C8) were delineated for the streams and selected relevant tributaries in proximity to the Project Area (Figure 7-1). Peak flows calculated using the RM3 and MIPI methods are of the same order of magnitude, hence the SDF flood peaks were considered an over-estimate for the site. RM3 flood peaks which were more conservative than those for the MIPI method were used in HEC-RAS for hydraulic modelling. Catchment characteristics and calculated peak flows are presented in Table 7-2 and Table 7-3, respectively.

Table 7-2: Characteristics of delineated catchments at Twyfelaar Coal Mine

Catchment	AREA	Longest Watercourse (L)	Distance to Centroid (Lc)	Elevation (mamsl)		Slope
	km²	*km*	*km*	*10%L*	*85%L*	*(m/m)*
C1	30.3	11.7	4.9	1457	1556	0.0112
C2	8.4	4.7	2.6	1488	1570	0.0236
C3	6.6	2.3	1.8	1514	1588	0.0436
C4	7.8	5.5	1.7	1498	1561	0.0154
C5	9.4	4.2	4.1	1459	1526	0.0215
C6	39.5	10.3	4.6	1454	1531	0.0100
C7	15.9	8.3	2.2	1467	1570	0.0165
C8	4.8	2.9	1.3	1514	1626	0.0518

Table 7-3: Peak flows in the delineated catchments

Catchment	Method					
	RM3		SDF		MIPI	
	1:50yr	1:100yr	1:50yr	1:100yr	1:50yr	1:100yr
	(m³/s)					
C1	126.05	170.10	255.88	324.04	128.37	162.15
C2	63.25	85.45	152.83	193.55	67.45	85.21
C3	55.01	74.10	138.72	175.67	58.57	73.98
C4	85.27	114.86	206.24	261.18	74.21	93.73
C5	74.68	100.89	177.91	225.30	68.66	86.73
C6	165.25	222.99	354.09	448.42	162.93	205.80
C7	97.46	131.42	138.72	175.67	58.57	73.98
C8	142.11	191.63	495.28	627.21	100.04	126.37

7.2 Inundation Results

The 1:50-year and 1:100-year floodlines for the streams and its tributaries were modelled and mapped. From the results, all the proposed infrastructures are outside of the delineated 1:50-year and 1:100-year floodlines, and outside the horizontal distance of 100 metres as required by regulation 704 of on the National Water Act. The general overview of the floodlines can be seen in Figure 7-2.

