HUMBA ENVIRONMENTAL CONSULTANCY

HYDROLOGICAL IMPACT ASSESSMENT FOR THE PROPOSED EXPANSION OF THE DCM WEST DISCARD DUMP FACILITY AND CONSTRUCTION OF A CONVEYOR BELT FROM DCM WEST TO DCM EAST WITHIN THE JURISDICTION OF EMALAHLENI LOCAL MUNICIPALITY, MPUMALANGA PROVINCE

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DISCLAIMER AND APPROACH

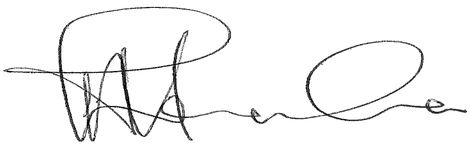
This report provides a description and assessment of identified local hydrological regimes and the larger study area. It also provides a concise description of the proposed development and identifies potential project-related impacts and mitigation measures.

This study does not provide detailed descriptions of the geology, soils, climate of the area, hydrology of the aquatic environments, assessments of surface water quality (sampling), detailed descriptions of aquatic and terrestrial flora and fauna, or provide a detailed review of the legal constraints associated with potential project related impacts on the environment. It has been assumed for the purposes of this report that these aspects will be the subject of separate specialist studies during the EIA/WUL application process.

DECLARATION

I, Tinashe Ronnie Maramba, declare that I –

- act as an independent specialist consultant in the fields of botanical and ecological science;
- 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 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 have or may have the potential to influence the decision of the competent authority or the objectivity of any report; and
- will provide the competent authority with access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not.



Tinashe Ronnie Maramba (*BESc Hydrology and Water Resources*)

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1. Introduction

Dorstfontein West mine is an underground mine with both 2- and 4-seams operated by Exxaro Coal Central (Pty) Ltd.

The Dorstfontein West mine is situated 5km south north of Kriel, along the R547 road, in Mpumalanga province, South Africa. The site is within the jurisdiction of Nkangala District Municipality and is located at the following co-ordinates; 26°13'24.84"S, 29°17'40.36"E.

Exxaro Dorstfontein West proposes to undertake the following activities:

- Pillar extraction mining which will be undertaken on the 4-seam for purposes of extending the operational life of the mine and creating an opportunity to derive value from resources that would have been sterilised;
  - Pillar extraction or retreat mining is a term used to reference the final phase of an underground mining technique known as room and pillar mining. This involves excavating a room or chamber while leaving behind pillars of material for support. This excavation is carried out in a pattern advancing away from the entrance of a mine. Once a deposit has been exhausted using this method, the pillars that were left behind initially are removed, or 'pulled', retreating back towards the mine's entrance. After the pillars are removed, the roof (or back) is allowed to collapse behind the mining area (Figure 1). Pillar removal must occur in a very precise order in order to reduce the risks to workers, due to the high stresses placed on the remaining pillars by the abutment stresses of the caving ground.

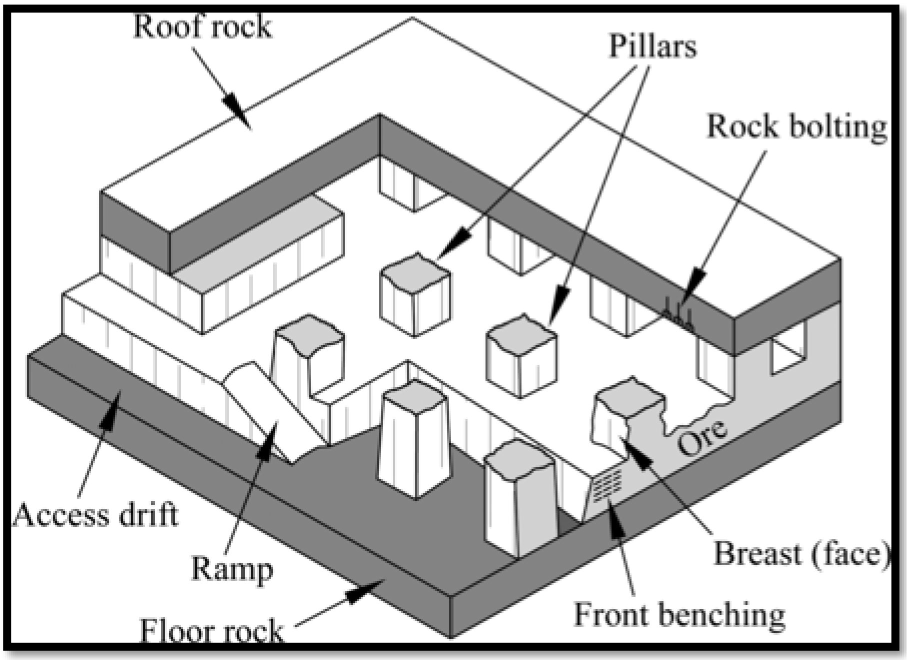

Figure 1: Diagrammatic representation of Pillar mining method

  - An investigation by EXXARO was conducted into the feasibility of implementing secondary extraction mining methodology within the S4L reserve area. The investigation found that secondary extraction is feasible except in areas with the following characteristics:

- Mining depth to roof less than 30m.
- Surface features such as graves and water features (rivers, pans and dams)

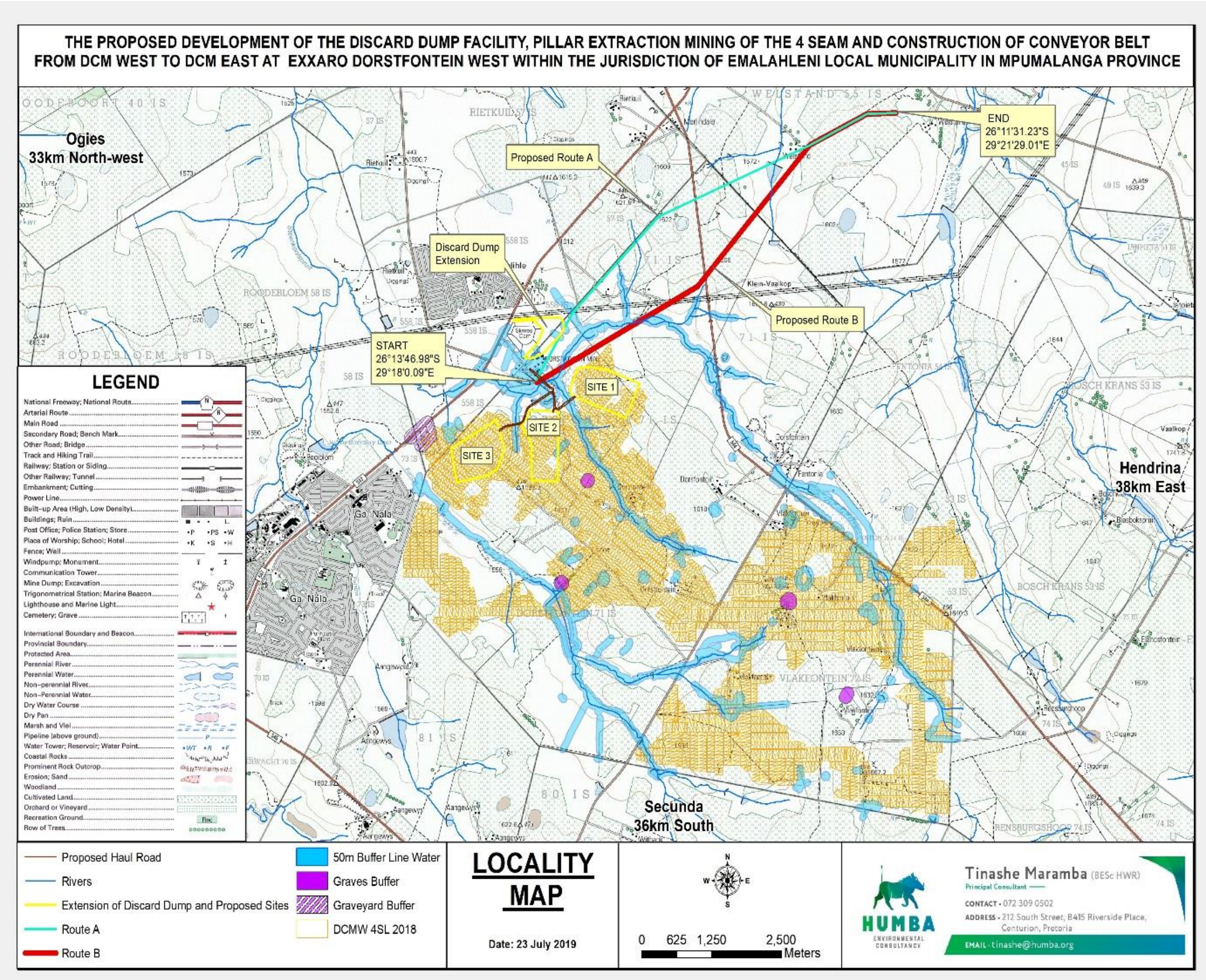

Figure 2: Map showing the DCMW Seam 4 Lower (S4L) Reserve and associated buffer zones

- ❖ The extension of the discard dump/development of a new discard dump which has become necessary due to the life of the current discard dump coming to the end in 2022. The discard dump extension will cater for both Slurry and discard coal and is expected to cater for the life of mine. 8m wide haul roads are proposed to be developed in association with the discard dump facility; and
- ❖ The construction of a conveyor belt which will cross over the R544 and run from Dorstfontein Coal Mine (DCM) West and link with the conveyor systems at Dorstfontein Coal Mine (DCM) East to ensure coal is seamlessly conveyed from DCM West to DCM East where the coal will be loaded into trains and thereafter transported to Richards Bay Terminal. Associated infrastructure will include a 7.3m high bridge and a 3 m X 7.5 km (7 500m) service road which will run along the conveyor belt.
  - ➢ Ground works and concrete plinths for the conveyor support (outside wetlands area):

