KOLOMELA MINE
Hydrological Assessment
and
Water Balance Report

Revision Log

File: DP21006 Kolomlea Hydraulic designs REV 1						
C	02/11/2021	Third issue	Y Penning	A de Klerk PrEng	A de Klerk PrEng	
B	20/08/2021	Second issue	Y Penning	A de Klerk PrEng	A de Klerk Pr.Eng.	
A	26/07/2021	First issue	Y Penning	A de Klerk PrEng	A de Klerk Pr.Eng.	
REV	DATE	DESCRIPTION	PREPARED by	CONTRIBUTION by	VERIFIED by	VALIDATED by
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EXECUTIVE SUMMARY

Design Point Consulting Engineers (Design Point) was appointed by EXM Environmental Advisory (EXM) to undertake a Hydrological Assessment and generate a Water Balance Report for Kolomela Mine in support of a Water Use Licence (WUL) Application for the proposed expansion of the mining activities. The purpose of the study is to determine potential hydrological risks associated with Kolomela as well as the proposed mine expansion, and to provide a framework for the management of such risks.

Mining activities by its very nature have a large topographic footprint and will invariably interact with the local drainage systems. Mine developments will often require diversions of watercourses are also likely to increase flood risks in surrounding areas due to floodplain storage los. Therefore, it is necessary to implement adequate mitigation to manage potential hydrological and flood risks.

The hydrological setting and factors that influence the hydrology for Kolomela mine is presented. The 1:50 and 1:100-year recurrence rainfall events is established and simulated on digital elevation model built on recent lidar data. The result of the simulation is presented in the form of hazard maps and identification. Furthermore, the interaction of the planned Kapstevel area expansion and the natural hydrology is presented.

Identified hazards that are classified as risks for the current topography and associated hydrology are identified and include the following items

1. All open pit areas
2. The broader areas around PCD1 and PCD3 in the plant
3. DMS area
4. Primary crusher conveyor belt inclined
5. Culverts under the haul road between Leeuwfontein and Kapstevel
6. Pooling east of the railway line and in the rail loop

Identified hydrological impacts associated with the planned expansion of the Kapstevel area were identified and included the following items

1. Stormwater diversion north of the haul road leading to the Kapstevel area
2. Haul road crossing over the non-perennial stream east of the proposed Kapstevel expansion
3. Possible PCD facilities to manage runoff from proposed Kapstevel rock dumps
4. Cut off berm southwest of the Kapstevel area

Identified hydrological impacts associated with the planned expansions in the Leeuwfontein and Plant area include the following items

1. Drainage underneath the planned railway line
2. Drainage through the planned solar farm
3. Pooling of water in rail loop can impact the operations of the proposed stockpile in the area.

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1 Introduction

Mining at Kolomela is carried out as part of Anglo American's Kumba Iron ore operation, with the bulk of the iron ore being exported to the international market. The ore from the opencast pit is transported to the DSO (Direct Shipping Ore) beneficiation plant where it is crushed and, screened. There is also a small Dense Media Separation (DMS) plant in place for the processing of some lower grade ore.

Mining activities by their very nature have a large topographic footprint and will invariably have significant interaction with the local drainage systems. Mine developments will often require diversions of watercourses. Mines are also likely to increase flood risks in surrounding areas due to floodplain storage lost resulting from flood mitigation measures for the mine.

Flooding can result in the suspension of operations due to:

- erosion and poor road conditions.
- water build-up at working faces and in mining areas.
- inadequate on-site water storage and the inability to discharge.
- accumulated runoff to surface water.
- damage to infrastructure, such as road, rail, and conveyor systems.
- catastrophic inundation from surrounding rivers due to dam failures.
- loss of containment of dirty water management facilities, i.e., pollution control dams.

2 Mandate and Scope of Work

Design Point Consulting Engineers was appointed by EXM Environmental Advisory Services (Pty) Ltd to assist with Hydrological and Hydraulic Engineering input to support environmental undertakings in compiling a Water Use License Application for planned expansions of the Kolomela mining operations. The scope of the appointment can be summarised in three aspects, i.e.,

1. Hydrological assessment and evaluation of the broader Kolomela mine for the 1:50-year up to a 1:100-year recurrence interval storm events. Two scenarios are considered, i.e.,
   - the current terrain with the current location of mine infrastructure,
   - anticipated response of planned mine expansion topographic arrangements.
2. Flood hazard identification for the considered scenarios.
3. Mine water balance review of the existing water infrastructure for 2020.

3 Report Structure

This interim report is structured in two sections as summarised below.

3.1 Section A: Hydrology and Stormwater

Information is presented in a top-down approach, i.e., and overview of the site and relevant climatological and hydrological information is provided. A brief overview of the hydrological simulation methodology is provided, followed by the results of the “current” and “planned” scenarios in terms of runoff flow paths, depths, and velocities.

The existing Stormwater Master Plan (SWMP) is reviewed and compared to General Notice 704 of the National Water Act (No 36 of 1998) requirements. The review uses flood lines to identify areas susceptible to flooding on the current and planned mining footprint. Perceived risk assessment results are presented and proposed design solutions for some elements of the risk assessment are provided.

3.2 Section B: Water balance

Review and presents current trends in water utilisation at Kolomela mine. The water balance includes current water utilisation processes, including water users on the mine, water provided to Sedibeng water scheme for use and aquifer recharge in the surrounding areas.

The water balance section includes a high-level estimate of the water use after expansion of the Kapstevel pit. A water balance analysis for the expansion will be done as soon as concept designs for the mine expansion have been approved.

4 Section A: Hydrology and stormwater

4.1 Introduction

The Kolomela mine operations are susceptible to flooding, resulting from high rainfall to catastrophic rainfall events. The exact nature of potential disruption depends on the mine location, mine type, and access routes for logistics and transport. Mines located in dry regions may be particularly susceptible to an underestimation of this risk. The changing landscape at most mines suggests that mine operations must continually re-review their risk and exposure to flood-related impacts and damage.