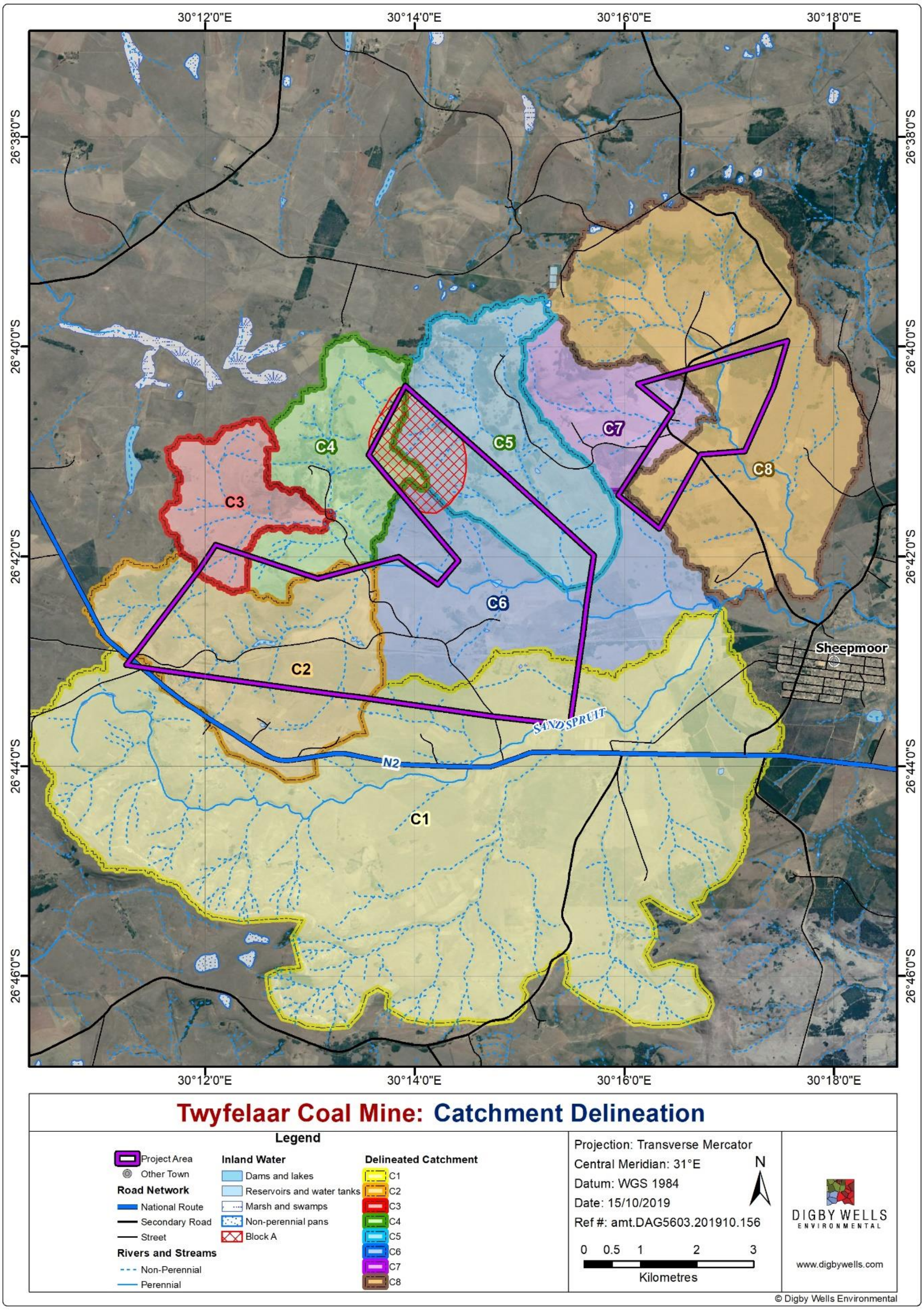


Figure 7-1: Delineated Subcatchments at Twyfelaar Coal Mine

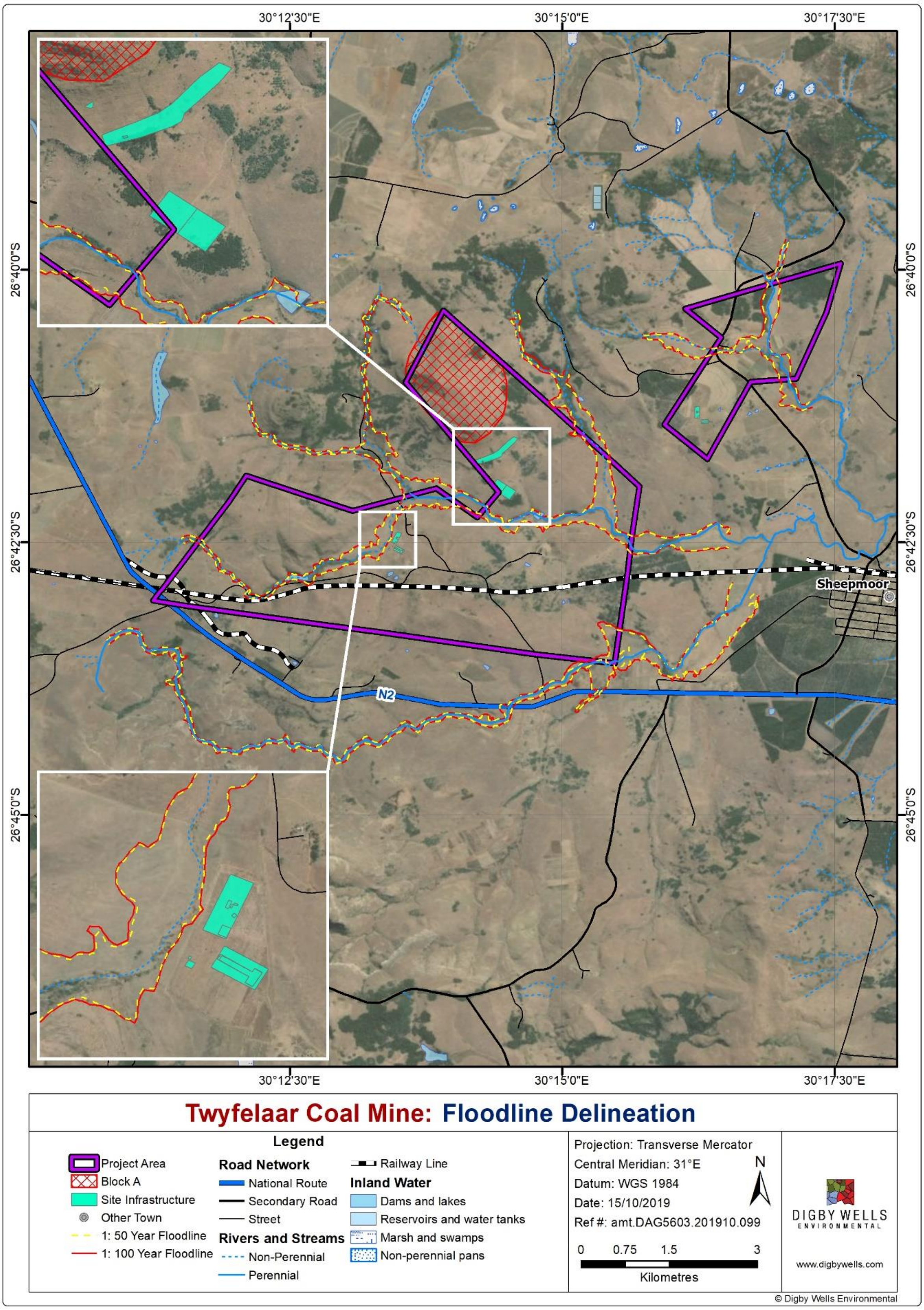


Figure 7-2: 1:50-year and 1:100-year Floodlines at Twyfelaar Coal Mine

8 Conceptual Stormwater Management Plan

8.1 Stormwater Sub-catchments

The delineation of stormwater sub-catchments was done for the Western, Northern and Eastern access areas at the Twyfelaar Coal Mine study area.

8.1.1 Clean and Contaminated Stormwater Catchments

The conceptual SWMP indicates the separation of clean and contaminated water catchments through storm water drains, and contaminated water dams or Pollution Control Dams (PCDs). The designation of the clean and contaminated water catchments was based on the proposed land usage. Due to the proximity of the mine infrastructure (dirty water catchments) and the minimal areas occupied by clean catchments (i.e. offices and sub-station areas), the general organization of the stormwater management infrastructure tends to generalize the catchments as dirty to maintain design simplicity, while diverting clean water away from the proposed mining areas.

8.1.2 Sub-catchment characteristics and stormflow

Manning's '*n*' or roughness coefficient used in the PC SWMM model for the impervious and pervious areas are 0.013 for HDPE or float finish concrete lining and 0.03 for grass vegetation (McCuen, 1996). The soil texture of the study was predominantly classified as loam texture based on site observations. These soils are characterised by moderate infiltration where the terrain is gentle to flat and moderate to high runoff is expected where slopes are generally steep. The PC SWMM model used within this study requires these criteria to incorporate infiltration into the analysis using the Green-Ampt infiltration method. The loam group resulted in a suction head of 88.9 mm, a hydraulic conductivity of 13.2 mm/hr and an initial deficit of 0.346 being used in the stormwater modelling. Modelled peak flows and runoff volumes for stormwater sub-catchments are summarised in Table 8-1 for the 1:50-year recurrence interval 24 hr flood event.

Table 8-1: Modelled peak flows and runoff volumes for stormwater sub-catchments

ID	Description	Classification	Area	Total Runoff	Peak Runoff	Runoff Coefficient
			ha	m^3	m^3/s	Dimensionless
Western Underground Access						

ID	Description	Classification	Area	Total Runoff	Peak Runoff	Runoff Coefficient
			ha	m^3	m^3/s	Dimensionless
S2_1.	Workshop, workshop store, wash bay and sub-station Offices, diesel bay and explosives delivery bay	Dirty	1.82	1 007.37	0.46	0.38
S2_2.	Adit	Dirty	1.93	1 068.26	0.49	0.38
Northern Underground Access						
S2.3	Discard dump	Dirty	3.18	1488.87	0.67	0.32
S2.4			3.61	1690.20	0.76	0.32
S2.5	PCD	Dirty	0.61	715.95	0.34	0.80
S2.6	Service water dams, visitors parking, potable water tank, Sewage treatment plant, LDV parking, workshop and store, brake test ramp, diesel bay and ROM area	Dirty	6.33	6142.63	2.98	0.66
Eastern Underground Access						
S4.1	Adit	Dirty	2.19	2627.04	1.11	0.86

ID	Description	Classification	Area	Total Runoff	Peak Runoff	Runoff Coefficient
			ha	m^3	m^3/s	Dimensionless
S4.2	Workshop and store, wash bay, offices, generator, diesel bay and explosives delivery bay	Dirty	1.42	1941.72	0.72	0.86

8.2 Proposed Stormwater Management Strategy

All diversion drains and containment dams have been sized to prevent flooding from the 1:50-year design rainfall event. A conservative approach was used to size all channels to accommodate a maximum flow rate of 2.771 m^3/s. The general dimensions of a proposed typical stormwater drain are presented in Table 8-2. The schematic of stormwater drains is presented in Figure 8-1 which shows an adjoining drain and berm structure required to channel stormflow as well as separate clean water from entering contaminated catchments. Dirty water channels should be lined to minimise contamination of clean water resources through seepage losses.

Table 8-2: Proposed stormwater drain dimensions

Drain Cross Section	Depth	Bottom Width	Left Slope	Right Slope	Max Flow	Max Velocity
	m	*m*	*(1:H)*	*(1:H)*	*m^3/s*	*m/s*
Trapezoidal	1	1	2	2	2.771	5.58

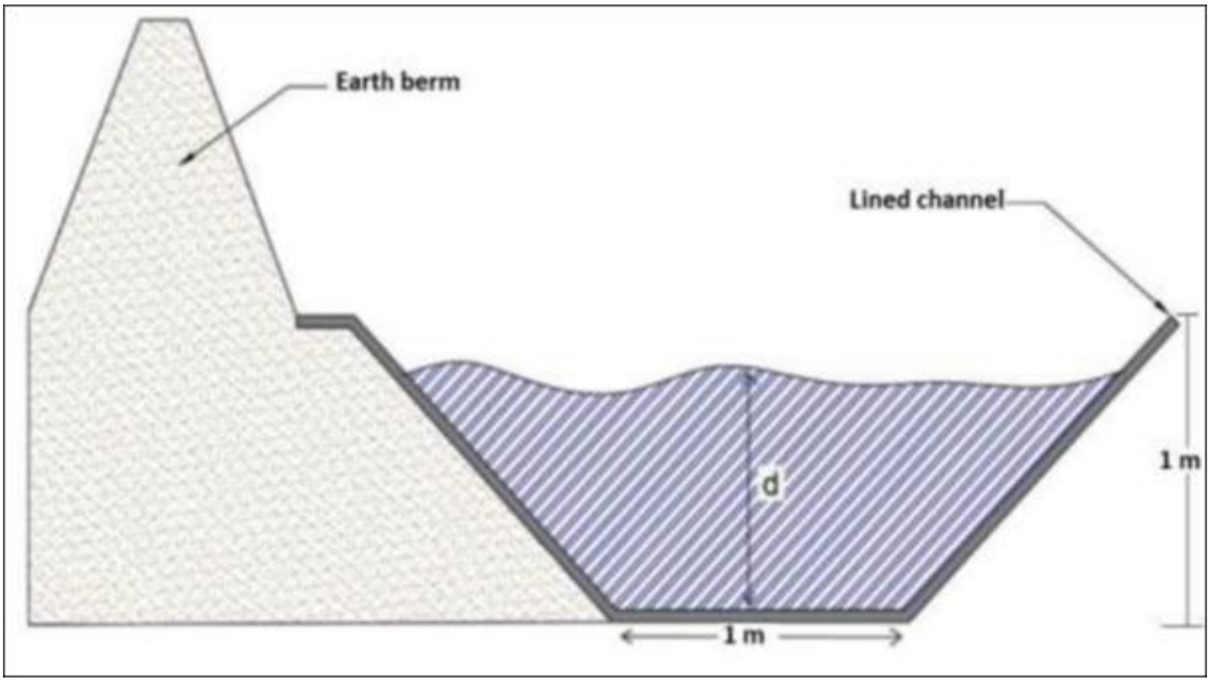


Figure 8-1: Typical drain adjoined to a berm for stormwater channelization

The conceptual capacities of PCDs can be seen in Table 8-3. A freeboard allowance of 0.8 m should be considered in the final design of each of the PCDs, direct rainfall into the PCD must also be taken into account when determining the freeboard. It is recommended that the dirty water stored in the PCDs be re-used in the mine process, where plausible.

Table 8-3: Conceptual storage capacities for proposed pollution control dams

Storage Facility	Description	Location		Storage Capacity
		Latitude	*Longitude*	*m^3*
SU1	Western underground access PCD	-26.709385°	30.223522°	4 650
SU2	Eastern underground access PCD	-26.709364°	30.223516°	2 072
SU3	Proposed discard dump PCD	-26.701544°	30.242111°	3 180
SU4	Northern underground access PCD	-26.696039°	30.237056°	6 844

8.2.1 Western Underground Access Water Management

The proposed infrastructure is situated close to a Non-perennial River. A diversion berm is proposed to divert clean water from entering the mine footprint area. A lined dirty water channel surrounding the mine footprint area and diverting the contaminated runoff into the PCD is recommended. Based on the infrastructure layout plan provided by the client, the PCD is situated at a higher elevation when compared to the rest of the infrastructure. It is therefore recommended that the proposed location of the PCD be relocated to a lower elevation area to enable runoff gravitational flow from the dirty water catchments into the PCD. The coordinates for the recommended alternate PCD location is approximately -26.706702°; 30.224699°, as depicted in (Figure 8-2).