  - Excavation need to be done every 4m for the conveyor support structure on all areas outside the indicated wetlands areas as indicated on the conveyor route drawing with the following specifications:
  - 2m long x 400mm wide x 400mm deep
  - G5 material to be inserted into the hole and compacted
  - 1.2m x 300mm x 250mm concrete plinths to be installed on the levelled G5 base
  - Steel conveyor gantry structure to be installed on the concrete plinths
- Ground works and piles for the conveyor support (inside wetlands area):
  - Pile holes to be done drilled every 6m for the conveyor support structure in the wetlands areas as indicated on the conveyor route drawing with the following specifications:
  - 2 x Diameter 300mm holes to be drilled 3m to 4m deep in the existing soil every 6m inside the wetlands area
  - 2 x Diameter 300mm concrete piles to the installed in the holes and levelled to 300mm protrusion above ground level
  - Steel conveyor gantry structure to be installed on the concrete piles
- Ground works and concrete plinths for the conveyor transfer steel structures (outside wetlands area):
  - Excavation need to be done for 2 x conveyor transfer steel support structure on the areas outside the indicated wetlands as indicated on the conveyor route drawing with the following specifications:
  - Excavation holes for the support foundation as per the drawings to be dig to 1m deep.
  - G5 material to be inserted into the holes and compacted
  - Concrete plinths to be installed on the levelled G5 base
  - Steel conveyor transfer structure to be installed on the concrete plinths

Accordingly, Humba Environmental Consultancy has been appointed by Nsovo Environmental Consulting to conduct a Hydrological Impact Assessment on the possible effects the proposed activities will have on the hydrological regime of the study area.

It must be noted that the proposed underground pillar extraction process will impact on surface hydrology. In light of this, the proposed mining method, extension of the discard dump and the construction of the conveyor belt will be assessed for possible negative impacts on the hydrological regime of the study area.

Figure 3 below shows the locality map of the area in relation to the proposed discard dump site alternatives; namely Site 1, 2 and 3 and the conveyor belt route options; namely Route A and B.

The potential impacts of these alternatives will be assessed in Section 7 of this report and a preferred alternative will be presented in Section 10 for selection in light of having the least negative impacts on the hydrological regime of the study area.

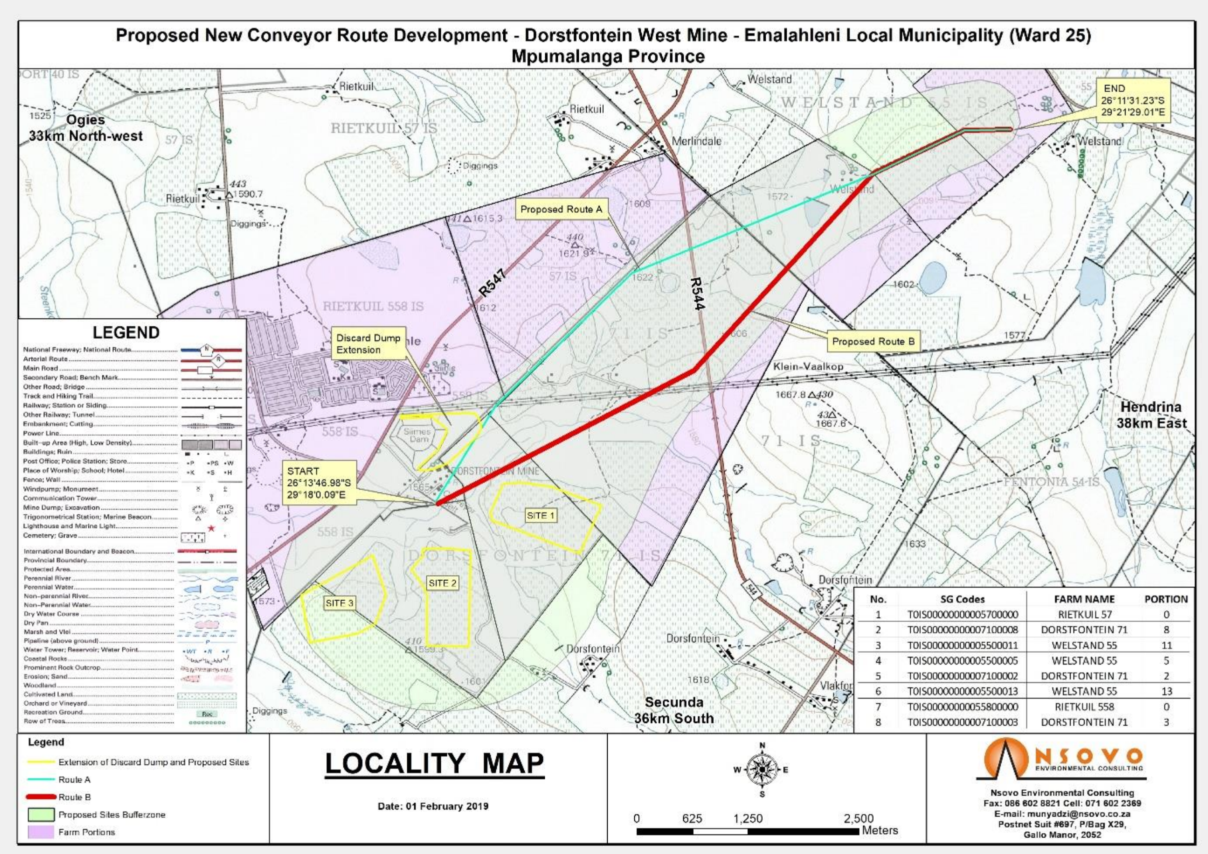

Figure 3: Map showing location of mine and alternatives to be assessed

2. Objectives & Scope of work

The main focus of this assessment was to assess possible impacts on the surface water environment and the following was required from this assessment:

2.1. Objectives

- Update the existing hydrological baseline description for the mine;
- Determine and assess the potential surface water impacts associated with the proposed mining method, extension of the existing/development of a new discard dump facility, proposed conveyor belt and associated service road and the proposed haul roads;
- Advise on mitigation measures for identified risks/impacts and enhance positive opportunities/impacts of the project; and
- Provide input to the WULA and NEMA documentation.

2.2. Scope of work

The Scope of Work (SoW) for the Hydrology Assessment is summarised as follows:

Phase 1:

- Information sourcing / literature review
- Collection and revision of relevant information

Phase 2:

- Undertake site Visit
  - Site assessment (better understanding of site)
- Update catchment hydrology with newly available data
  - Catchment characteristics and delineation
  - Meteorological analysis
  - Average runoff analyses
  - Peak flow analyses for 1:50 and 1:100 floods
  - Assessing hydrology of the mine itself;

3. Approach & Methodology

The following methodologies were used for the hydrological assessment of the catchment that the mine is situated in. A holistic approach was followed, and an attempt was made to link the local hydrological and environmental studies to regional and national concerns, regulations and management strategies.

3.1. Literature Review

Previous reports, which were made available, were reviewed and relevant information utilised. Rainfall data that is being collected in situ at the mine was also reviewed.

3.2. Site Visit

A site visit was conducted on the 31st of January 2019 in order to obtain information on normal flow rates, river health and potential factors that could influence hydrological modelling of flows. Also, a better understanding of the physical environment around which the proposed developments were proposed to occur was sought in order to be able to come up with cogent and feasible preferred options. Figure 4 and Figure 5 below show some of the activities currently happening on site.

From the site visit, it was deduced that there were a number of drainage lines in and around the DCM West mining precinct and a non-perennial stream to the south of the mine that flows in a westerly direction away from the mine to the Steenkoolspruit perennial river

Figure 4: Photo of Discard dump that is meant to be expanded

Figure 5: Photo showing terrain across which the proposed conveyor is to traverse (taken from the top of the Discard Dump)

3.3. Assessment of hydrological impacts

The hydrological impacts of the proposed activities were assessed and quantified for all phases of the project, thus from construction to operation. The following aspects were addressed:

- The proposed project footprint was assessed and its impact on hydrology determined;
- Flood peaks and runoff volumes were calculated for the 50- and 100-year recurrence interval storm events;

- The project impact on Mean Annual Runoff (MAR) was determined;
- Surface water quality issues were identified and qualified; and
- Flood lines were determined for the 100-year recurrence interval storm event synthesis was done for the 100 year return period. The Rational, Alternative Rational, and the Standard Design Flood and HEC-RAS methods, were used to calculate the 1:100 year return period storm event flow.

3.4. Hydrological Impact Report

Compile a hydrological impact report containing inter alia:

- Identification and mapping of sensitive areas, affected receptors and areas of influence;
- Direct, indirect, irreversible and cumulative impact of anticipated activities on surface water resources;
- Compliance with legal and policy framework;
- Recommendation of mitigating and monitoring measures; and
- Evaluation and assessment of residual (post mitigation) impacts.

3.5. Monitoring Programme

Develop guidelines towards an operational management programme for activities in and around surface water features.

4. Applicable Policies, Legislation, Standards & Guidelines

Water management at mines is controlled by the National Water Act (NWA), (Act 36 of 1998), which is the primary statute providing the legal basis for water management in South Africa and has to ensure ecological integrity, economic growth and social equity when managing and using water. Use of water for mining and related activities is also regulated through regulations that were updated after the promulgation of the NWA.