4.2 Setting

The location of Kolomela mine is indicated in Figure 1. The mine is in Semi-Arid zone of South Africa, with an expected Mean Annual Precipitation (MAP) of 200 and 400 mm.

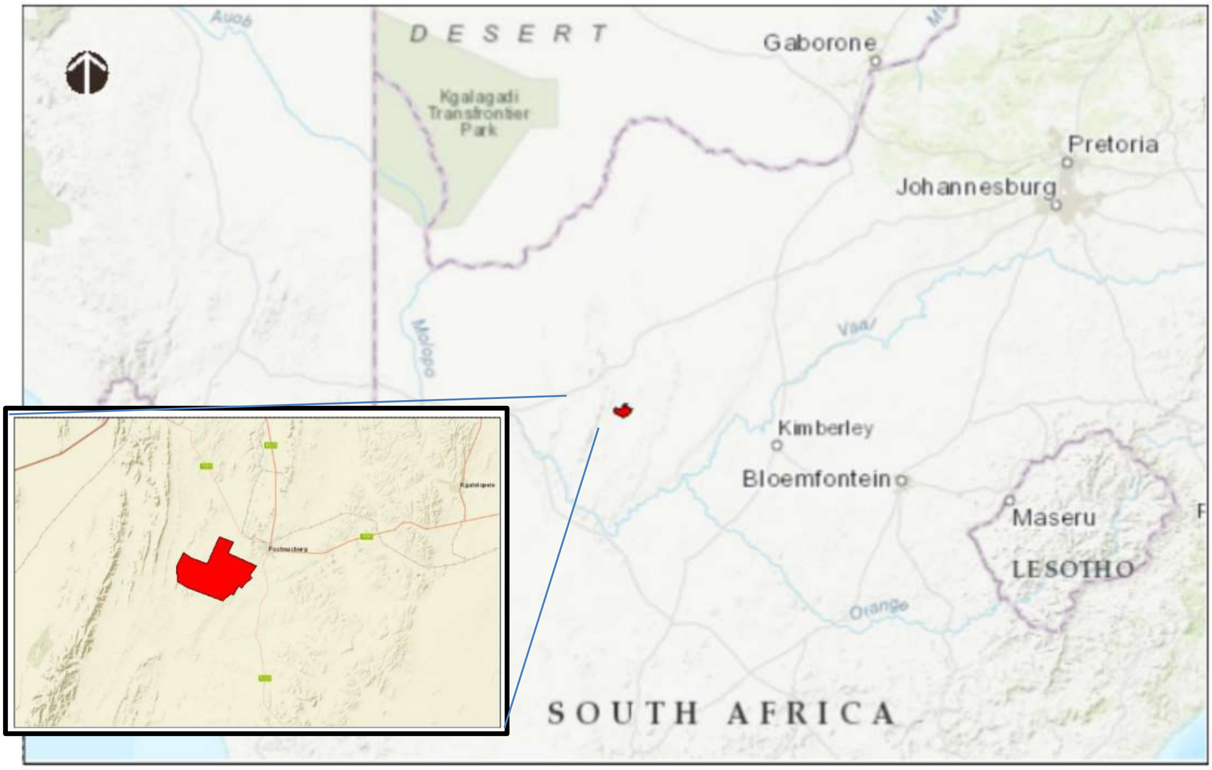


Figure 1 : Kolomela mine location map

4.3 Topography

Lidar survey data was obtained from Kolomela mine and used to construct a digital elevation model of the area flown by the lidar survey. The scope of the project and the elevation shaded DEM of the lidar data is indicated in Figure 2.