8.2.2 Northern Underground Access Water Management

A clean water diversion berm is proposed from the upstream catchment. The berm intersects a haul road, at which point, a culvert is recommended. The diversion berm will release clean water to the nearby stream. A dirty water channel is recommended to contain water from the dirty catchments. The dirty water channel can feed into the PCD by gravity as the PCD is located at the lowest point when compared to the dirty water catchments.

8.2.3 Discard Dump Water Management

Geochemical analysis is required to determine the nature of the leachate expected from the discard dump. The geochemical analysis report that was undertaken by Digby Wells indicated that the presence of pyrite was detected at 1.8 % in one of the samples, and this is above 0.3% which indicates that this sample could be potentially acid generating. Hence a stormwater management plan was developed for the discard dump area (Digby Wells, 2019). It was proposed that dirty channels be constructed around the discard dump and a PCD be constructed to collect the leachate from the lined discard dump.

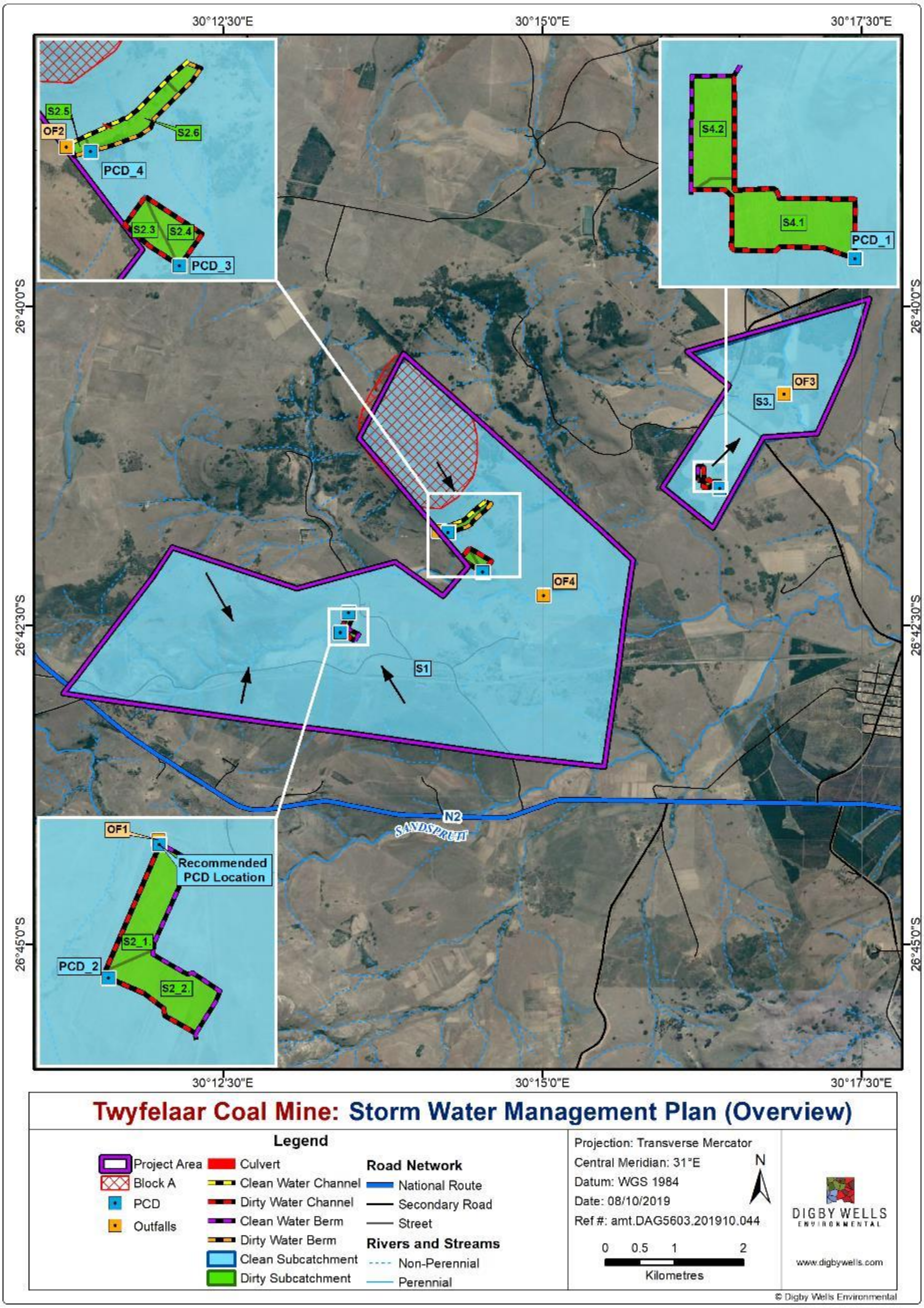


Figure 8-2: General Overview of the Proposed Stormwater management measures at the Twyfelaar Coal Mine