4.1. Government Notice 704

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

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

- Condition 5 which indicates that no residue or substance which causes or is likely to cause pollution of a water resource may be used in the construction of any dams, impoundments or embankments or any other infrastructure which may cause pollution of a water resource;
- Condition 6 which describes the capacity requirements of clean and dirty water systems. Clean and dirty water systems must be kept separate and must be designed, constructed, maintained and operated to ensure conveyance 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; and
- 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.

4.2. Other overarching Legislation/policies

- Constitution of South Africa
- National Environmental Management Act (Act 107 of 1998)
- Mining and Petroleum Resources Development Act, (Act 28 of 2002)
- Department of Water and Sanitation Best Practice Guidelines

5. Hydrological Determinations

5.1. Catchment characteristics

Exxaro's Dorstfontein operations are situated in the Upper Olifants Primary Catchment. The DCM West is located in quaternary catchment B11D and the DCM East is located in quaternary catchment B11B. ***Table 1*** below shows the characteristics of each quaternary catchment.

Table 1: Quaternary catchment characteristics

Quaternary Catchment	Area (km^2)	MAP (mm)	MAR (mm)	MAE	Main River
B11B	435	687	36	1550	Koringspruit
B11D	551	671	30	1600	Steenkoolspruit

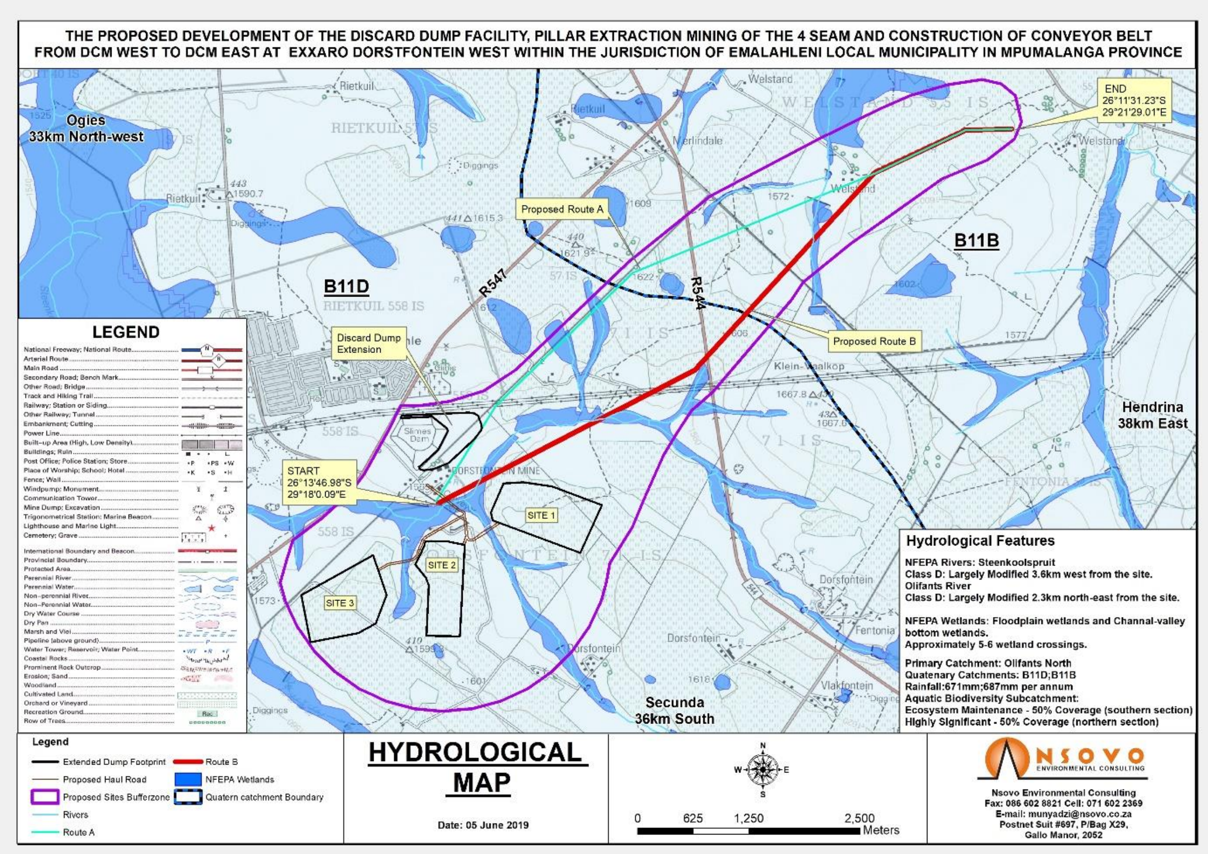

Figure 6: Hydrology of the study area in relation to the quaternary catchments B11B & B11D

Figure 6 above shows a single drainage line crossing that was identified in Quaternary catchment B11B. The probable risks associated with the proposed conveyor belt is that it spans across the drainage line, as such the impacts are deemed to be low. Quaternary catchment B11D is then made the focus of this study due to the high risks associated with the following:

1. the vicinity of the drainage lines to the proposed discard dump sites; and
2. the high negative impacts associated with the conveyor belt running along drainage lines.

The baseline surface water assessment identified 8 sub-catchments totalling 37 km^2. ***Table 2*** compares the baseline catchment nomenclature adopted for this report. As the other baseline sub-catchments are unaffected by proposed mining infrastructure, they were not assessed for this impact assessment. ***Figure 7*** below shows a diagrammatic representation of the sub-catchments that were assessed. The catchment area was determined from the surveyor general 1:50,000 map contours and ortho photos.

Table 2: Baseline Sub-Catchment Nomenclature

Sub-Catchment	Catchment area (km^2)	Quaternary catchment
Catchment 1	19.484528	B11D
Catchment 2	7.03346	B11D
Catchment 3	2.696483	B11D
Catchment 4	2.371512	B11D
Catchment 5	0.892523	B11D
Catchment 6	1.558621	B11D

Catchment 7	1.422585	B11D
Catchment 8	2.053274	B11D
Total	37.512986	

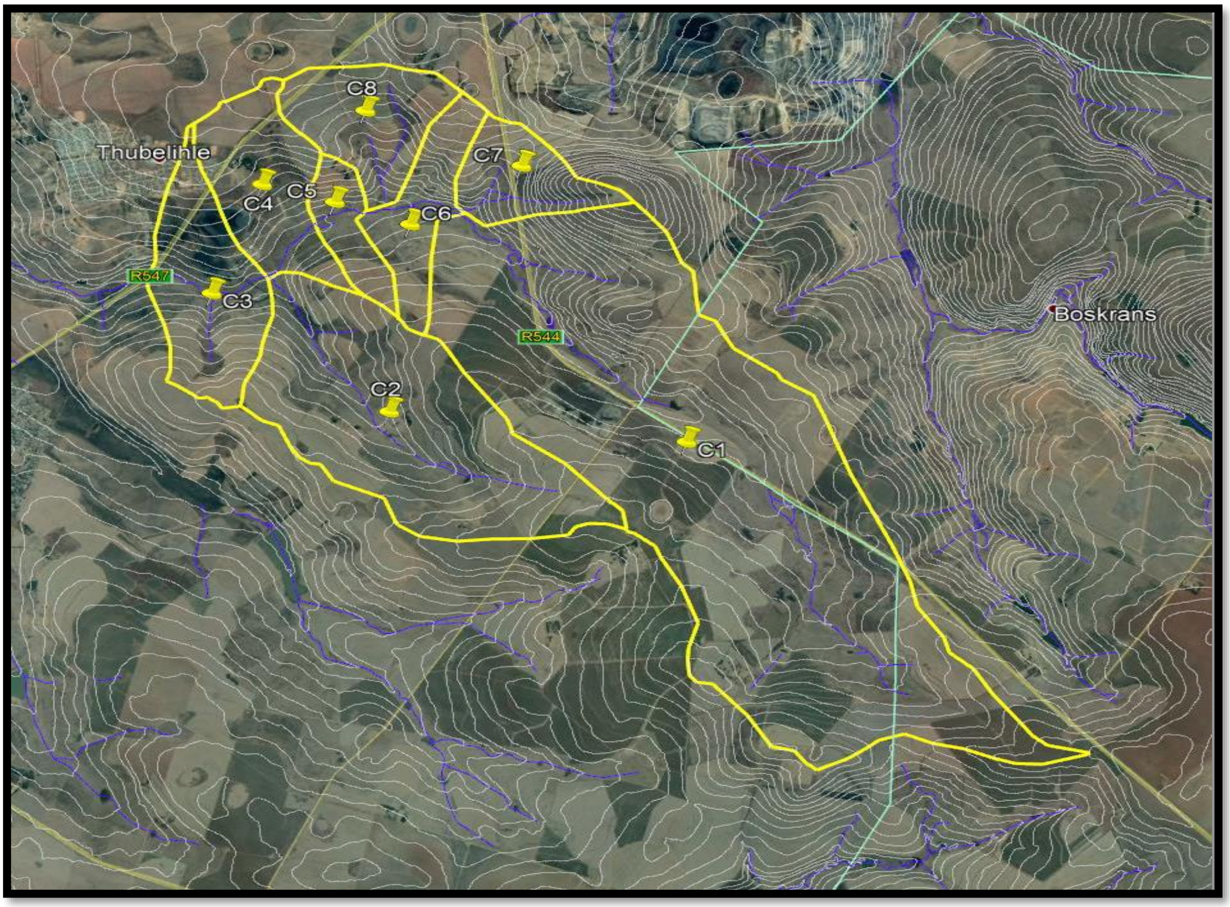

Figure 7: Baseline Sub-catchments assessed for this study

For the baseline assessment, no ineffective areas were identified. Runoff was therefore deemed to be generated by the entire catchment and calculated accordingly.