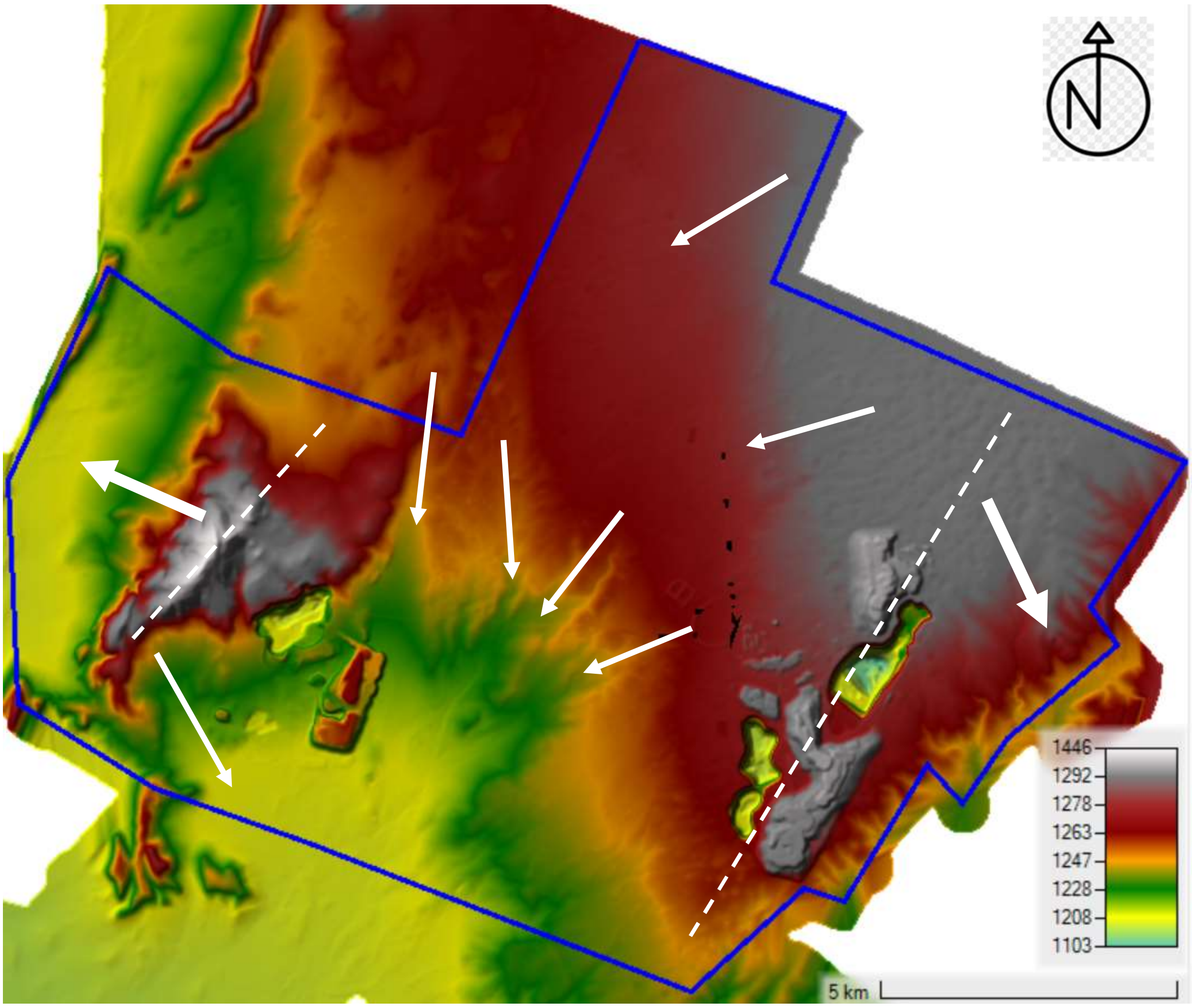


Figure 2 : Kolomela Mine broader area topography and primary runoff flow directions (white arrows)

The following general interpretations and deductions from the topography and the hydrological response of the terrain can be made, i.e.,

i. The high point of the terrain (grey areas) elevation is in the north-eastern area of the site, i.e., between 1305 and 1310 meter above sea level (masl).
ii. The low point of the terrain (green-yellow areas) elevation is in the southern boundary of the site, i.e., between 1194 and 1196 meter above sea level (masl).
iii. Most of the terrain can be consider as having a slight slope (less than 1%) toward the low point of the terrain.
iv. There are various established topographic watercourses, that are indicative of flow well defined flow directions in the southern regions of the site.
v. The Leeuwfontein, Klipbankfiontein and Kapstevel pits can act as runoff sinks.

4.4 Land classification and Roughness

The South African National Land Cover dataset of the 2018 *dataset* is based primarily on the gazetted *land*-cover *classification* standard (SANS 19144-2) with 73 land use categories. The relevant spatial extract is represented in Figure 3.

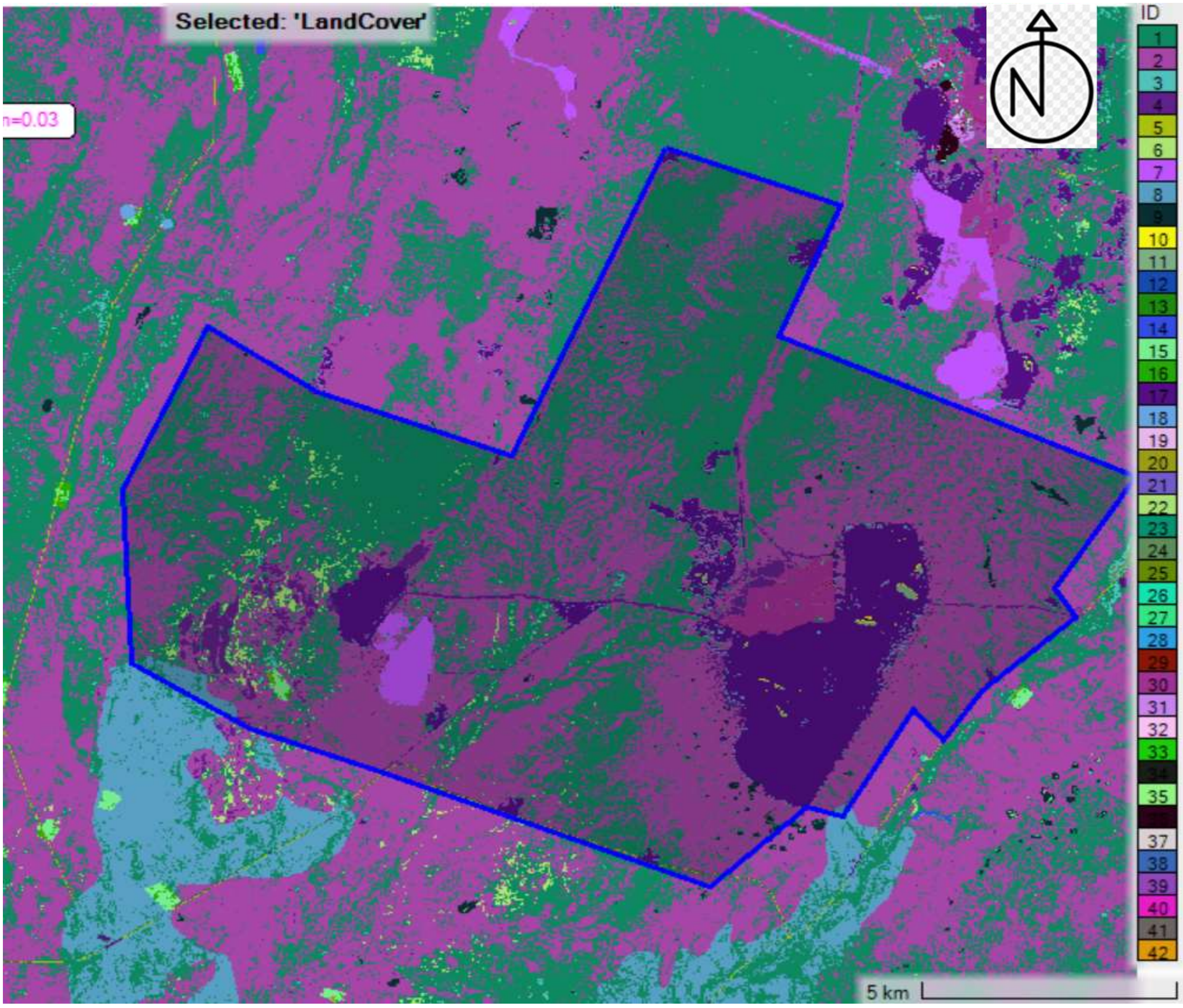


Figure 3 : Kolomela Mina land use spatial data

The area is dominated by 4 land use categories, described in Table 1(relatable to Figure 3).