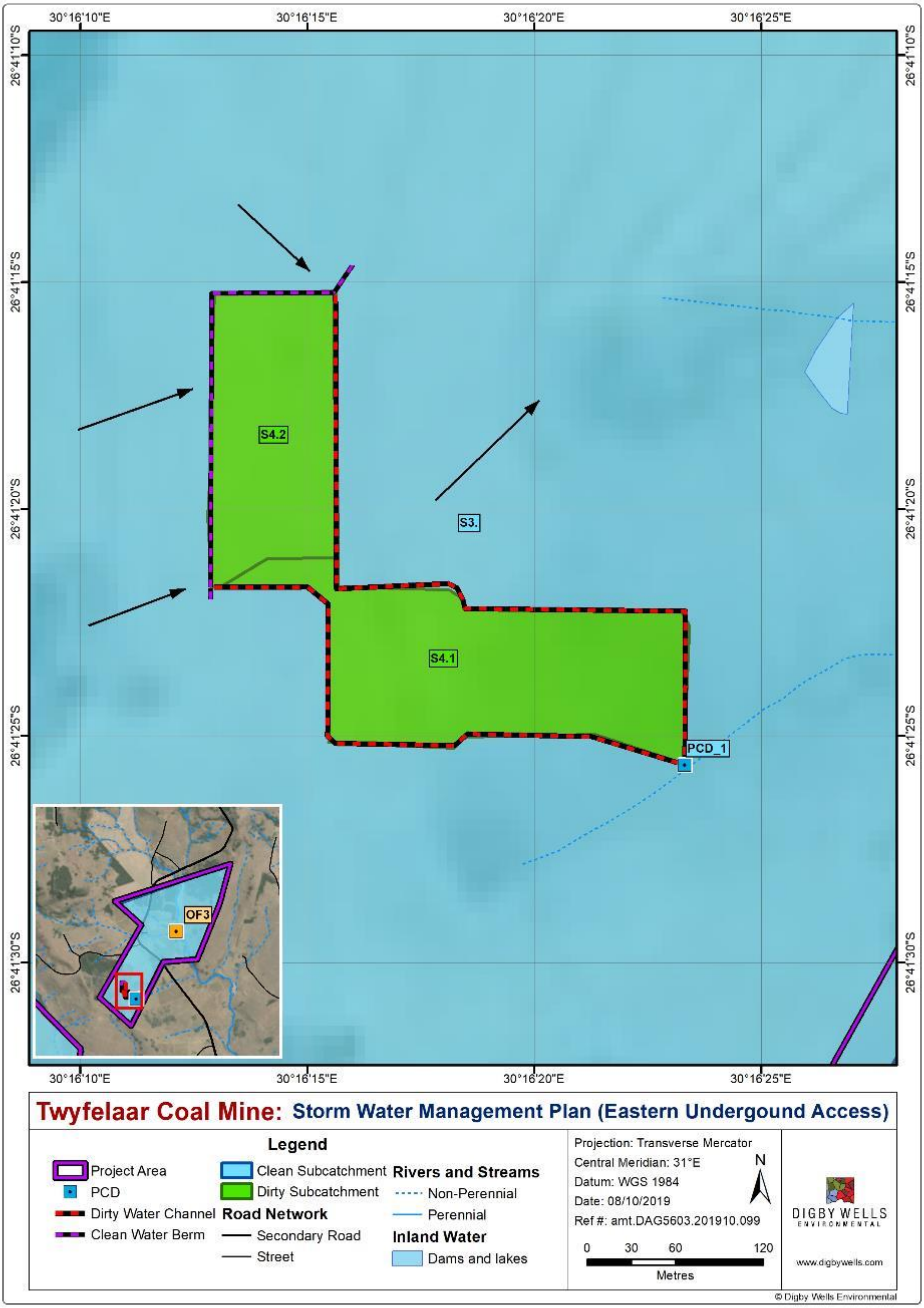


Figure 8-3: Stormwater management measures at the Eastern Underground Access

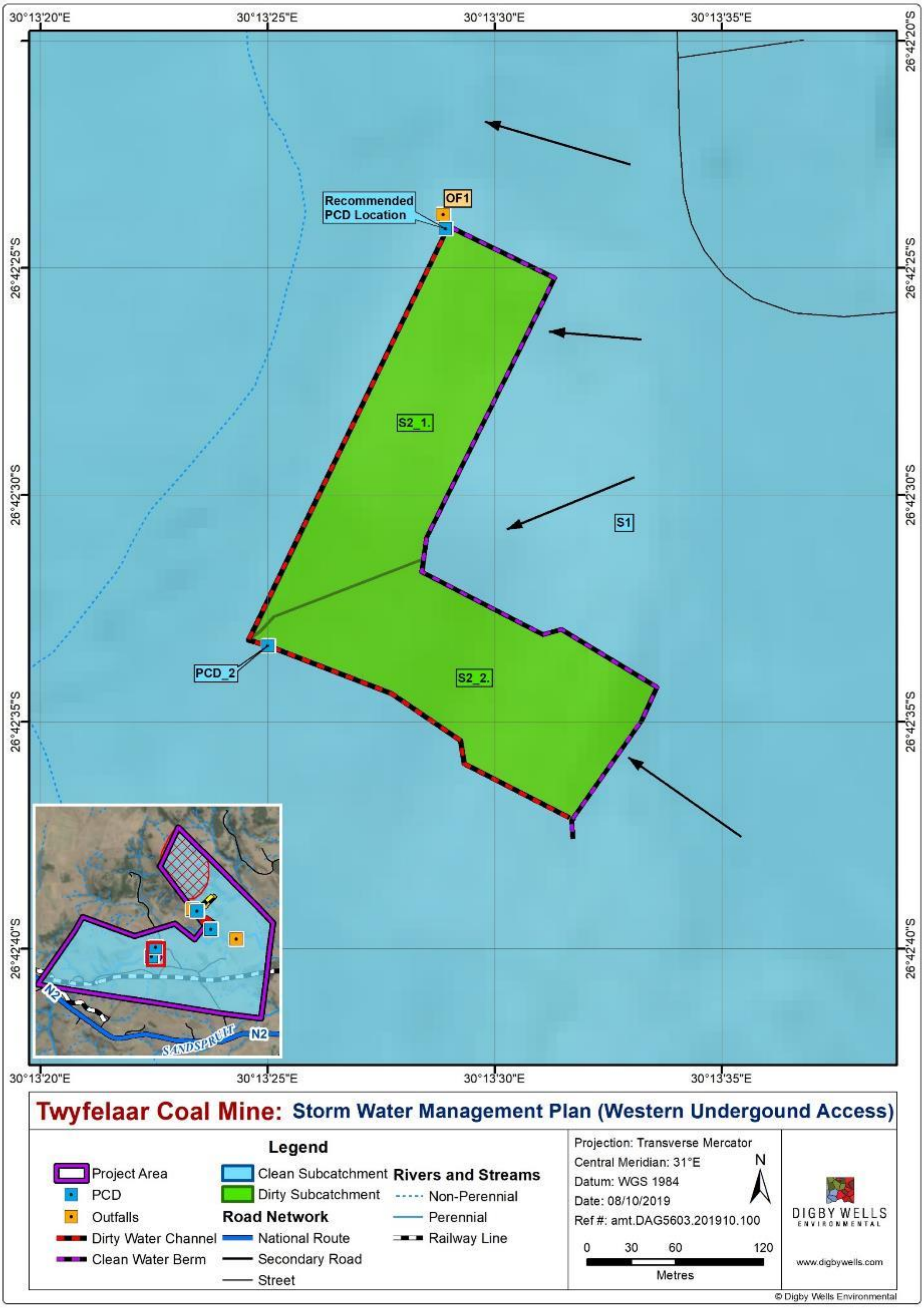


Figure 8-4: Stormwater management measures at the Western Underground Access

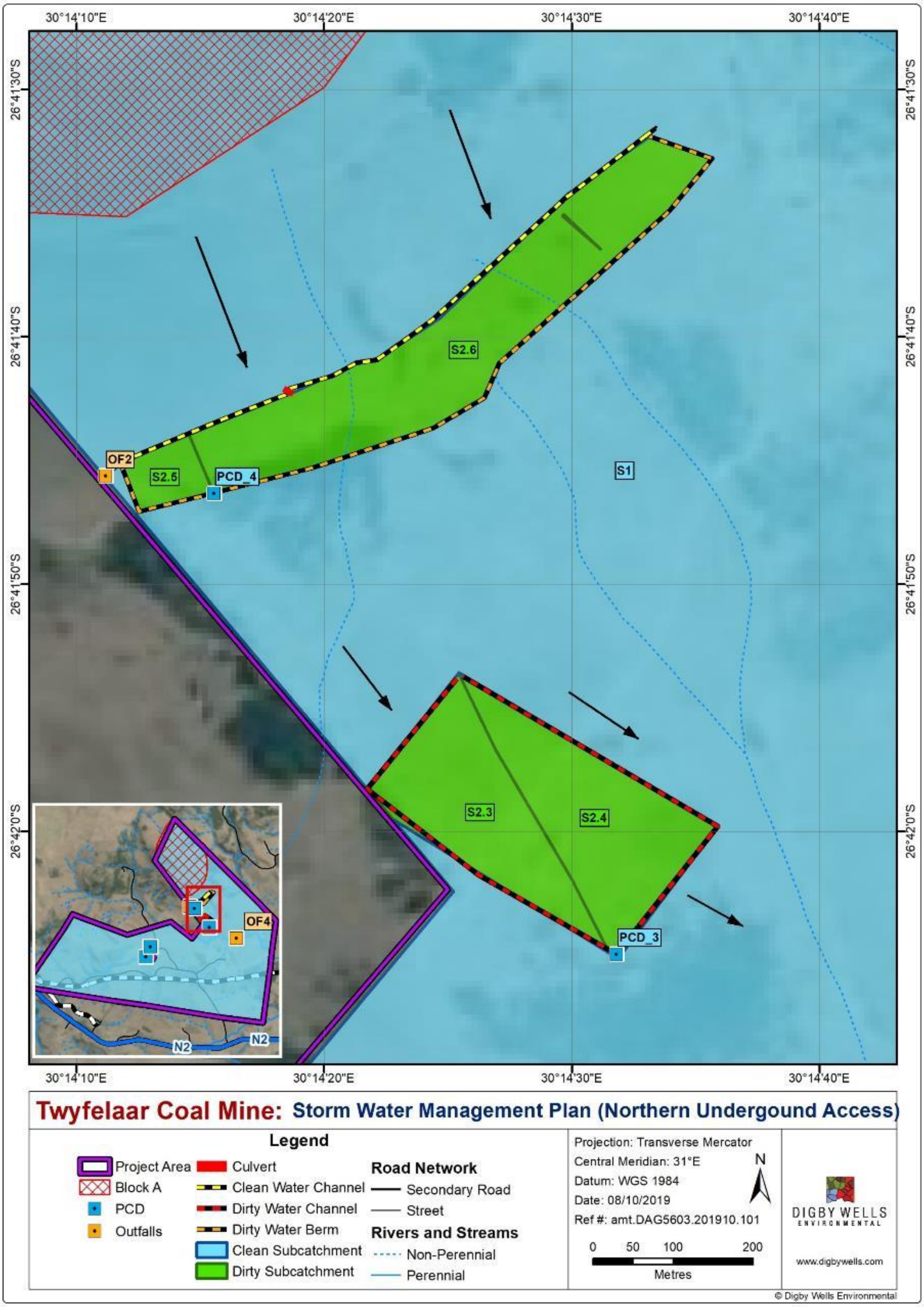


Figure 8-5: Stormwater management measures at the Northern Underground Access

9 Water Balance

Sustainable water resource management forms part of the mine's integrated water management principles and involves the development of an integrated water accounting approach that accurately reflects the reality of water use on the mine. Water accounting uses a site wide water balance approach to quantify the amount of water entering a system (external sources, precipitation, groundwater inflows etc.) and the amount leaving a system (evaporation, portable consumption, loss on product, seepage, dust suppression etc.

As indicated, the water balance was based on the water Process Flow Diagram (PFD) shown in the processing report compiled by Scorpion Mineral Processing (SMP) South Africa LTD for Twyfelaar Greenfields Coal Mine in September 2014.

There are three processing options in consideration for the proposed Twyfelaar Coal Mine which include the Sell ROM (base case), DMS Upgrade3 (Option 2) and XRT Sorting Upgrade (Option 3). It must be noted that the base case and Option 3 water balances have similar water use requirements while the water balance for option 2 is different since Option 3 considers a dry processing circuit which has additional water requirements for the DMS plant. The additional water requirements for option 3 have been indicated (highlighted in green) on the water balance for areas where the required volume differs with the requirements for the other processing options

The different water use requirements for the processing plant based on the three processing options, consumption volumes and required dust suppression volumes were provided in the SMP processing report and only the rainfall, runoff and evaporation volumes were calculated or adjusted based on the updated WRC, 2015 climate data, a monthly rainfall time series record of 89 years from 1920 to 2009 was used (WRC, 2015). It is recommended that storm water runoff contained in the PCD must be re used in mine process to reduce the raw water intake, thereby preventing potential water resource pollution should water sitting at the PCD overflow onto the natural environment. Table 9-1 present the key assumption and data input used as part of the water balance model and the water process flow, together with the site wide water balance can be seen on Figure 9-1.