5.2. Subsidence

Subsidence engineering can be defined as the prediction of mining-induced surface movements and the assessment of how these movements affect the surface and surface features/structures (Wagner, 1991). Subsidence and hydrology impacts occur at every underground mining operation bringing about changes to surface landforms, ground water and surface water. Although the same impacts to mining operations, man-made surface structures and other features are relatively well known and studied, the environmental impacts related to subsidence and hydrology at underground mines are not well known and have not been extensively described

The act of pillar extraction mining may result in some sort of surface subsidence. Whether the subsidence is visible or not is dependent on the following factors:

- Depth of mining;

- Percentage extraction; and
- The time at which the subsidence occurs (Dorstfontein West Colliery: Pillar Extraction Feasibility Investigation, 2019)

According to the Dorstfontein West Colliery: Pillar Extraction Feasibility Investigation, 2019, the magnitude of subsidence in a stable pillar system is negligible. The magnitude of maximum subsidence in a bord and pillar layout is dependent on the unlikely event that panel's pillar system fails. Subsidence is however guaranteed in the case of pillar extraction. Cognisance must be given to the fact that although highly unlikely, pillar failure might occur resulting in the subsidence.

Van der Merwe and Madden (2010) further classifies the expected subsidence profile into the following classes based on the panel width and magnitude of subsidence:

Table 3: Classification of subsidence profiles (Van der Merwe et al, 2010)

Class	Sm/H	Description
A	<0.001	Barely noticeable, smooth, continuous profile, hairline cracks
B	0.001 - 0.005	Difficult to notice, smooth profile, cracks 1 to 2 cm wide
C	0.005 - 0.02	Noticeable in flat terrain, smooth, cracks 2 to 10 cm wide, compression ridges 1 to 5 cm high
D	0.02 - 0.05	Noticeable in most terrains, visible vertical displacements across cracks, cracks 10 to 50 cm wide, compression ridges 5 to 50 cm high
E	>0.05	Severe profile, almost vertical sides, cracks wider than 50 cm, compression ridges higher than 50 cm

In relation to Table 3 above, the investigation by EXXARO's Rock Engineers showed that a class **C, D** and **E** subsidence profile will occur when pillar extraction is undertaken.

The investigation found that pillar extraction will be not be undertaken in areas with surface water features (dams, streams, wetlands and pans) and graves (refer to Figure 2). These areas will not be undermined with either bord and pillar mining or pillar extraction. These have been termed "constrained or restricted areas". Secondary pillar extraction is feasible for panels outside of the constrained or restricted and a buffer of at least 50m will be left against constrained or restricted zones. Pillar extraction will also be limited to a cover depth of a least 30m below ground level.

Several case histories are presented to illustrate the mechanisms and impacts of hard-rock mining subsidence and hydrologic impacts. In some cases, subsidence and hydrologic impacts will affect the surface environment more than 100 years after mining occurred (Blodgett, *et al*, 2002). These cases illustrate the wide variability of conditions at hard-rock mines and emphasize the basic fact that opening a void underground to conduct mining operations inevitably results in some impacts to surface and hydrologic features.

5.2.1. Measurement and prediction

Subsidence measurements are based upon a survey of the vertical and horizontal displacements that take place on the ground (Blodgett, *et al*, 2002). A variety of specific methods may be used depending on the objectives, site, spacing and number, duration and cost. Automatic data acquisition systems have been utilized and are gaining acceptance (SME, 1986). The actual range of subsidence varies between a few feet to as much as several hundred feet vertically, and horizontal displacement may occur as well. It is important in monitoring subsidence that full coordinates (x, y, z) are measured in order to track the progress of ground movements.

Methods based on modelling principles have been made possible by advances in technology, and recent computerized models that take into account overburden, rock mass, and simulated mine geometry include Finite Element, Boundary Element and Distinct Element methods. However, simple analytical models cannot simulate the complex forces that strata undergo in the process of subsidence.

The impacts on hydrology of subsidence are discussed further in Section 7.3 below.

5.3. Topography, Soils & Vegetation

In terms of topography, the elevation at the point of tipping the coal at DCM East is 1588 masl. The proposed point of extraction, i.e. DCM West is 1561 masl.

The soil type in the area is Bb4 and Bb5. These soils are Plinthic catena with dystrophic and/or mesotrophic, red soils not widespread, upland duplex and margalitic rare soils. The depths of these soils are between 450 mm and 700 mm. The soils in the area are mainly of high suitability for arable agriculture where the climate permits. Figure 8 below shows evidence of in situ soil erosion which is commonly influenced by a combination of physical soil properties (erodability), lack of vegetation cover, local topography (slope gradient) and surface water runoff. Shallow, light textured soil of low clay content, as well as soils located on higher landscape positions more prone to erosion risk. Vegetation cover is directly influenced by anthropogenic land use activities, whereas and surface water runoff is primarily influenced by rainfall intensity and vegetation cover.

The proposed project falls within the Grassland Biome, Mesic Highveld Grassland Bioregion and Eastern Highveld Grassland vegetation type (Mucina & Rutherford, 2011). Following the assessment of the linear development and the associated habitat, it has been concluded that there are 3 main habitat units that will impacted upon, i.e., transformed agricultural and mining habitat (either side of the R544, Figure 9), Wetland Habitat (either side of the R544) and Grassland Habitat Unit (south of the R544, Figure 8)

Figure 8: Evidence of in-situ soil erosion along the non-perennial stream at DCM West mine

Figure 9: Transformed agricultural land with DCM East operations in the backdrop

5.4. Catchment Slope

The slope of a catchment is a very important characteristic in the determination of flood peaks. Steep slopes cause water to run faster and to shorten the critical duration of flood inducing storms, thus leading to the use of higher rainfall intensities in the runoff formulae. On steep slopes the vegetation is generally less dense, soil layers are shallower, and there are fewer depressions, all of which cause water to run off more rapidly. The result is that infiltration is reduced and flood peaks are consequently even higher.

The average catchment slopes for the sub-catchments under consideration is presented in Table 4 below. Average watercourse slopes (S_{av}) were determined using the 10/85 method developed by the US Geological Survey. This method has been found to yield accurate results for relatively small catchments such as these.

Table 4: Baseline Catchment slope determinations

Catchment Site	Catchment area (km^2)	Longest water course, L (km)	Height difference along 10-85 slope (m)	Average slope S_{av} (m/m)	Time of concentration, Tc (hours)	% Slope	MAP (mm)	Run-off factor C
Catchment 1	19.484528	10.343	70.039	0.0090288	2.455129242	0.90%	680	0.311
Catchment 2	7.03346	5.193	68.199	0.0175105	1.119224295	1.75%	680	0.311
Catchment 3	2.696483	2.295	49.289	0.0286356	0.493865573	2.86%	680	0.311
Catchment 4	2.371512	2.996	58.606	0.0260819	0.628581488	2.61%	680	0.311
Catchment 5	0.892523	1.735	32.931	0.0253072	0.417567321	2.53%	680	0.311
Catchment 6	1.558621	1.838	33.238	0.0241117	0.444736864	2.41%	680	0.311
Catchment 7	1.422585	1.389	35.437	0.0340168	0.313973987	3.40%	680	0.311
Catchment 8	2.053274	1.986	49.023	0.0329124	0.418770008	3.29%	680	0.324

5.5. Collector Length

The longest watercourse (L) is defined as the route that will be followed by a water particle taking the longest time to reach the catchment outlet from a point on the catchment boundary. This distance consists of both the natural channel and overland flow and, along with the slope of the watercourse, determines the time of concentration for the catchment. The lengths of the main surface water collectors are given in Table 4 above.

The centre of gravity of each sub-catchment area was calculated. This information was used to determine the centre of gravity catchment length (L), which is the distance from the catchment outlet to the point on the longest collector opposite the centre of gravity of the catchment area. This was used to calculate the catchment lag time (T_c) for the catchment as presented in Table 4.

5.6. Climate

The Dorstfontein Mine is located in the Highveld climatic region of South Africa, which is a summer rainfall area. Temperature classifications for the region are hot in summer and mild to warm in winter, with significant diurnal fluctuations. Climate Data was obtained from the South African Weather Service (SAWS) and databases of WR2005.

The local climate can be described as semi-arid high-veld conditions, with warm summers and moderate dry winters. Average daily summer temperatures of approximately 27°C are experienced, while peak temperatures of up to 36°C do occur. Average daily winter temperatures are approximately 4°C, with minimum temperatures reaching around -4°C. The number of days when heavy frost occurs is however, limited and freezing of wet soils, frost heave and permafrost do not occur (SAWS, 2017)

Relative humidity ranges from a minimum of 34% to a maximum of 94%, with dry atmospheric conditions dominating. The average annual rainfall of 700 mm is considerably less than the average annual A-pan evaporation of 1 600 mm. This results in the project area experiencing a negative water balance in relation to rainfall and evaporation. Evaporation, off open surfaces of water (lake evaporation), though less than A-pan values, will be significant (calculated at 1500 mm per annum) and plant-life in natural local grasslands will be dormant for long periods during the year

Rainfall data was collected from Exxaro and the rain data is shown in Table 5 below.

Table 5: Rainfall data from DCM East & West for 2018 (values are in mm*)

Month	Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18	Annual Total	Annual Average
DCM East	70	121	144	24	25	0	0	0	26	64	75	166	715	59.5833333
DCM West	129	108	25	44	0	0	0	0	16	57	164	137	680	56.6666667

5.7. Floodline Determinations

5.7.1. Methodology

The first part of modelling was done for a series of storms with a return period of 100 years and different durations falling over the catchment.