Table 1 : Majority of land use classifications at Kolomela Mine

Class	Colour	Description
8	Magenta	Low Shrubland
13	Green	Natural Grassland
69	Dark purple	Mines: Extraction Sites: Open Cast & Quarries combined

71	Light Purple	Mines: Waste (Tailings) & Resource Dumps

4.5 Soil Classification and Infiltration

Soil hydraulic properties controlling infiltration and runoff play an important part in capturing and distributing water resources in dry riverbeds and floodplains. These fluvial environments are strategic sites for groundwater recharge and water-resource development. Modelling surface and subsurface water-flow requires knowledge of soil classification and hydraulic parameters.

The International Soil Reference and Information Centre (ISRIC) Soil and Terrain (SOTER) database is used as reference for soil classification. The relevant potion of the SOTER GIS soil and terrain database for South Africa is shown in Figure 4, overlayed by the terrain boundary. Two soil type can be identified, i.e., Calcic Solonckaks and Rhodic Cambisols.

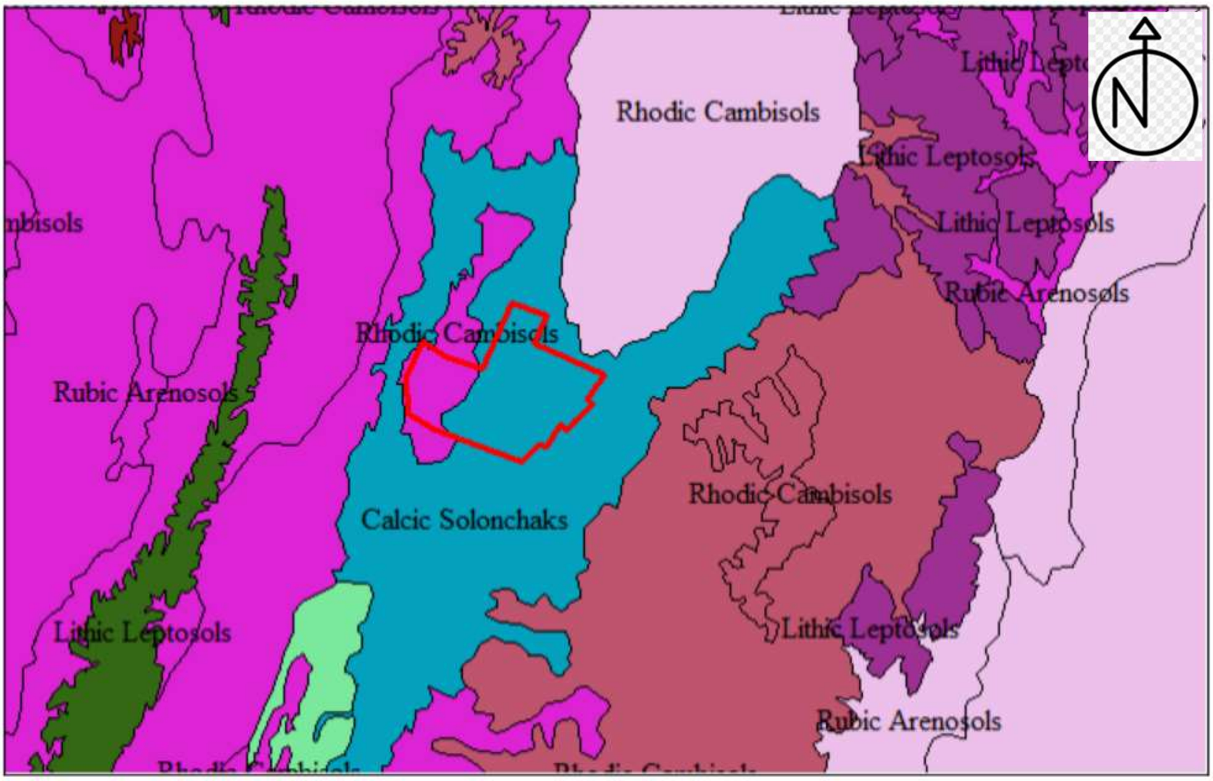


Figure 4 : Study area soil classification map

Solonchaks are defined by high soluble salt accumulation within 30 cm of the land surface and by the absence of distinct subsurface horizonation (layering), except possibly for accumulations of gypsum, sodium, or calcium carbonate or layers showing the effects of waterlogging.

Cambisols are characterized by slight or moderate weathering of parent material and by absence of appreciable quantities of illuviated clay, organic matter, aluminium and/or iron compounds.

Infiltration rates are of both soils are low and have been estimated by others as between 0.13 – 0.2 mm/min (1).

4.6 Hydrological data

4.6.1 Yearly Rainfall

The total annual rainfall at Postmasburg since 1920 is reflected in Figure 5. The MAP since 1920 is 317 mm.