Table 9-1: Data input and key assumptions used for the site water balance

Description	Value	Unit	Source/comment
Runoff coefficient	0.6	%	Assumed
Dust suppression	75 000	litres/day	SMP Report
Groundwater Inflow range	50 - 80	m3/d	Digby Wells, 2019
Mean annual rainfall	817	mm/yr	WRC,2015
Mean annual evaporation	1 400	mm/yr	WRC,2015
Groundwater recharge	1870	litres/day	SMP Report (0.34 l/d/ha)
PCD West	480	m2	Dagsoom Site Layout Plan
PCD East	480	m2	Dagsoom Site Layout Plan
PCD North	3000	m2	Dagsoom Site Layout Plan
Loss of water on STP	20	%	Assumed

Process Water Tank/Dam	192	m2	Assumed (40% of PCD west size)
Process Water Tank/Dam	192	m2	Assumed (40% of PCD west size)

The water management boundaries are defined according to the mine processes and these are subdivided into water demand, water sources and water storage.

9.1.1 Water Sources

There are three proposed main water sources which include:

- Rainfall and runoff;
- Groundwater; and
- Raw water from a dam/river (Potable water supply)

9.1.2 Water Storage/ Containment Facilities

The water storage infrastructure will include:

- Three pollution control dams;
- Process water dam; and
- Water tanks.

9.1.3 Water Demand/ Usage

Water uses will include:

- Potable water at the mine offices and workshops (Drinking, washing and ablution);
- Process water for coal washing.
- Dust suppression at the mine.

The water balance estimates total new water inflows to the mine system of approximately 21242 m^3/month on average, while an additional volumes of 6355 m^3/month will be required for processing option 2 which involves a density medium separation plant and required additional use of water.

About half of the inflow volume (21242 m^3/month) goes out of the mine system with the other half (approximately 10931 m^3/annum) remains in circulation within the mine system (Figure 9-1). The amount of water in circulation include a water recovered or recycled from the sewage treatment plant and water that is recovered from the mine processes thereby saving on new water intakes to the mine.

The total volume of potable water obtained from the nearby river is indicated to be 858 m^3/month for the base case and 908 m^3/month for option 2. This water will be sent to a water treatment plant where the output volume will be shared the Offices, Change houses and Workshops areas.

From the adopted process flow, storm water collected at the three PCD's is only kept within the PCD's for evaporation purposes. And PCD at the Northen Adit will also receive an overflow volume from the process water dam. It is recommended to recycle the storm water runoff the PCD's for use in mine Processes including dust suppression, mining process and washing of coal.

Also, once the final processing option and the layout designs have been decided upon, the water balance will

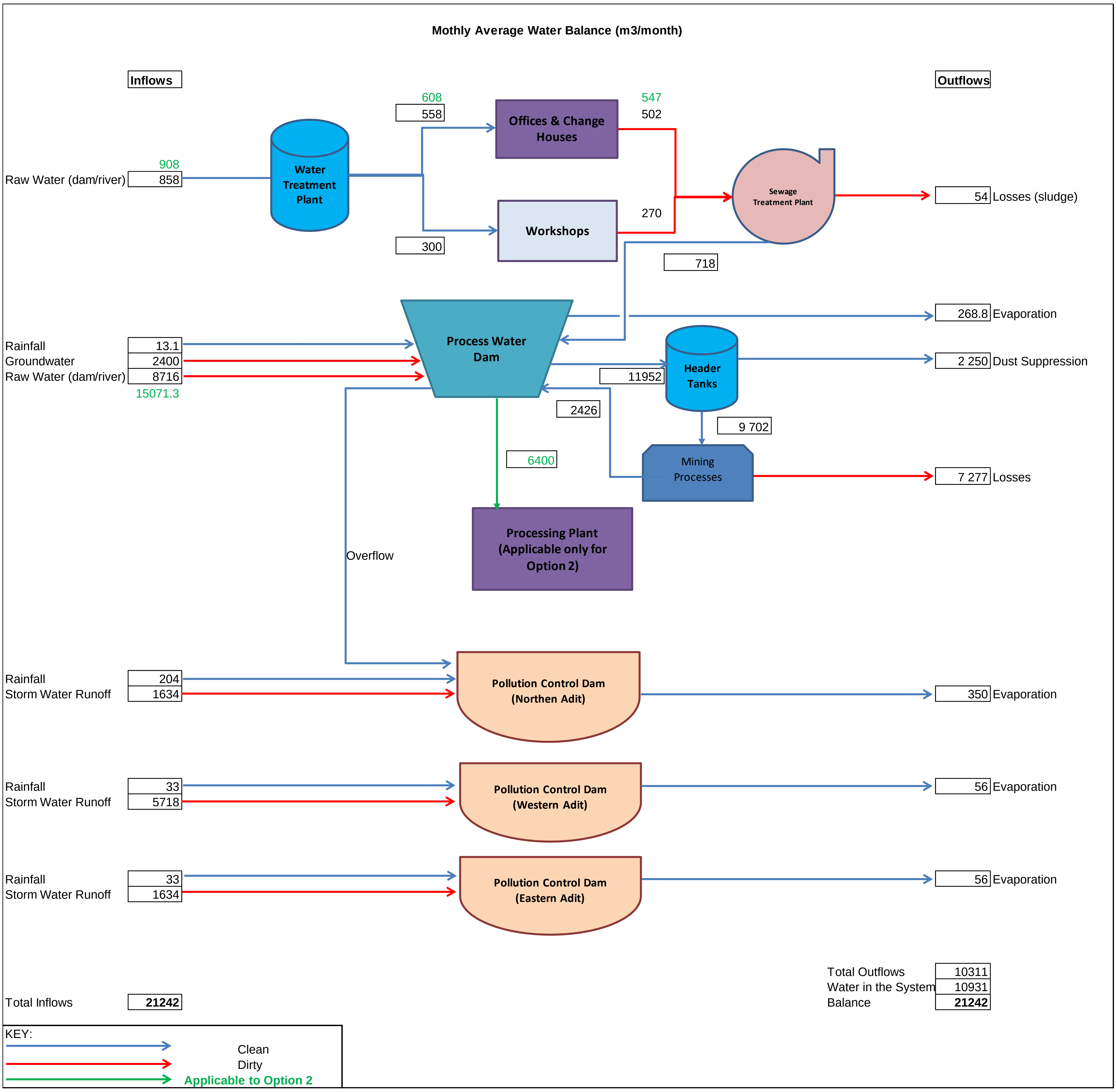


Figure 9-1: Water Process Flow and the Site Wide Water Balance for the Proposed Twyfelaar Coal Mine

10 Surface Water Impact Assessment

Surface water impacts were assessed for the three phases of the project life which are construction, operation and decommissioning phases.

10.1 Construction Phase

Activities during the construction phase that may have potential impacts (Table 10-1) on the surface water resources are described and the appropriate management/mitigation measures are provided below.

Table 10-1: Interactions and Impacts of Activity

Interaction	Impact
Site preparation including vegetation clearance and excavations, leading to exposure of soils	Siltation/Sedimentation of surface water resources leading to deteriorated water quality
Construction and installation of infrastructural facilities including administration offices, ablutions, storerooms, workshops, pollution control dams, processing plant, roads, pipelines etc.	Increase of paved surfaces and subsequent increase in runoff and potential flooding
Handling of hydrocarbons and other chemicals; Loading, hauling and transportation of product coal.	Surface water contamination leading to deterioration of water quality

10.1.1.1 Impact Description: Sedimentation and siltation of nearby watercourses

Clearing or removal of vegetation leaves the soils prone to erosion during rainfall events, and as a result runoff from these areas will be high in suspended solids increasing turbidity in the natural water resources.

Also, dust generated during the construction activities and caused by increased vehicle movements can also be deposited into the local water courses, thereby contributing to the accumulation of suspended solids in the water course, leading to the siltation of these water bodies.

10.1.1.2 Impact Description: Increase of impermeable surfaces and subsequent increase in runoff and potential flooding

Construction of infrastructure such as administration offices, ablutions, storerooms, workshops, processing plant and roads will increase the total area of paved surfaces. The process of installing pipelines and other infrastructures will likely cause soil compaction along these servitudes due to movement of vehicles and machinery. Increased impermeable areas or compacted soils will reduce infiltration, subsequently increasing runoff which may lead to potential flooding in nearby watercourses.

10.1.1.3 Impact Description: Surface water contamination leading to deterioration of water quality

Handling of general and hazardous waste including spillages of hydrocarbons such as oils, fuels and grease potentially contaminate nearby water resources when washed off into rivers, streams and pans.