Storms with durations of 1, 1.5, 2, 4, 6, 8, 10, 12, 16, 20 and 24hour were synthesised using procedures to estimate design rainfall in South Africa developed by J.C. Smithers and R.E. Schulze, working under the Water

Research Commission through a project entitled “Rainfall Statistics for Design Flood Estimation in South Africa” (WRC Project KS/1060).

The synthesis was done for the 100 -year return period. The Rational, Alternative Rational, and the Standard Design Flood methods, were used to calculate the 1:100 -year return period storm event flow.

Secondly, the flood line was determined through utilising the river analysis program HEC-RAS. The methods described in the 6th edition of the SANRAL Drainage Manual (2013) were used to determine the flood peaks.

Mean Annual Precipitation (MAP) values for the Flood line study were obtained Weather Bureau stations in the immediate area listed below. The gridded MAP for the catchment is estimated to be 680mm.

The selection of the peak flow was based on the size of the catchment. The Rational method confidence level is for a catchment area that is smaller than 15km2. The Alternative Rational confidence level is for a catchment just above 15 km2. The Standard method caters for any catchment size.

Figure 10 below shows the proposed discard dump sites in relation to the 1:100 year floodline. All the discard dumps were found to be outside the modelled 1:100 year floodline.

Table 6: Rainfall data (South African Weather Bureau Stations*)

Station number	Description	MAP (mm)
0478406_W	KRIEL (POL)	626
0478546_W	VANDYKSDRIFT	679
0478853_W	MIDDELKRAAL	694
0478862_W	VLAKLAAGTE	701
0478292_W	LANGSLOOT	698
0478386_W	TWEEDRAAI	667

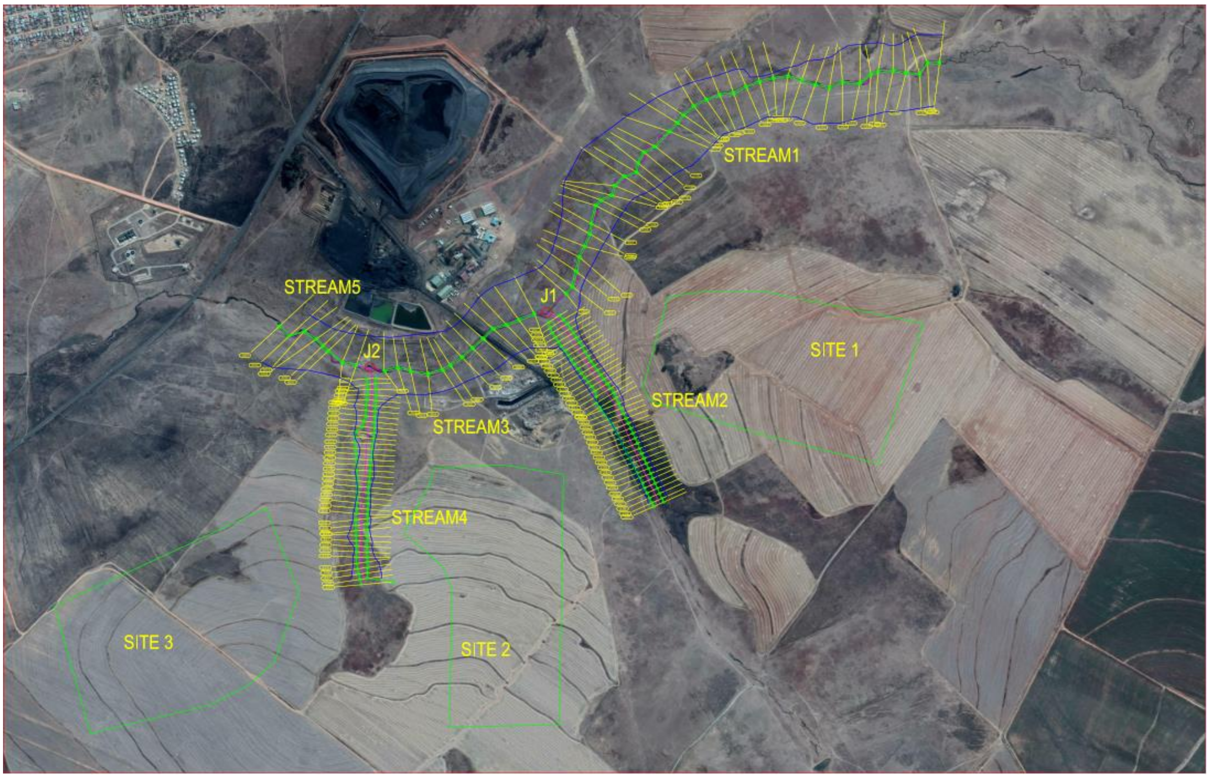

Figure 10: Imagery of proposed discard dump sites in relation to the 1:100 year floodline

Table 7: Peak flows (m3/s)

		1:20yr			1:50yr			1:100yr					
		Rational	Alternative Rational	Standard Design Flood	Rational	Alternative Rational	Standard Design Flood	Rational	Alternative Rational	Standard Design Flood	Selected peak flow (m^3/s)		
Catchment	**Area (km^2)**	**Q_{20} Peak flow (m^3/s)**	**Q_{20} Peak flow (m^3/s)**	**Q_{20} Peak flow (m^3/s)**	**Q_{50} Peak flow (m^3/s)**	**Q_{50} Peak flow (m^3/s)**	**Q_{50} Peak flow (m^3/s)**	**Q_{100} Peak flow (m^3/s)**	**Q_{100} Peak flow (m^3/s)**	**Q_{100} Peak flow (m^3/s)**	**Q_{20}**	**Q_{50}**	**Q_{100}**
Catchment 1	19.485	51.09	58.67	64.98	69.53	77.53	96.36	89.34	94.04	122.85	58.67	77.53	94.04
Catchment 2	7.033	34.21	38.45	42.58	46.77	50.81	63.15	60.38	61.62	80.5	34.21	46.77	60.38
Catchment 3	2.696	22.74	26.26	29.08	31.13	34.7	43.13	40.23	42.09	54.98	22.74	31.13	40.23
Catchment 4	2.372	17.23	19.57	21.68	23.6	25.87	32.15	30.52	31.37	40.99	17.23	23.6	30.52
Catchment 5	0.893	8.328	9.693	10.74	11.42	12.81	15.92	14.78	15.54	20.3	8.328	11.42	14.78
Catchment 6	1.559	14.01	16.26	18	19.2	21.48	26.7	24.83	26.06	34.04	14.01	19.2	24.83
Catchment 7	1.423	15.4	18.46	20.45	21.1	24.4	30.32	27.29	29.59	38.66	15.4	21.1	27.29
Catchment 8	2.053	19.81	23.14	24.64	27.13	30.59	36.54	35.08	37.1	46.58	19.81	27.13	35.08

5.7.2. River Hydraulics

The river cross-sections for the non-perennial stream were extracted from the topographical information from 5m contours from the Surveyor General.

Modelling the design flood within the river channel utilises detailed hydraulic calculations between marked river sections so as to calculate the flow conditions of the entire stream reach by back-calculating the flow from the reach end point upstream to the reach start point.

The HEC-RAS program was used to model the river reaches in question by describing the reach as a segmented geometrical line with cross-sectional information at specified points.

The cross-sectional data can be seen in Figure 11 below with the resultant flood levels included.

After running the model, the resulting flood levels, flow velocities, etc are retrieved and this information is plotted to show the 1:100-year flood line.

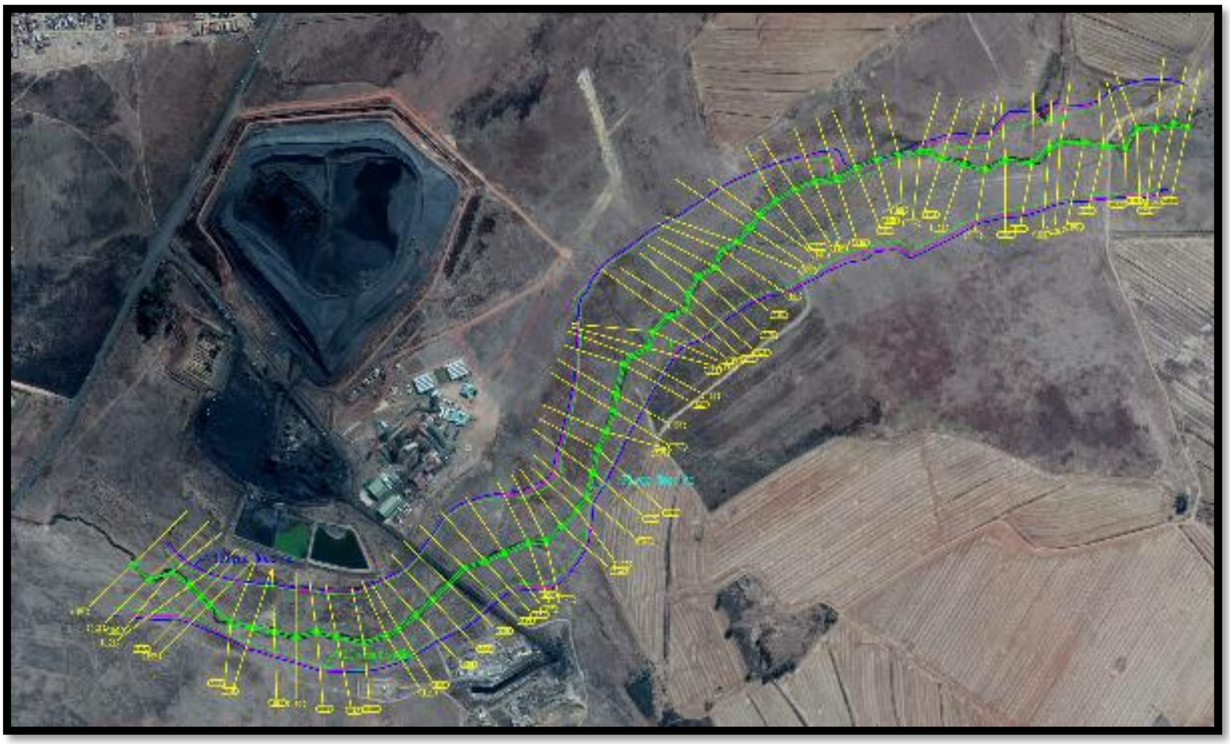

Figure 11: Floodline cross-sectional data

6. Key Issues & Scenarios

From a hydrological perspective, the following key issues have been identified and discussed below, and the impact and possible mitigation measures are discussed in Section 7

6.1. Changes in Catchment Characteristics

The catchment characteristics of the DCM West sub-catchment will be altered by the proposed extension/construction of a new discard dump. The discard dump has been classified as “dirty” in terms of the DWA Best Practice Guideline (BGP). Every effort must be made to separate clean and dirty area by containing runoff from “dirty” areas.