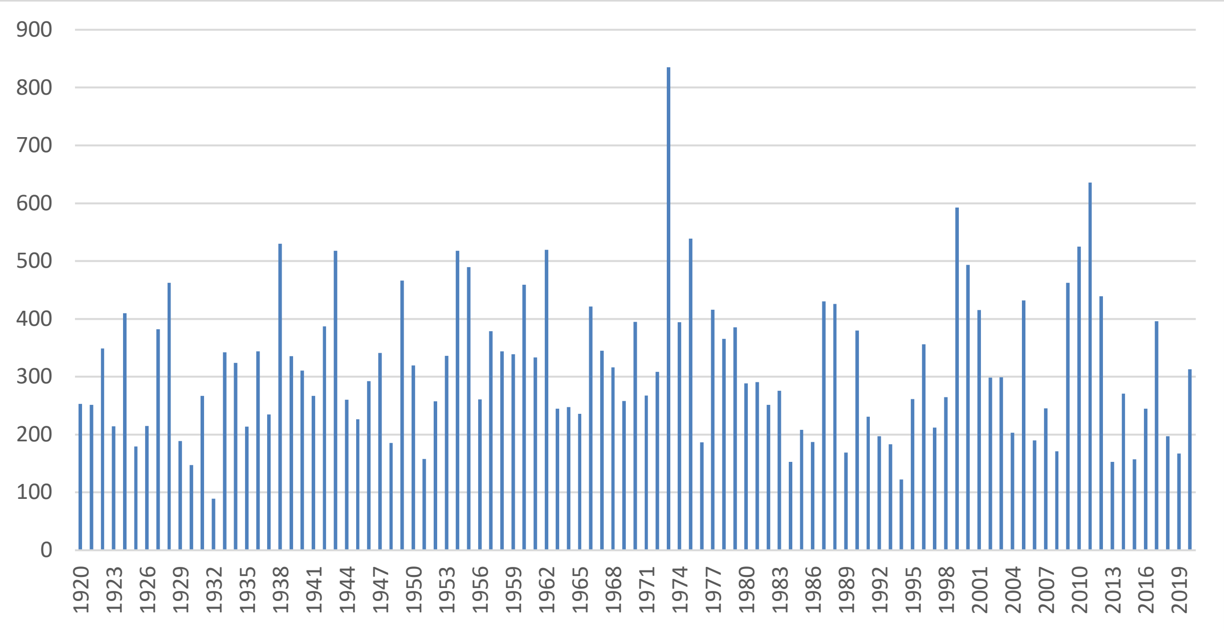


Figure 5 : Postmasburg yearly rainfall

4.6.2 Monthly Rainfall

The monthly average, 10-, 50- and 90- percentile rainfall at Postmasburg 1920 is reflected in Figure 6.

Figure 6 : Postmasburg monthly rainfall percentiles

4.6.3 Daily Rainfall

Daily rainfall records obtained from Kolomela mine indicate that point rainfall is measured and stored on a per calendar day basis, reflected in Figure 7. It is important to note that rainfall duration is not recorded, and hence rainfall intensity for other periods must be deduced with statistical norms applicable to the rainfall region.

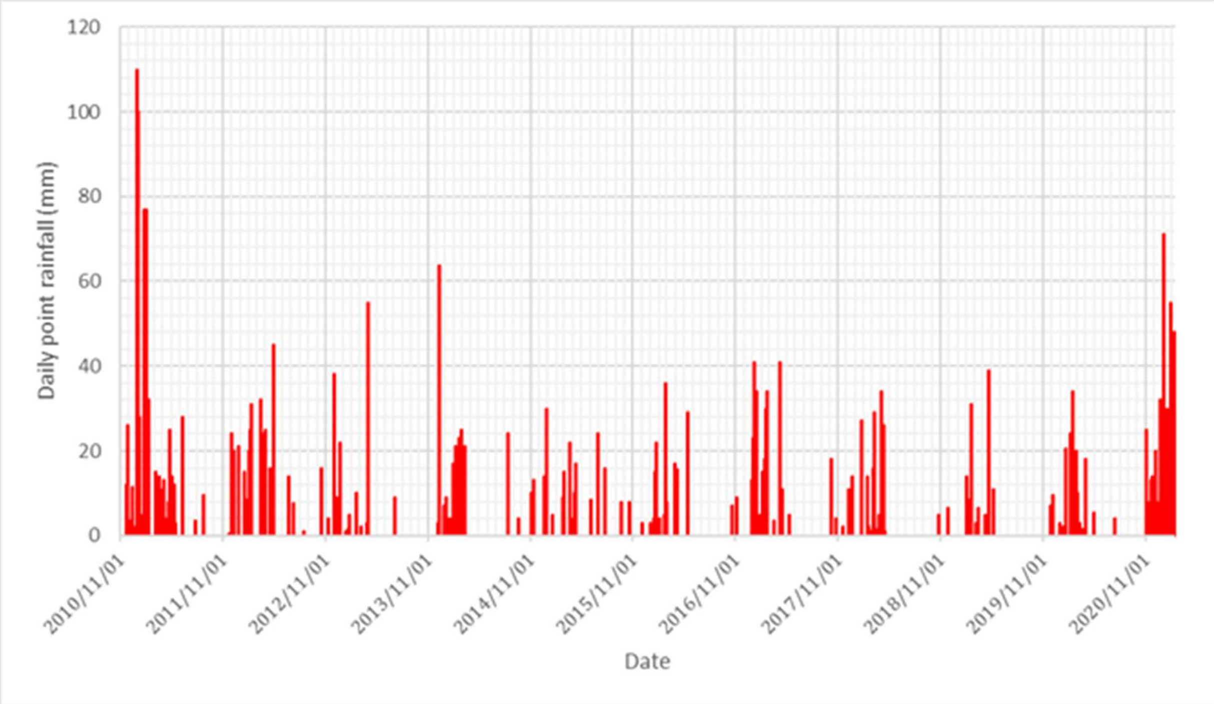


Figure 7 : Kolomela daily rainfall since November 2010

The frequency of extreme events such as floods can be expressed in terms of the "return period," also known as the "recurrence interval." In extreme value analysis, the return period is defined as "*the average length of time between events of the same magnitude or greater. It is derived from quantiles of a parametric probability distribution fitted to the extreme values of the recorded data*". A goal of the frequency analysis of extreme events is to estimate the value of the event magnitude corresponding to a given return period i.e., the maximum daily rainfall that can be expected to occur every 50 or 100 years.