10.1.1.4 Management/Mitigation Measures

- Clearing of vegetation must be limited to the development footprint, and the use of any existing access roads must be prioritised so as to minimise creation of new ones;
- If possible, construction activities must be prioritised to the dry months of the year to limit mobilisation of sediments, dust generation and hazardous substances from construction vehicles used during site clearing;
- Dust suppression with water on the haul roads and cleared areas must be undertaken to limit dust;
- Avoid placement of any infrastructure within the 100-year floodlines or 100 m buffer from watercourses, whichever is greater;
- Hydrocarbon and hazardous waste storage facilities must be appropriately bunded to ensure that leakages can be contained. Spill kits should be in place and construction workers should be trained in the use of spill kits, to contain and immediately clean up any potential leakages or spills;
- Vehicles should regularly be maintained as per the developed maintenance program. This should also be inspected daily before use to ensure there are no leakages underneath
- Drip trays must be used to capture any oil leakages. Servicing of vehicles and machinery should be undertaken at designated hard park areas. Any used oil should be disposed of by accredited contractors;

Table 10-2: Impact Significance Rating for Construction Phase

Dimension	Rating	Motivation	Significance
Impact: Sedimentation and siltation of nearby watercourses			
Duration	5	The impact will likely occur during the construction and decommissioning phases	78- Moderate (negative)
Intensity	4	Serious to medium term environmental effects	
Spatial scale	4	Impact has the potential to affect a wider area beyond the mining right area	
Probability	6	Almost certain that the impact will occur.	
Post-mitigation			

Dimension	Rating	Motivation	Significance
Duration	2	The impact will only likely occur in the short term given implementation of recommended mitigation measures	18- Negligible (negative)
Intensity	2	Minor effects on biological or physical environment are expected if silt traps and soil stabilisation procedures are followed	
Spatial scale	2	With proper management, the impact will be localized to the immediate downstream of the site	
Probability	3	There is a possibility that the impact will occur	

Dimension	Rating	Motivation	Significance
Impact: Increase of impermeable surfaces, subsequently increasing runoff and potential flooding			
Duration	5	This is a long term impact which will occur for the life of the project	60- Minor (negative)
Intensity	4	Increased runoff velocities on impermeable areas will cause sedimentation and possible siltation of nearby watercourses	
Spatial scale	3	The impacts will be localised to the immediate surroundings of the mine site.	
Probability	5	The impact will likely occur	
Post-mitigation			
Duration	5	Impact will occur for the duration of the project	27-Negligible (negative)
Intensity	2	Implementation of recommended storm water management measures will cause the impact to be low on the receiving environment	
Spatial scale	2	With proper management, the impact will be localised to operational areas within the mine’s footprint.	
Probability	3	There is a possibility that the impact will occur	

Dimension	Rating	Motivation	Significance
Impact: Surface water contamination leading to deterioration of water quality			
Duration	5	The impact will likely occur for the life of the project	60- Minor (negative)
Intensity	4	This will moderately impact the water quality and the ecosystem functionality for downstream users.	
Spatial scale	3	The impacts will be localised extending across the site and to nearby downstream.	
Probability	5	The impact will likely occur	
Post-mitigation			
Duration	5	The impact will likely occur for the life of the project	18-Negligible (negative)
Intensity	2	With proper management of hydrocarbon and chemicals on site the impact will have low intensity	
Spatial scale	2	With proper management, the impact will be localised to sites where incidents occur	
Probability	2	The possibility of the impact occurring is very low as a result of implementation of adequate mitigation measures	

10.2 Operational Phase

Activities during the operational phase that may have potential impacts on surface water resources are summarised in Table 10-3 and further described together with recommended management/mitigation measures in the following subsections. A number of wetlands have been identified around the Project Area and these wetlands contribute into recharging the nearby by streams (Digby Wells Wetland Report, 2019. Based on the groundwater assessment, wetlands on the hillslopes seem to originate from a perched aquifer in the dolerite sill cap, therefore dewatering the underground workings may not have an impact on these wetlands, hence no impact is anticipated on the surface water streams due to dewatering of the underground workings (Digby Wells Groundwater Report, 2019).

Table 10-3: Interactions and Impact Activity

Interaction	Impact

Runoff from the dirty water areas or catchments (coal stockpile areas, mine processing plant, workshops etc.)	Surface water contamination and deterioration of water quality
Hydrocarbons and chemicals spillages and leakages from equipment, moving haulage trucks and machinery.	Surface water contamination by hydrocarbon waste and deterioration of water quality
Containment of dirty runoff in the PCDs	Reduction of catchment runoff yield

10.2.1.1 Impact Description: Surface water contamination by runoff from dirty water areas

Water contamination may occur as a result of runoff from contaminated surfaces within the mine into nearby watercourses. The dirty water areas include coal stockpile areas, processing plant areas, workshop areas etc. The runoff generated from these areas will likely be contaminated and thus will have a detrimental effect on the water quality of nearby streams thereby affecting aquatic ecosystems and downstream water users.

10.2.1.2 Impact Description: Surface water Contamination from hydrocarbon and chemical spillages and leakages

The operational machinery, transportation and storage at the mine site are potential sources of hydrocarbon and chemical spills and leakages. When not properly managed, hydrocarbon and chemical spills and leakages will contaminate surface water resources within and in proximity to the project area.

10.2.1.1 Impact Description: Containment of runoff and interception of rainfall in the PCDs

Containing runoff and intercepting rainfall in open storage facilities will capture runoff that was supposed to report to the nearby streams. This will lead to reduced runoff yield within the catchment and subsequently reduce streamflow downstream.

10.2.1.2 Management/Mitigation Measures

The following mitigation measures are recommended:

- Runoff from dirty areas should be directed to the storm water management infrastructure (drains and PCDs) and should not be allowed to flow into the stream, unless DWS discharge authorisation and compliance with relevant discharge standards as stipulated in the NWA is obtained;
- The PCDs and dirty water channels should be lined either by concrete or High Density Polyethylene (HDPE) in order to prevent contamination of groundwater through seepage;

- Water quality monitoring program should be as provided in this report should be adhered with to monitor water resources within and in proximity to the Project Area to allow for detect any contamination arising from operational activities;
- The management of general and other forms of waste must ensure collection and disposal into clearly marked skip bins that can be collected by approved contractors for disposal to appropriate disposal sites;
- The hydrocarbon and chemical storage areas and facilities must be located on hard-standing area (paved or concrete surface that is impermeable), roofed and bunded in accordance with SANS1200 specifications. This will prevent mobilisation of leaked hazardous substances;
- Training of mine personnel and contractors in proper hydrocarbon and chemical waste handling procedures is recommended;
- Vehicles must only be serviced within designated service bays;
- Wash bay and workshop runoff should flow through an oil separator as indicated on the infrastructure plan prior to discharge into the PCD.

Table 10-4: Impact Significance Rating for Operational Phase

Dimension	Rating	Motivation	Significance
Impact: Surface water contamination by runoff from dirty water areas			
Duration	6	The impact will remain for some time after the life of the mining project.	105-Moderate (negative)
Intensity	5	Very serious, long-term environmental impairment of ecosystem function that may take several years to rehabilitate	
Spatial scale	4	The impacts will likely extend to watercourses in the whole municipal area affecting downstream water users	
Probability	7	The impact will definitely occur if no measures are put in place	
Post-mitigation			
Duration	5	The impact is expected to occur for the whole life of the coal mining project	18-Negligible (negative)
Intensity	2	Proper and continued implementation of storm water management plan and water quality monitoring will lower the intensity of the contaminated runoff impact on proximal water resources.	

Dimension	Rating	Motivation	Significance
Spatial scale	2	Limited spatial extent if mitigation measures are adequately implemented.	
Probability	2	The possibility of the impact occurring is very low if mitigation measures are adequately implemented.	

Dimension	Rating	Motivation	Significance
Impact: Surface water Contamination from hydrocarbon and chemical spillages and leakages			
Duration	5	The impact will likely occur for the whole life of the project	72- Minor (negative)
Intensity	4	Moderate impacts to water quality and ecosystem functionality are expected	
Spatial scale	3	The impact may extend across the site and to nearby settlements if contaminants are washed into proximal watercourses	
Probability	6	It is most likely that the impact will occur	
Post-mitigation			
Duration	5	The impact will likely occur for the life of the project	18-Negligible (negative)
Intensity	2	With proper management of hydrocarbon and chemicals on site the impact intensity will be low	
Spatial scale	2	With proper management, the impact will be localised to incident sites, where contaminants will quickly be cleaned up.	
Probability	2	The possibility of the impact occurring is very low if mitigation measures re adequately implemented	

Dimension	Rating	Motivation	Significance
Impact: Reduction of catchment runoff yield			

Dimension	Rating	Motivation	Significance
Duration	5	The impact will occur for the duration of the project	91 - Moderate (negative)
Intensity	4	Impact will be felt across the site to downstream reaches	
Spatial scale	4	Moderate to medium intensity since the proposed project area is significantly smaller compared to the entire contributing catchment into the Sandspruit (<5% of total catchment)	
Probability	7	The impact will definitely occur if no measures are put in place	

Management Measures

Although there are no mitigation measures to prevent this kind of impact. The following management measures can be applied to ensure that the impact is limited to the site and its immediate surrounding:

- Infrastructure development must be limited to the demarcated footprint to minimize the dirty runoff generating catchments within the project area.
- As per the recommended storm water management plan, clean water runoff from the upstream catchment of the mine should be diverted around the site into the natural environment, this will minimize the runoff that will potentially be contaminated by mine waste
- All the runoff captured on the storm water dam and RWD should be re-used in the mine processes to avoid sourcing raw water from external sources.
- Should the contaminated water stored water be more than the storage capacities and discharge is considered, this water should be treated to acceptable water quality prior to discharge into the natural environment. In this case, acceptable water quality should at least be benchmarked with the baseline surface water quality of the surrounding streams

10.3 Decommissioning Phase

Activities during the decommissioning and closure phase that pose potential impacts on surface water resources are summarised in and further described together with recommended management/mitigation measures in the following subsections. Please note that groundwater model was conducted to determine potential for decant post closure of the mine, and it was determined that it is very unlikely that decant will occur from the proposed underground mine (Digby Wells Groundwater Report, 2019). Therefore, contamination of surface water resources as a result of decant was not identified as a potential impact on this hydrological report.