Surface water runoff from the discard dump area should be collected and contained in order to ensure the following objectives are met:

- Minimisation of contaminated areas and reuse of dirty water (where possible);
- Minimisation of seepage from the discard facility; and
- Prevention of overflows and minimization of seepage losses from storage facilities (pollution control dams) Prevention of further deterioration of water quality.

Being dirty, surface water emanating from the discard dump would be captured as close as possible. The return water dam would also cause an increase in hydrologically ineffective areas. Consequently, the calculated flood peak flow values and MAR would decrease.

Table 8 demonstrates the likely effect of the proposed development on peak flows and runoff volumes for the proposed discard dumps, post mitigation. Of the simulated Baseline Sub-catchments in Figure 7, above, Sub-catchments 2 to 6 would be most impacted in relation to the proposed discard dumps. An 8.6% reduction factor has been applied to the simulated peak discharge volumes.

Table 8: Reduction in Selected peak flows (m3/s) with reduction factor applied

Catchment	Area (km^2)	Selected peak flow (m^3/s) Q_{20}	Reduction Factor	Selected peak flow (m^3/s) Q_{50}	Reduction Factor	Selected peak flow (m^3/s) Q_{100}	Reduction Factor
Catchment 2	7.033	34.21	31.26794	46.77	42.74778	60.38	55.18732
Catchment 3	2.696	22.74	20.78436	31.13	28.45282	40.23	36.77022
Catchment 4	2.372	17.23	15.74822	23.6	21.5704	30.52	27.89528
Catchment 5	0.893	8.328	7.611792	11.42	10.43788	14.78	13.50892
Catchment 6	1.559	14.01	12.80514	19.2	17.5488	24.83	22.69462

6.2. Changes in Peak flows and Volumes

Peak runoff flows and volume changes are anticipated when comparing the baseline and anticipated post-development peak flows and volumes. This section assesses the key issues associated with these changes whilst the impact on surface water follows below.

6.3. Changes in Mean Annul Runoff

The MAR of the sub-catchments that the proposed discard dump would affect would be significantly distorted as a result of the discard dump. The impact of this change on surface water follows in Section

7 below. The reduction in the MAR of the quaternary catchment would be in order of 0.2%, which would be negligible. However, the reduction in MAR for the sub-catchments 2,3,4,5 and 6 would be about 6.8%.

6.4. Increased Sediment Yield

Notwithstanding the arid, sparsely planted terrain, the proposed mine infrastructure would require removal of vegetation and the stripping of topsoil. This would increase the erosion potential of the sub-catchments and subsequently result in increased sediment deposition in water courses.

The construction of haul roads and transport of discard material would increase the quantity of airborne sediments. This dust would settle of the ground surface where it would present additional sediments during rainfall events.

7. Surface Water Impact Assessment

This section evaluates the potential impact of the proposed development on watercourses present within the two conveyor route alternatives and discard dump site options. Watercourse is a term used in the National Water Act (Act No. 36 of 1998) (NWA) that includes various water resources, such as different types of wetlands (both natural and artificial), rivers, riparian habitat, dams and drainage lines (e.g. natural channels in which water flows regularly or intermittently). Results and discussions of delineated watercourses (Section 4.2) are used as part of the impact assessment that considers both corridor alternatives separately.

Expected watercourse impacts associated with the proposed development is assessed in detail for the construction and operational phases of the project using the approach provided in the Impact Assessment methodology Section below, which includes the provision of recommended mitigation measures.

An impact can be defined as any change in the physical-chemical, biological, cultural and/or socio-economic environmental system that can be attributed to human activities related to alternatives under study for meeting a project need. The significance of the aspects / impacts of the process will be rated by using a matrix derived from Nsovo and adapted to some extent to fit this process. These matrices use the consequence and the likelihood of the different aspects and associated impacts to determine the significance of the impacts.

7.1. Impact Assessment methodology

Status of Impact

The impacts are assessed as either having a:

- Negative effect (i.e. at a `cost' to the environment),
- Positive effect (i.e. a `benefit' to the environment), or
- Neutral effect on the environment.

Extent of the Impact

- (1) Site (site only),
- (2) Local (site boundary and immediate surrounds),
- (3) Regional,
- (4) National, or
- (5) International.

Duration of the Impact; The length that the impact will last for is described as either:

- (1) Immediate (<1 year)
- (2) Short term (1-5 years),
- (3) Medium term (5-15 years),
- (4) Long term (ceases after the operational life span of the project),
- (5) Permanent.

Magnitude of the Impact; The intensity or severity of the impacts is indicated as either:

- (0) none,
- (2) Minor,
- (4) Low,
- (6) Moderate (environmental functions altered but continue),
- (8) High (environmental functions temporarily cease), or
- (10) Very high / unsure (environmental functions permanently cease).

Probability of Occurrence; The likelihood of the impact actually occurring is indicated as either:

- (0) None (the impact will not occur),
- (1) Improbable (probability very low due to design or experience)
- (2) Low probability (unlikely to occur),
- (3) Medium probability (distinct probability that the impact will occur),
- (4) High probability (most likely to occur), or
- (5) Definite.

Significance of the Impact

Based on the information contained in the points above, the potential impacts are assigned a significance rating (S). This rating is formulated by adding the sum of the numbers assigned to extent (E), duration (D) and magnitude (M) and multiplying this sum by the probability (P) of the impact.

S= (E+D+M) P

The significance ratings are given below;

- **(<30) low** (i.e. where this impact would not have a direct influence on the decision to develop in the area),
- **(30-60) medium** (i.e. where the impact could influence the decision to develop in the area unless it is effectively mitigated),

- **(>60) high** (i.e. where the impact must have an influence on the decision process to develop in the area).

The existing discard dump site was assessed independently of the proposed new discard sites. The new proposed sites were assessed jointly as;

1. they are situated similarly between drainage lines i.e., drainage lines on either side of the proposed new discard dump options; and
2. they are all proposed on currently "undisturbed" land.

The conveyor belt route options were assessed separately as they have distinctly different routes and either run along or across differing numbers of drainage lines thereby weighting the potentially impacts substantially differently.

7.2. Construction Phase

Most of the required infrastructure are already in place and has been previously assessed under the existing and approved EMP (GCS, 2008). However, the proposed discard dump extension will result in new areas being disturbed.

The construction phase consists of the following activities:

- Footprint area clearance;
- The maintenance and upgrading of the total clean water and dirty water diversion trenches; and
- Handling of truck fuel and oil spills.

The potential impacts of the proposed development during the construction phase before and after mitigation are listed and ranked in.

7.2.1. Surface water contamination

Truck oils and fuel could leak and spill to water resources. All oils and fuels must be stored in bunded areas and any spillages must be managed immediately in accordance with the Emergency Response plan. The emergency response plan must be provided by contractors. This will reduce the risks from medium to low. The current discard dump could be disturbed and cause instability resulting in more seepage to surface water resources. Any seepage must be contained according to design criteria. The berms must be constructed upslope of the footprint area to divert clean water to the discard dump and dirty water emanating from the dump should be captured and contained. This will reduce the risks from high to low.

7.2.2. Siltation of surface water

Footprint clearance will expose bare soil that could result in sheet wash into nearby watercourses during a precipitation event. In addition, dust can further be transported into watercourses or be deposited on infrastructure near watercourses thereby exacerbating the impact of siltation during rainfall events.

Prior to construction, clean and dirty separation infrastructure need to be in place to manage runoff velocity preventing erosion gullies.

Table 9: Discard Dump Impact Assessment: Construction phase

Issue	Site Description	Corrective measures	Impact rating criteria					Significance
			Nature	Extent	Duration	Magnitude	Probability	
Siltation of surface water resources & associated contamination	Proposed sites 1,2 &3	No	Negative	2	1	6	4	36 Medium
		Yes	Negative	1	1	4	2	12 Low
	Existing Site	No	Negative	1	1	4	4	24 Low
		Yes	Negative	1	1	2	2	12 Low
Corrective Actions	• Ensure that clean and dirty water separation infrastructure is in place prior to the commencement of construction • Minimise the dirty water area. Appropriate SWMP 1:50 year storm event to be contained and water re-used in processing • Prevent spillage of fuel and oils by using drip trays and storing hazardous substances and vehicles in bunded areas • Design criteria should prevent seepage. Any seepage must be contained to avoid lateral subsurface movement of contaminants into drainage lines • The conveyor belt must be constructed across drainage lies and not along drainage lines. Spanning across drainage lines is encouraged.							