The extreme value distribution (Weibull) for 10 year's measured rainfall data is presented in Figure 8.

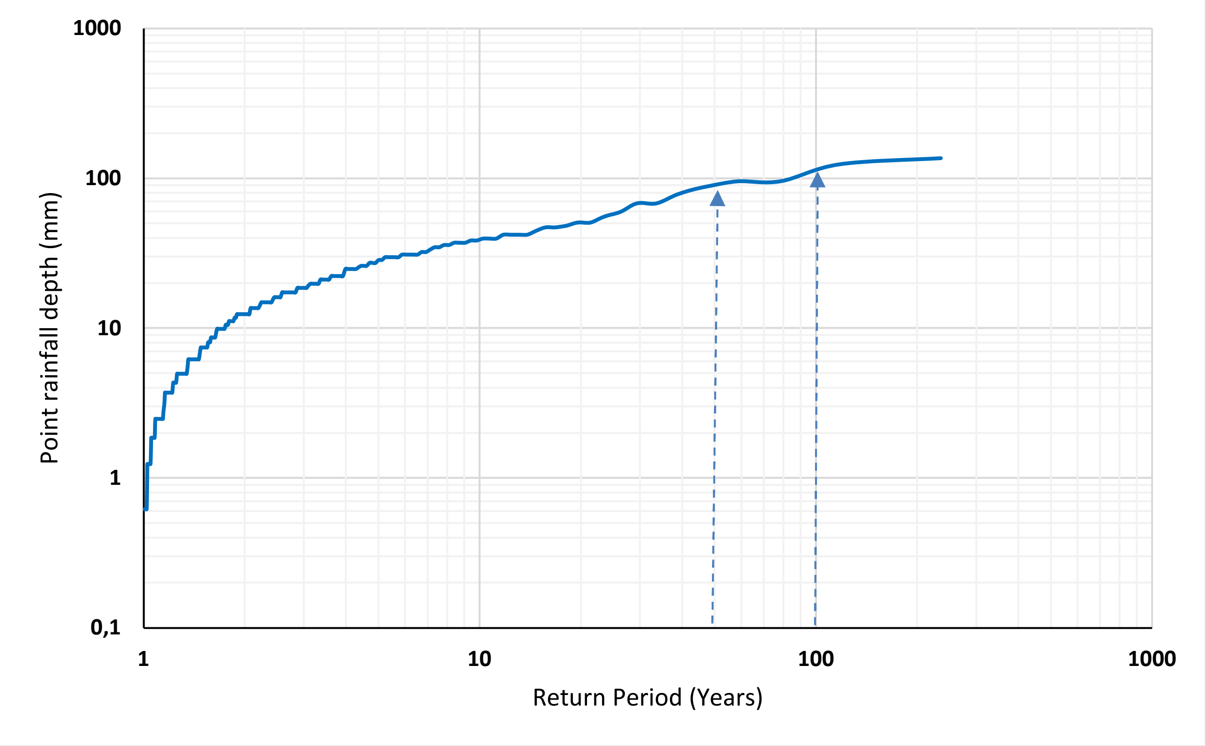


Figure 8 : Rainfall - extreme value probability graph

The 1:50 year 24-hour design point rainfall depth for the site is interpolated from TR102 (Department of Environment Affairs, Directorate of Water Affairs, Branch of Scientific Services, Technical Report TR 102, Southern African Storm Rainfall, P. T. Adamson, 1981). A copy of the relevant map, with the site location indicated, is reflected in Figure 9.