Table 10-5: Interactions and Impact Activity

Interaction	Impact
Demolition of mine infrastructure (PCDs, workshops, haul roads, processing plant etc.) Disturbance of soils and erosion by overland flow	Sedimentation and siltation of nearby watercourses and deterioration of water quality
Rehabilitation of disturbed sites close to pre-mining conditions	Restoration of pre-mining streamflow regime in nearby watercourses

10.3.1.1 Impact Description: Sedimentation and siltation of nearby watercourses and deterioration of water quality

During the decommissioning phase demolition of infrastructure, will cause disturbance and subsequent erosion of soils into nearby watercourses. This will result in higher rates of sedimentation and siltation in nearby streams thereby reducing their flow/storage capacities and their ability to sustain aquatic ecosystems. The quantity and quality of water for downstream water users will thus be compromised.

10.3.1.2 Impact Description: Restoration of pre-mining streamflow regime in nearby watercourses

In accordance with the Government Notice 704 (GN 704) of the NWA, the mine is required to separate clean and dirty water to prevent contamination of the clean water resources. Dirty water is required to be contained on site for re-use in mine processes or allowed to evaporate. In pre-mining period, this is the runoff which could have been reporting to natural streams, so containment of dirty water runoff in the mine reduces the amount of runoff reporting to downstream segments of the Project Area. A decrease in the catchment yield may have an impact on downstream water users as they may not have sufficient water for their needs, while also decreasing the required natural ecological flows.

A positive impact thus occurs as water freely flows to downstream water users due to restoration of higher streamflow regime close to pre-mining conditions.

10.3.1.3 Management/Mitigation Measures

The following mitigation measures are recommended:

- Disturbance of soils during infrastructure demolition should be restricted to relevant footprint areas;
- Movement of demolition machinery and vehicles should be restricted to designated access roads to minimise the extent of soil disturbance;

Table 10-6: Impact Significance Rating for Decommissioning Phase and Closure Phase

Dimension	Rating	Motivation	Significance
Impact: Sedimentation and siltation of nearby watercourses and deterioration of water quality			
Duration	2	The impact will short term during the decommissioning phase.	63-Minor (negative)
Intensity	4	Serious to medium term environmental effects	
Spatial scale	3	The impacts might extend across the site and to nearby settlements	
Probability	7	Without appropriate mitigation, it is probable that this impact will occur	
Post-mitigation			
Duration	2	The impact will likely only occur during the decommissioning phase	12-Negligible (negative)
Intensity	2	due to implementation of mitigation measures	
Spatial scale	2	The impacts will be localised to sites where demolition will be undertaken and contained by silt traps on site	
Probability	2	The possibility of the impact occurring is very low due to implementation of adequate mitigation measures.	

Dimension	Rating	Motivation	Significance
Impact: Restoration of pre-mining streamflow regime in nearby watercourses			
Duration	7	The impact will remain long after the life of the Project.	112-Major (positive)
Intensity	4	The impact leads to significant increase in the quality of the receiving environment.	
Spatial scale	5	The impact may extend across the project area and to nearby settlements	
Probability	7	It is definite that this positive impact will occur (there is no mitigation for this impact)	

10.3.2 Cumulative Impacts

The predominant water use around the project area is farming and irrigational use. Mining and associated activities requires a significant amount water, and this may pose a threat to water availability for the available water resources in the area.

The proposed mine infrastructure have the potential to reduce catchment yields if not properly managed. Coal mining and processing, through use of water for dust suppression and in processing plants, are relatively water intensive activities. Although mines recycle water extensively, a significant amount of additional (make-up) water is required for such activities. Furthermore, contaminated (acidic/high sulphate) decant water from the mined areas often finds its way to surface streams, reducing the quality of water in these streams. Against this background the cumulative effect may be significant.

11 Surface Water Monitoring Programme

A monitoring programme is essential as a management tool to detect negative impacts as they arise and allow the necessary mitigation measures to be implemented. Monitoring also ensures that storm water management structures are in good working order which reduces potential for surface water pollution resulting from mining activities.

The proposed monitoring plan should be initiated prior to construction in order to determine a sufficient water quality baseline which covers the dry and wet season periods prior to commencement of mining. This should continue throughout the construction phase, operation and decommissioning phases of the project. Post closure monitoring must be undertaken for at least three (3) years after the project has ceased, or until rehabilitation has reached a sustainable state with no further changes to the environment, as recommended by the Department of Water and Sanitation (DWS). Monitoring points are indicated in Figure 6-1 while monitoring frequencies are described in this monitoring plan.

All water quality results should be benchmarked with the South African Water Quality guidelines: (for domestic use, aquatic ecosystems, livestock watering and irrigation) and any other prescribed standards i.e Water Use License, to determine the impacts of the proposed mining activities on the natural surface water resources (positive/negative). The surface water monitoring plan is summarised in Table 11-1.

Table 11-1: Surface Water Monitoring Plan

Monitoring Element	Comment	Frequency	Responsibility
Water quality	Ensure water quality monitoring as per sampled and proposed monitoring locations (See Table 6-1). Parameters should include but not limited to pH; Electrical Conductivity; Sulphate; major cations (K, Ca, Mg & Na); trace metals (Al, Fe, Zn, Cu, Mn, Co, Se, Mo, Cd, Ni, Cr (VI), Pb, Hg & As); Anions (NO_3, NO_2, NH_4, Cl, F, PO_4); Total Dissolved Solids; Total Suspended solids. It is also recommended to monitor water quality within the mine water dams or water containment facilities to determine the concentration levels in case of an overflow or need for discharge.	Monthly monitoring during construction, operation, decommissioning and for at least three (3) years after closure, or until rehabilitation has reached a sustainable state with no further changes.	Environmental Officer
Sedimentation	Inspect construction sites, sites where infrastructure is demolished and rehabilitated sites for traces of erosion to ensure no entrance of sediment occurs into nearby watercourses, especially after rainfall events. Temporary silt fences, soil stabilization blankets should be installed and maintained until vegetation is established.	After rainfall event, until the establishment of vegetation on all rehabilitated sites	Environmental Officer
Water quantity and water balance	Monitoring or measuring of all the water inflows into the mine, reticulation within the mine and the outflows from the mine. This can be achieved by installing automatic flow meters to ensure real time measurements of water.	In operational areas where automatic flow meters are in place, daily records need to be kept	Environmental Officer

Monitoring Element	Comment	Frequency	Responsibility
Physical structures and Storm Water Management Plan (SWMP) performance	Personnel should have a walk around facilities to determine the facilities conditions and pick out any anomalies such as leaks or overflows and system malfunctions.	Continuous process and yearly formal report	Environmental Officer
	Storm water channels, and existing mine dams are inspected for silting and blockages of inflows, pipelines for hydraulic integrity; monitor the overall SWMP performance.		

12 Conclusions and Recommendations

The study area is located within the W53A quaternary catchment of the Inkomati-Usuthu Water Management Area (WMA 3). The Project Area is characterised by a temperate climate with dry winters and warm summers, while it generally receives moderate to high rainfall during the rainy season. The MAP and MAE of this region is 825 mm and 1400 mm respectively. The MAR depth for the area was calculated to be 91.25 mm. This runoff accounts for approximately 11% of the MAP for the area.

Water quality samples were collected on the streams within and around the Project Area determine the baseline water quality conditions prior to commencement of mining activities and enable monitoring of any potential water quality impact that could emanate from the mine. It is therefore recommended that water quality monitoring should continue as advised in this report, for all baseline parameters, at the sampled & proposed monitoring points, and in all mine water storage facilities (surface dams) at the mine site.