Table 10: Conveyor Impact Assessment: Construction phase

Issue	Site Description	Corrective measures	Impact rating criteria					Significance
			Nature	Extent	Duration	Magnitude	Probability	
Siltation of surface water resources & associated contamination	Route A	No	Negative	2	1	6	4	36 Medium
		Yes	Negative	1	1	2	2	8 Low
	Route B	No	Negative	2	1	6	4	36 Medium
		Yes	Negative	1	1	4	2	12 Low
Corrective Actions	• New headcut and channel features that have resulted during construction should be stabilised once observed. • Restrict the construction of infrastructure in watercourses as far as possible. • Watercourses and their buffers affected by unavoidable construction activities should be rehabilitated soon after construction. Emphasis should be placed on the reinstatement of the topography to a similar profile as was present pre-construction • Construction and access tracks roads should be located outside of watercourses as far as practically possible. • Avoid driving in watercourses during construction phase to prevent vehicle track incision and the potential for channel initiation • The implementation of erosion protection measures, such as energy dissipaters, at new formalised vehicle tracks the contain pipes or culverts. • New access tracks should be designed and implemented • During rehabilitation at the end of the construction phase emphasis should be placed on the reinstatement of the topography to a similar profile as was present pre-construction and to create stable and well vegetated surfaces. The separate removal and storage of top soils, as well as the correct reintroduction of top soil (after subsoil has been reintroduced) is also important to help create stable surfaces in areas affected by construction.							

Table 11: Haul Roads Impact Assessment: Construction Phase

Issue	Site Description	Corrective measures	Impact rating criteria					Significance
			Nature	Extent	Duration	Magnitude	Probability	
Siltation of surface water resources & associated contamination	Haul Roads and service roads	No	Negative	2	1	8	4	44 Medium
		Yes	Negative	1	1	2	2	8 Low
Corrective Actions	• Where mining infrastructure, such as haul roads, are required across natural watercourses, new storm water infrastructure, such as pipes and culverts could replace the hydraulic function currently offered by the natural water courses. This infrastructure should be designed for both hydraulic performance and environmental functionality. A thorough assessment of the suitability of the new stormwater infrastructure must be made at preliminary design stage. • The water quality of rivers and the proposed canals should be monitored on a monthly basis as described in the operational management plan • Dust mitigation should be implemented i.e. having a water bowser perform dust suppression							

7.3. Operational Phase

During the operational phase, coal will be mined and processed in the crushing and screening plant. The coal will be washed and transported by conveyor belt to the stockpile area after processing. The associated residue will be disposed of at the discard dump facility.

The Operational phase consists of the following activities:

- Dirty runoff from the discard;
- Exposure of soil surface and ineffective rehabilitation; and
- Discard dump risk of failure.

7.3.1. Stream Peak Flow Reduction (Change in Hydraulic Regime)

The discard dump extension will reduce the DCM West sub-catchment areas and runoff volumes. The proposed development is not anticipated to have a large potential peak flow reduction impact on the runoff of the immediate and general areas.

This impact refers to changes in water flow patterns caused by construction activities within watercourses. It is also associated with watercourse habitat loss, but focusses more on habitat modification, specifically regarding changes in water movement. Water flow changes can also occur as a result of heavy motorised vehicles driving through watercourse and the need for access tracks in watercourses that have channels. Vehicle track entrenchment commonly occur due to vehicles driving in wetlands with temporary, seasonal or permanent zones of wetness.

Dust mitigation measures must be implemented at this stage of the project.

7.3.2. Subsidence (Change in Hydraulic Regime)

Subsidence can cause both surface water and ground water impacts. The degree to which those impacts change the land use typically depends on the unaltered (pre-mining) surface water and ground water characteristics. Mining subsidence influences hydrologic systems in ways that cause changes to both water quality and quantity.

Subsidence can cause the formation of open cracks, fissures or pits, which, if connected either directly or indirectly to surface water (streams, lakes, ponds), may lead to partial or complete loss of water that is drained to lower strata or mine workings. Surface water may also be "trapped" in pans therefore creating a deficit downstream. Depletion of water resources in this manner can massively impact on the hydrologic regime of a catchment.

Surface flow can be affected by water table changes caused by surface subsidence and mine dewatering and by the discharge of inflows into surface water from mine dewatering. Changes in surface water quantity and timing can change the frequency, magnitude, and duration of flood events and natural baseline flow conditions.

Table 12: Discard Dump Impact Assessment: Operational phase

Issue	Site Description	Corrective measures	Impact rating criteria					Significance
			Nature	Extent	Duration	Magnitude	Probability	
Deterioration of surface water Quality, Siltation of water resources	Proposed sites 1,2 &3	No	Negative	3	2	8	4	52 Medium
		Yes	Negative	1	2	4	2	14 Low
	Existing Site	No	Negative	1	2	6	4	36 Medium
		Yes	Negative	1	2	4	2	14 Low
Corrective Actions	• Consider runoff from discard dump as dirty water. Maintain all water control infrastructure. Design pollution control structures to contain the 1:50 year flood event • Maintain storm water infrastructure, ensure effective rehabilitation • Ensure regular inspection and maintenance of the extension dump • During the operation of the conveyor belt, mechanisms to capture any spillages must be employed as far as possible especially across drainage lines							

Table 13: Conveyor Impact Assessment: Operational phase

Issue	Site Description	Corrective measures	Impact rating criteria					Significance
			Nature	Extent	Duration	Magnitude	Probability	
Deterioration of surface water Quality, Siltation of water resources	Route A	No	Negative	2	1	4	6	42 Medium
		Yes	Negative	1	1	2	4	16 Low
	Route B	No	Negative	3	1	6	8	80 High
		Yes	Negative	1	1	4	4	24 Low
Corrective Actions	• No furrows or drains should be made to channel water from infrastructure. Where this is unavoidable, these furrows and drains need to be closed and revegetated as soon as possible. • Where this is unavoidable in watercourses with channels or wetlands with temporary seasonal or permanent zones of wetness, crossing structures should be in place within affected wetlands and other watercourses.							

	• Additional benefits of using a formal crossing structure that has received engineering input to mitigate watercourse impacts based on site conditions, include the following: o It defines a single route alignment for vehicle travel. o Provides a 'wear and carry' surface over unsuitable and easily compactable wetland soils. o This results in a stable, durable crossing surface for vehicle access, including heavy motor vehicle traffic. o Halts the widening and the development of braided crossing sections, while formerly used track alignments are allowed to naturally stabilise and revegetate.

Table 14: Haul Roads Impact Assessment: Operational Phase

Issue	Site Description	Corrective measures	Impact rating criteria					Significance
			Nature	Extent	Duration	Magnitude	Probability	
Decrease in water quality attributable to increased sediment load	Haul Roads and service road	No	Negative	2	1	6	8	72 High
		Yes	Negative	1	1	2	4	16 Low
Corrective Actions	• The water quality of rivers and the proposed canals should be monitored on a monthly basis as described in the operational management plan • Dust mitigation should be implemented i.e. having a water bowser perform dust suppression • A soil erosion assessment must be conducted bi-annually so as to monitor the efficacy of erosion reduction measures • A maintenance schedule must be produced for maintenance of roads in order to prevent and manage sediment transport. The plan should include among other aspect, the maintenance of berms and velocity dissipating and channelling mechanisms such as wind rows. This will also assist with commitments to the statutes of the GN704 Regulations in ensuring clean and dirty water are separated. • The water quality of rivers and the proposed canals should be monitored on a monthly basis as described in the operational management plan							

Table 15: Subsidence Impact Assessment: Operational Phase

Issue	Site Description	Corrective measures	Impact rating criteria					Significance
			Nature	Extent	Duration	Magnitude	Probability	
Changes in the overall Hydrologic Regime	Subsidence due to undermining	No	Negative	3	5	10	4	72 High
		Yes	Negative	2	4	6	3	36 Medium
Corrective Actions	• Subsidence damage may be controlled by alteration in mining techniques; post mining stabilization; architectural and structural design; and comprehensive planning. However, none of these measures entirely prevents subsidence • Because it is not possible to incorporate all the factors in the design of a protective layer, mitigations that use buffer zones would likely be ineffective in preventing impacts to aquifers or watersheds in which underground mining is proposed. • In order to be effective, seal designs should be site-specific, performance-based and address geotechnical and hydro geological considerations.							

7.4. Decommissioning Phase

The loss of watercourse habitat as a result of infrastructure removal is the one major threat to the hydrologic regime of the study area. Decommission refers to the end of life of the project and the removal of project-related infrastructure. Anticipated impacts refer to the removal of all infrastructure features. It may be possible that some infrastructure would be left in place during the decommissioning phase, such as vehicle access tracks due the insistence of landowners or other third parties that have gotten used to using them during the operational phase of the project.

Removal of infrastructure without any rehabilitation (no mitigation scenario), will result in a High to medium impact in watercourse habitat in both corridor alternatives, while the design and implementation of a site- specific rehabilitation during the decommissioning phase (with mitigation scenario) will result in a medium to low impact in both corridor alternatives.

Unplanned haul/access roads are, more often than not, created as a result of decommissioning activities. Notwithstanding the arid, sparsely planted terrain, the proposed mine infrastructure would require removal of vegetation and the stripping of topsoil. This would increase the erosion potential of the sub-catchments and subsequently result in increased sediment deposition in water courses.