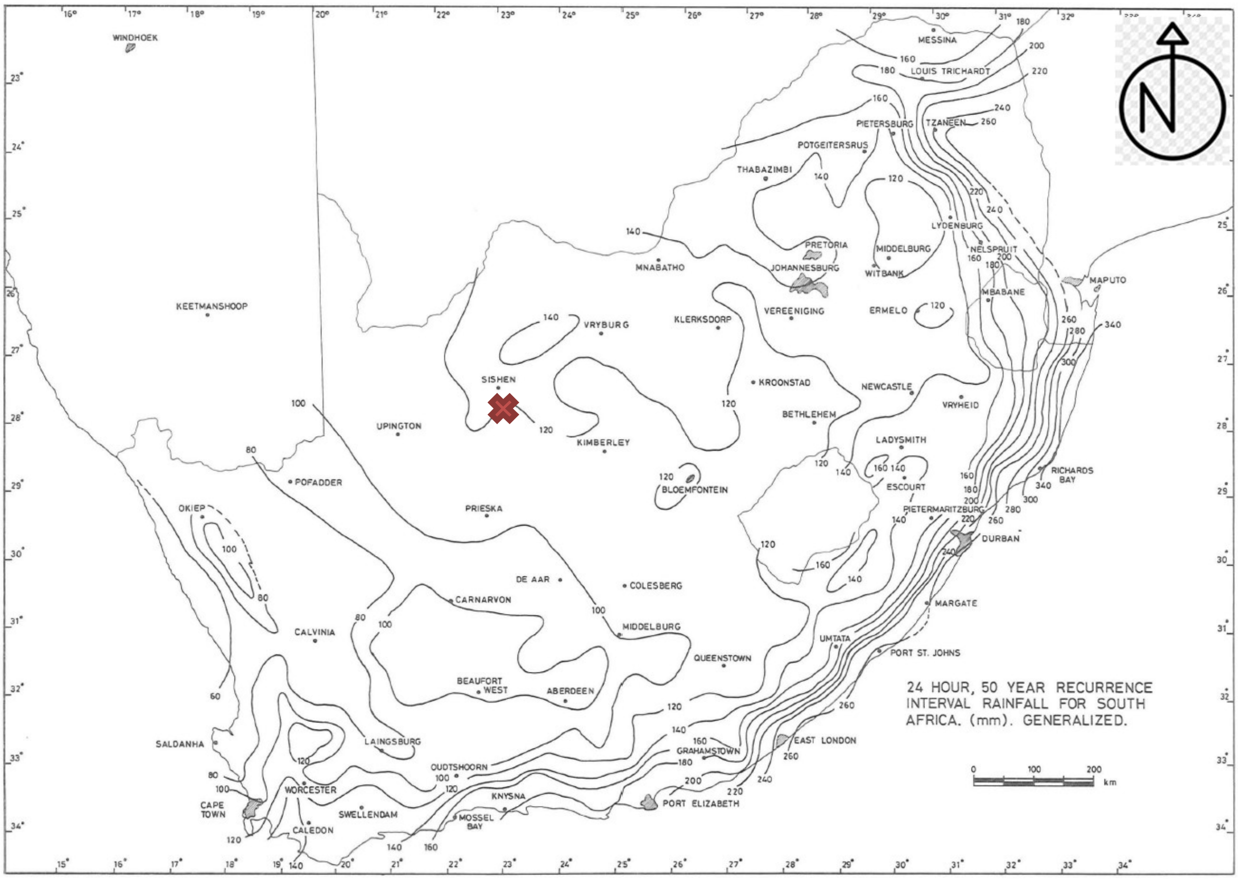


Figure 9 : 1:50 year 24-hour design point rainfall depth form TR102

The extreme value distribution based on 10 years of daily rainfall data reflects a 1:50 24-hour storm rainfall depth of 100 mm. TR102 reflects a design storm rainfall depth for the 1:50 24-hour storm of 120 mm

The extreme value distribution based on 10 years of daily rainfall data reflects a 1:100 24-hour storm rainfall depth of 136 mm. TR102 reflects a design storm rainfall depth for the 1:100 24-hour storm of 140 mm (TR102 do not present 1:100 event data).

A value of 120 mm for the 1:50 year, and 138 mm for the 1:100-year 24-hour storm are used in the hydrological simulation (hyetograph composition) for rainfall.

4.6.4 Evaporation

The hydrological simulation duration of 24 hours is too short for evaporation to affect the outcome of the flood risk results. It is therefore not considered, and presents a conservative approach

4.7 Flood Assessment

4.7.1 Introduction

The goal of flood assessment is to understand the probability that a flood of a particular intensity will occur over an extended period. Hazard assessment aims to estimate this probability over periods of years to decades to support risk management activities. Intensity usually refers to the combination of flood depth and horizontal flood extent, although other intensity measures such as flow velocity and flood duration can also be important factors depending on the situation.

This relationship between the probability of a flood and its intensity gives rise to the concept of return period (also known as recurrence interval), represented by the symbol T and expressed in terms of years. A T-year flood is the flood intensity that has a probability of 1/T of being exceeded each year. This probability is called the exceedance probability. For example, there is an exceedance probability of 1/10 (0.10) that each year that a flood larger than the 10-year flood intensity will occur. Flood hazard assessments usually aim to estimate the flood intensity for a range of exceedance probabilities, for example from 0.1 to 0.001. It is important to point out that this definition of return period is contrary to what the term “10-year flood” or “100-year flood” would seem to imply, (i.e., the intensity of a flood that would occur once every ten or one hundred years).

4.7.2 Runoff Modelling & Simulation

Hydrological studies are useful tools to quantify the impacts of land changes and damages induced from storm events, amongst a multitude of other uses. The current industry standard is for flood models to utilise both hydrologic and hydraulic components. Hydrology first identifies the relevant catchments draining into the area of interest, then develops catchment parameters to hydrologically route storage to the boundary of the area of interest. Boundary flows are then utilised to hydraulically route through the area of interest to assess the flood extents and other behaviour.

The hydrology component is implemented through a hydrologic model, which exhibits two processes - converting rainfall to catchment runoff and routing the runoff through the catchment. The hydrology component is implemented through a hydrologic model, which exhibits two processes - converting rainfall to catchment runoff and routing the runoff through the catchment. Hydrologic routing is based on the temporal changes that relate storage, inflow and outflow in a control volume, i.e.,

$$^{dS}/_{dt} = I(t) - O(t)$$

where S (m^3) is the storage component, t (s) is time, I (m^3/s) is the inflow, and O (m^3/s) is the outflow. This is a simple lumped water balance and is further developed into a simplified equation for overland flow containing several lumped catchment parameters. The application of hydrologic modelling software using these fundamental principles is common in the Hydrology Engineering field.

This approach is limited due to simplification and abstraction of the underlying physical process. Examples of this include the combining of infiltration and interception stores, and the grouping of groundwater flow, interflow, and direct runoff. This method also assumes the sub-catchments are well defined and no crossover will occur during significant events.

Recently, what is referred to as direct precipitation or rain-on-grid modelling has become prevalent for simulating hydrology and stormwater runoff. The approach makes use of finite discretisation of topography data, including roughness, infiltration, and spatial orientation. Each discrete element (or grid cell) is loaded with precipitation at a specific frequency. The response of each cell is quantified in terms of velocity, flow depth, and direction of flow. Adjacent cells receive and discharge in a two-dimensional matrix, as reflected in Figure 10. This process is sustained up to a point where a hydraulic steady state is reached. The steady state is used as an indication of the topographic response to a specific rainfall event, i.e., a flood or runoff map. This method is well suited to establish hydrological response of a system if the catchment boundary, time of concentration and roughness varies in a study area.

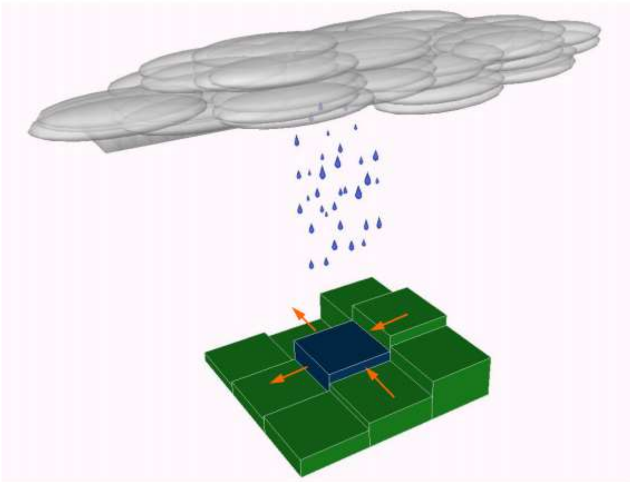


Figure 10 : Rain on grid methodology.