Generally, the water quality as compared to the DWS irrigational and domestic standards did not show any significant contamination. All major cations and Anions were within the set standards, except for Iron which exceeded the domestic use standards at monitoring point SW3, SW4 and SW5 while Lead so exceeded the domestic use standard at SW1 monitoring point. All other trace analysed elements were within the set DWS water quality standards

To ensure separation of clean and dirty water (as stipulated in regulation 704 of on the National Water Act), a conceptual storm water management plan was developed for this project. Separation of clean and dirty water will be done through the recommended storm water management infrastructures which include storm water drains or channels, clean water diversion berms, silt traps and PCDs. A conservative approach was used to size all channels to accommodate 1:50 year storm event with a maximum flow rate of 2.771 m3/s and a maximum velocity of 5.58 m/s.

It is recommended that the proposed PCD location at the Western Underground Access area be relocated to the northern boundary of western block, this is mainly because the currently proposed location is at a higher elevation and would not allow gravitational flow of dirty water runoff into the PCD. Lastly, it is recommended that the dirty water channels be lined to prevent contamination of groundwater resources through seepage.

The 1:50 and 1:100 year floodlines were calculated for the streams within and around the mining right boundaries and It was found that the floodlines will not encroach on the proposed mine infrastructures.

An impact assessment was conducted, and a number of potential surface water/hydrological impacts that could emanate from the project and its associated activities were identified, these include:

- Siltation of surface water resources leading to a poor water quality as a result of eroded material reporting into the streams;
- Contamination of surface water resources when dirty water runoff from the mine reports into the nearby streams; and
- Reduction in runoff to the natural streams when all the dirty water runoff is contained within the proposed pollution control dams

This study also provided the appropriate mitigation/management measures to prevent, and/or minimise the identified potential surface water impacts. With all the mitigation and management measures in place, this project is unlikely to pose a significant threat to the natural water courses and the hydrological features within and around the project area

13 References

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Appendix A: Impact Assessment Methodology

13.1 Surface Water Impact Assessment

Potential and existing surface water impacts (quality and quantity) that may result from the proposed project activities, based on the established baseline conditions, were identified. The detailed impact assessment methodology is appended in Appendix A.

Impact Rating Methodology

The significance rating formula is as follows:

Significance = Consequence x Probability

Where

Consequence = Type of Impact x (Intensity + Spatial Scale + Duration)

And

Probability = Likelihood of an Impact Occurring

In addition, the formula for calculating consequence:

***Type of Impact** = **+1** (Positive Impact) or **-1** (Negative Impact)*

The weighting assigned to the various parameters for positive and negative impacts is provided for in the formula and is presented in Table 13-1The probability consequence matrix for impacts is displayed in Table 13-2, with the impact significance rating described in Table 13-3.

Table 13-1: Surface water Impact Assessment Parameter ratings

Rating	Intensity		Spatial scale	Duration	Probability
	Negative Impacts (Type of Impact = -1)	*Positive Impacts (Type of Impact = +1)*			
7	High significant impact on the environment. Irreparable damage to highly valued species, habitat or ecosystem. Persistent severe damage. Irreparable damage to highly valued items of great cultural significance or complete breakdown of social order.	Noticeable, on-going social and environmental benefits which have improved the livelihoods and living standards of the local community in general and the environmental features.	International The effect will occur across international borders.	Permanent: No Mitigation The impact will remain long after the life of the Project.	Certain/ Definite. There are sound scientific reasons to expect that the impact will definitely occur.
6	Significant impact on highly valued species, habitat or ecosystem. Irreparable damage to highly valued items of cultural significance or breakdown of social order.	Great improvement to livelihoods and living standards of a large percentage of population, as well as significant increase in the quality of the receiving environment.	National Will affect the entire country.	Beyond Project Life The impact will remain for some time after the life of a Project.	Almost certain/Highly probable It is most likely that the impact will occur.
5	Very serious, long-term environmental impairment of ecosystem function that may take several years to rehabilitate.	On-going and widespread positive benefits to local communities which improves livelihoods, as	Province/ Region Will affect the entire province or region.	Project Life The impact will cease after the operational	Likely The impact may occur.

Rating	Intensity		Spatial scale	Duration	Probability
	Negative Impacts (Type of Impact = -1)	***Positive Impacts (Type of Impact = +1)***			
	Very serious widespread social impacts. Irreparable damage to highly valued items.	well as a positive improvement to the receiving environment.		life span of the Project.	
4	Serious medium-term environmental effects. Environmental damage can be reversed in less than a year. On-going serious social issues. Significant damage to structures / items of cultural significance.	Average to intense social benefits to some people. Average to intense environmental enhancements.	<u>Municipal Area</u> Will affect the whole municipal area.	<u>Long term</u> 6-15 years.	<u>Probable</u> Has occurred here or elsewhere and could therefore occur.
3	Moderate, short-term effects but not affecting ecosystem functions. Rehabilitation requires intervention of external specialists and can be done in less than a month. On-going social issues. Damage to items of cultural significance.	Average, on-going positive benefits, not widespread but felt by some.	<u>Local</u> Extending across the site and to nearby settlements.	<u>Medium term</u> 1-5 years.	<u>Unlikely</u> Has not happened yet but could happen once in the lifetime of the Project, therefore there is a possibility that the impact will occur.
2	Minor effects on biological or physical environment. Environmental damage can be	Low positive impacts experience by very few of population.	<u>Limited</u> Limited to the site and its	<u>Short term</u> Less than 1 year.	<u>Rare/ improbable</u> Conceivable, but only in extreme circumstances and/ or has not

Rating	Intensity		Spatial scale	Duration	Probability
	Negative Impacts (Type of Impact = -1)	***Positive Impacts (Type of Impact = +1)***			
	rehabilitated internally with/ without help of external consultants. Minor medium-term social impacts on local population. Mostly repairable. Cultural functions and processes not affected.		immediate surroundings.		happened during lifetime of the Project but has happened elsewhere. The possibility of the impact materialising is very low as a result of design, historic experience or implementation of adequate mitigation measures.
1	Limited damage to minimal area of low significance that will have no impact on the environment. Minimal social impacts, low-level repairable damage to commonplace structures.	Some low-level social and environmental benefits felt by very few of the population.	Very limited Limited to specific isolated parts of the site.	Immediate Less than 1 month.	Highly unlikely/None Expected never to happen.

Table 13-2: Probability Consequence Matrix for Impacts

		Significance																																					
Probability	7	-147	-140	-133	-126	-119	-112	-105	-98	-91	-84	-77	-70	-63	-56	-49	-42	-35	-28	-21	21	28	35	42	49	56	63	70	77	84	91	98	105	112	119	126	133	140	147
	6	-126	-120	-114	-108	-102	-96	-90	-84	-78	-72	-66	-60	-54	-48	-42	-36	-30	-24	-18	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120	126
	5	-105	-100	-95	-90	-85	-80	-75	-70	-65	-60	-55	-50	-45	-40	-35	-30	-25	-20	-15	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105
	4	-84	-80	-76	-72	-68	-64	-60	-56	-52	-48	-44	-40	-36	-32	-28	-24	-20	-16	-12	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	84
	3	-63	-60	-57	-54	-51	-48	-45	-42	-39	-36	-33	-30	-27	-24	-21	-18	-15	-12	-9	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63
	2	-42	-40	-38	-36	-34	-32	-30	-28	-26	-24	-22	-20	-18	-16	-14	-12	-10	-8	-6	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42
	1	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
		-21	**-20**	**-19**	**-18**	**-17**	**-16**	**-15**	**-14**	**-13**	**-12**	**-11**	**-10**	**-9**	**-8**	**-7**	**-6**	**-5**	**-4**	**-3**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
		Consequence																																					

Table 13-3: Significance Threshold Limits

Score	Description	Rating
109 to 147	A very beneficial impact which may be sufficient by itself to justify implementation of the Project. The impact may result in permanent positive change.	**Major (positive)**
73 to 108	A beneficial impact which may help to justify the implementation of the Project. These impacts would be considered by society as constituting a major and usually a long-term positive change to the (natural and/or social) environment.	Moderate (positive)
36 to 72	An important positive impact. The impact is insufficient by itself to justify the implementation of the Project. These impacts will usually result in positive medium to long-term effect on the social and/or natural environment.	Minor (positive)
3 to 35	A small positive impact. The impact will result in medium to short term effects on the social and/or natural environment.	Negligible (positive)
-3 to -35	An acceptable negative impact for which mitigation is desirable but not essential. The impact by itself is insufficient even in combination with other low impacts to prevent the development being approved. These impacts will result in negative medium to short term effects on the social and/or natural environment.	Negligible (negative)
-36 to -72	An important negative impact which requires mitigation. The impact is insufficient by itself to prevent the implementation of the Project but which in conjunction with other impacts may prevent its implementation. These impacts will usually result in negative medium to long-term effect on the social and/or natural environment.	Minor (negative)
-73 to -108	A serious negative impact which may prevent the implementation of the Project. These impacts would be considered by society as constituting a major and usually a long-term change to the (natural and/or social) environment and result in severe effects.	Moderate (negative)
-109 to -147	A very serious negative impact which may be sufficient by itself to prevent implementation of the Project. The impact may result in permanent change. Very often these impacts are immitigable and usually result in very severe effects.	Major (negative)