Table 16: Discard Dump Impact Assessment: Decommissioning phase

Issue	Site Description	Corrective measures	Impact rating criteria					Significance
			Nature	Extent	Duration	Magnitude	Probability	
Runoff and drainage from discard dump continue to yield polluted water & Siltation of water courses	Proposed sites 1,2 &3	No	Negative	3	2	10	4	60 Medium
		Yes	Negative	1	2	6	3	27 Low
	Existing Site	No	Negative	3	2	10	4	60 Medium
		Yes	Negative	1	2	6	3	27 Low
Corrective Actions	• Manage waste effectively to prevent pollution of water resources • Maintain dirty water separation systems until the site is rehabilitated and free draining • Rehabilitate as soon as possible, maintain erosion control for the duration of rehabilitation							

Table 17: Conveyor Impact Assessment: Decommissioning phase

Issue	Site Description	Corrective measures	Impact rating criteria					Significance
			Nature	Extent	Duration	Magnitude	Probability	
The loss of watercourse habitat as a result of infrastructure removal	Route A	No	Negative	2	1	4	8	56 Medium
		Yes	Negative	1	1	2	2	8 Low
	Route B	No	Negative	2	1	4	8	56 Medium
		Yes	Negative	1	1	2	2	8 Low

Corrective Actions	• Rehabilitate old stilt footprints and access road footprints that will no longer be used. • It is recommended that a site specific rehabilitation plan be developed and implemented to address affected infrastructure footprints located within watercourses and watercourse buffers, and other sensitive areas during the decommissioning phase.

Table 18: Haul Roads Impact Assessment: Decommissioning Phase

Issue	Site Description	Corrective measures	Impact rating criteria					Significance
			Nature	Extent	Duration	Magnitude	Probability	
Decrease in water quality attributable to increased sediment load	Haul Roads and service road	No	Negative	2	2	8	6	72 High
		Yes	Negative	1	1	2	2	8 Low
Corrective Actions	• During the decommissioning phase, all unnecessary bare surfaces and developed zones should be removed and, as far as is possible, restored to their natural state e.g. hydro seeded with indigenous species of vegetation							

Table 19: Subsidence Impact Assessment: Decommissioning Phase

Issue	Site Description	Corrective measures	Impact rating criteria					Significance
			Nature	Extent	Duration	Magnitude	Probability	
Changes in the overall Hydrologic Regime	Subsidence due to undermining	No	Negative	3	5	10	4	72 High
		Yes	Negative	2	4	6	3	36 Medium
Corrective Actions	• Subsidence damage may be controlled by alteration in mining techniques; post mining stabilization; architectural and structural design; and comprehensive planning. However, none of these measures entirely prevents subsidence • Because it is not possible to incorporate all the factors in the design of a protective layer, mitigations that use buffer zones would likely be ineffective in preventing impacts to aquifers or watersheds in which underground mining is proposed. • In order to be effective, seal designs should be site-specific, performance-based and address geotechnical and hydro geological considerations.							

8. Monitoring Programme

Monitoring measures on the mine are characterised by monthly surfacewater quality monitoring at specific locations. Quarterly Water Quality Monitoring. Reports are submitted to the mine by Aquatico Laboratories. During the 1st quarter of 2019, of the eleven (11) surface water monitoring localities (three waste water and nine resource localities) located in the 2 seam area, five (5) were sampled in every month. Locality DFSW07 was not sampled once during this quarter as it was dry. The sampling points are depicted in Figure 12 below.

The current sampling regime is deemed adequate for the needs of this assessment as the sampling points would sufficiently address the proposed locations of the planned infrastructure.

Figure 12: Surface water sampling points at DWCM (Q1, 2019)

9. Operational Management Plan

The legal requirements governing surface water are presented in Section 4 of this report. In order to assist Applicants, achieve compliance, the DWS have compiled Best Practice Guidelines (BPG). The following sections reflect a few specific excerpts from the BPG, but are by no means a comprehensive summary. The Applicant is referred to the full do Storm water management and drainage planning are critical components of integrated water and waste management (IWWM) at mining sites. While storm water management is an integral part of the IWWM and is documented as part of the Integrated Water and Waste Management Plan (IWWMP), for the purpose of this document, the component of the IWWMP that refers to storm water management is referred to separately as the storm water management plan (SWMP). A SWMP must address the impact of:

- Mining operations on the water flow and water quality processes of the hydrological cycle, and the associated upstream and downstream environmental impacts;
- The hydrological cycle on mining operations, including effects such as loss of production, costs, and impacts of both floods and droughts on the mining operations.

The objectives of a SWMP are site-specific but some general objectives include:

- Protection of life (prevent loss of life) and property (reduce damage to infrastructure) from flood hazards;
- Planning for drought periods in a mining operation;
- Prevention of land and watercourse erosion (especially during storm events);

- Protection of water resources from pollution;
- Ensuring continuous operation and production through different hydrological cycles;
- Maintaining the downstream water quantity and quality requirements;
- Minimizing the impact of mining operations on downstream users; and
- Preservation of the natural environment (water courses and their ecosystems).

The SWMP must cover the life cycle of the mine from exploration, through construction, operation, decommissioning, and up to post-closure. Potential adverse effects of inadequate storm water management include:

- Downstream contamination of natural watercourses due to runoff or spillage of contaminated storm water.
- Flooding, with the resultant damage to property, land and potentially loss of life.
- Loss of catchment yield and addition of large volumes of water to the mine water balance when optimal runoff of clean storm water is not achieved.
- Erosion of beds and banks of waterways.
- Increased recharge through spoils or fracture zones, unnecessarily increasing the water volume that comes into contact with contaminants.

10. Rationale for preferred alternatives

10.1. Discard Dump Site

The discard dump site options are all "sandwiched" between drainage lines which makes the rationale for a preferred site inconsequential as the level of risk on the hydrologic regimes that surround them is ubiquitous. As such, this report finds that the existing Dump Site and Alternative sites 1,2 and 3 are **all suitable** for the location of a discard dump provided all mitigation measure presented herein are adhered to.

However, when environmental best practice is taken into consideration, it is deemed as less of an environmental risk when "impacts are put upon impacts". Proposing the construction of a new dump site, i.e. Alternatives sites 1,2, and 3 would mean introducing impacts to currently undisturbed areas.

The existing dump site has already impacted on the in-situ hydrological regime of the study area and has all the existing infrastructure, e.g, haul roads, in place. As such, this report finds that extending the existing dumpsite would be the preferred alternative option. Furthermore, ***Table 20*** below is a risk matrix that shows that in cumulative terms, the existing discard dump scores a lesser score as compared to the proposed sites.

Table 20: Summary of comparison of Discard Dump Alternatives vs the Existing Discard Dump

Issue	Corrective measures	New Discard Dumps	Existing Discard dump
Siltation of surface water resources &	No	**36 Medium**	**24 Low**

associated contamination	Yes	**12 Low**	**12 Low**
Deterioration of surface water Quality, Siltation of water resources	No	**52 Medium**	**36 Medium**
	Yes	**14 Low**	**14 Low**
Runoff and drainage from discard dump continue to yield polluted water & Siltation of water courses	No	60 Medium	60 Medium
	Yes	27 Low	27 Low
Total		***201***	***173***

10.2. Conveyor Belt Route

When assessing the preferred conveyor belt route alternative, the following critical considerations were promoted:

1. The fewest number of crossings are encouraged; and
2. Perpendicular crossings are preferred over route alternatives that run along a drainage line.

In light of this, Route alternative A was found to have 2 drainage line crossings as compared to Route Alternative B which was found to have a total of 4 drainage line crossings. In addition, Route alternative B was found to run near parallel in parts as can be seen in ***Figure 6***.

Table 21: Summary of comparison of Conveyor Route A vs Conveyor Route B

Issue	Corrective measures	Conveyor Route A	Conveyor Route B
Siltation of surface water resources & associated contamination	No	**36 Medium**	**36 Medium**
	Yes	**8 Low**	**12 Low**
Deterioration of surface water Quality, Siltation of water resources	No	**42 Medium**	**80 High**
	Yes	**16 Low**	**24 Low**
Runoff and drainage from discard dump continue to yield polluted water & Siltation of water courses	No	**60 Medium**	**60 Medium**
	Yes	**27 Low**	**27 Low**
Total		***189***	***239***

Table 21 above is a risk matrix that shows that in cumulative terms, Route A scores a lesser score as compared to the Route B. The preferred conveyor belt route was concluded to be **Route alternative A**.

11. Conclusion and Recommendations

In conclusion, the proposed mine infrastructure development can take place provided mitigation measures in line with this write-up are adhered to. In addition, the SWMP, IWWMP, approved WUL and EMPr must all be implemented during the different life cycles of the proposed project.

The following recommendations have been made:

- Surface water quality monitoring is to be conducted monthly during the construction and operational phases of the project;
- A GN 704 audit is to be conducted bi-annually to assist with compliance to the separation of clean and dirty water infrastructure, unless otherwise, the frequency of the audit is determined by the existing Water Use Licence;
- The construction phase of the project must take place during the dry months so as to minimise pollutant runoff; and
- An independent ECO is to be appointed during construction. The mine's internal Environmental officers must be conversant with best practices in line with rehabilitation during decommissioning and an audit is to be conducted during and after rehabilitation.
- A comprehensive water balance model should be created. Surface water should be used in the mining process as far as is possible.
- Where mining infrastructure, such as haul roads, are required across natural watercourses, new storm water infrastructure, such as pipes and culverts could replace the hydraulic function currently offered by the natural water courses. This infrastructure should be designed for both hydraulic performance and environmental functionality. A thorough assessment of the suitability of the new stormwater infrastructure must be made at preliminary design stage.