Compared to the hydrologic methods, *rain-on-grid* or *direct precipitation* models is a significantly more detailed approach with especially beneficial uses for catchments where topography variations make it difficult to define flow paths. This is particularly useful for modelling complex situations which hydrologic methods tend to oversimplify. However, the extra complexity comes with the cost of a computation time magnitudes slower than those of traditional hydrologic models, which arises largely from the number of discrete topographic units (cells) needed in a hydraulic model compared to a hydrologic model. This necessitated a compromise between quick run times and model complexity, resulting in the use of hydrologic models due to economics.

In direct rainfall models, typically a significant area of the model contains water flowing at very shallow depths. The mean hydraulic depth and its relative scale to the size of the resisting elements in its flow path is a fundamental concept in understanding hydraulic resistance at shallow flow. Flow resistance has a direct bearing on the relationship between flow depth and flow velocity. Flow resistance changes at different scales, i.e.

- Sheet flow: Runoff depth generally at a scale of millimetres (sometimes fractions of millimetres) to centimetres. Elements producing resistance are not completely submerged. Drag force, secondary flows and skin friction are very important in the velocity distribution.

- Shallow flow: Runoff depth generally at a scale of centimetres. Elements producing resistance are submerged, but flow depth is still very shallow. Skin friction begins to dominate, but secondary flows and drag force are still significant in the velocity distribution.
- Deep flow: Runoff depth at a scale of metres. Elements producing resistance are submerged, and flow is at least twice as deep as a shallow flow. Skin friction dominates in the velocity distribution.
- Ocean flow: Runoff depth is orders of magnitude larger than a deep flow. Significant vertical velocities. Roughness terms are not significant in the hydrodynamic equations. Inertial terms dominate.

Hydrologically flat and steep zones (deep excavations and fill) will produce two distinct types of flood related responses. The flat areas will be characterised by relatively low flow velocities with a gradually build-up of ponds with varying depts. In discrete locations fast flowing concentrated flow can be expected, i.e. culverts and flow diversion structures. Steep areas will lead to concentrated flows along haul roads that will accumulate at low points. Accumulated haul road runoff and excavation slope releases will result in deep ponds in discrete locations.

Sheet and shallow flows will predominate the even zones and a combination of shallow and deep flow will predominate in steep zones. The mixture of flow regimes, computational identification of flow paths and the stormwater runoff will progress in and available information lead to the decision to use the direct rainfall method for the compilation of flood risk assessment maps.

4.7.3 Software

The HEC-RAS 6 (developed by US Army Corps of Engineers' Hydrologic Engineering Centre) was used to model and simulate the hydrological and hydraulic response of the mine areas. HEC-RAS is designed to perform one-dimensional and two-dimensional hydraulic calculations for a full network of natural and constructed channels.

The process of converting, modelling topographic data, refining the topographic data to include conveyances structures that will impact the flood modelling results (i.e., culverts and roadways), rainfall data processing and input to HECRS is laid out in the 16 steps below. The workflow assumes that data that describes all existing water related conveyance structure geometries and locations are known.

1. Establish horizontal coordinate projection to use for model within HECRAS Mapper.
2. Develop terrain model in HECRAS Mapper
3. Build land classification dataset within HECRAS Mapper to establish Manning's n within 2D flow areas
4. Add any additional mapping layers that may be needed for visualization
5. Use Geometry editor to draw boundary polygon for each 2D flow area
6. Layout and construct any break lines within the 2D flow area to represent significant barriers to flow, i.e. roads, berms, embankment, hydraulic structures etc.
7. Create 2D computational mesh for each 2D flow area
8. Edit 2D flow area mesh to refine and improve hydrological response.
9. Run 2D geometric pre-processor from RAS Mapper to create the cell and face hydraulic property table
10. Connect the 2D flow areas to 1D flow elements.
11. Add any hydraulic structures (culverts etc)
12. Use geometric data editor to construct to draw any external boundary condition lines along 2D flow area perimeter.
13. Enter all boundary and initial condition data for all 2D flow areas
14. Add boundary conditions (rainfall hyetograph etc)
15. Run unsteady flow simulation
16. Review results and refine inputs if required.

4.8 Simulation Results

4.8.1 Flow depth and flow velocity

The hydrological response of the study area is presented by geographic mapping of the runoff for the 1:50 and 1:100 recurrence interval 24-hour storm in terms of runoff depth and runoff velocity. It is important to note that the maximums do not necessarily geographically take place at the same time. The produced flood risk maps therefore give an overview in terms of worst-case scenarios on a geographical basis and not on a time basis. The time domain effects of flooding are considered during specific engineering or project orientated investigations.

Runoff over the study area during a 24-hour simulation period is presented through two aspect of the conveyed water, i.e., water depth and flow velocity. The maximum depth at any particular point during the simulation and the maximum flow velocity at a particular location are determined are presented.

Flow Depth: Depth reflects risk associated with rising water levels, i.e., flooding of equipment, breaching of water retaining systems, and accumulation of water in otherwise dry areas.

Flow Velocity (faster flowing water pose a higher risk). Velocity is a measure that present a water streams capacity to do work, i.e., erosion, lifting or moving of objects in the water stream.

Simulation result maps are presented as figures, described in Table 2.

Table 2 : Hydrological flood maps

Scenario	Recurrence Interval	Aspect	Figure Number	Page
Current	1:50	Flow Depth	11	32
	1:50	Velocity	13	33
	1:100	Flow Depth	13	34
	1:100	Velocity	14	35

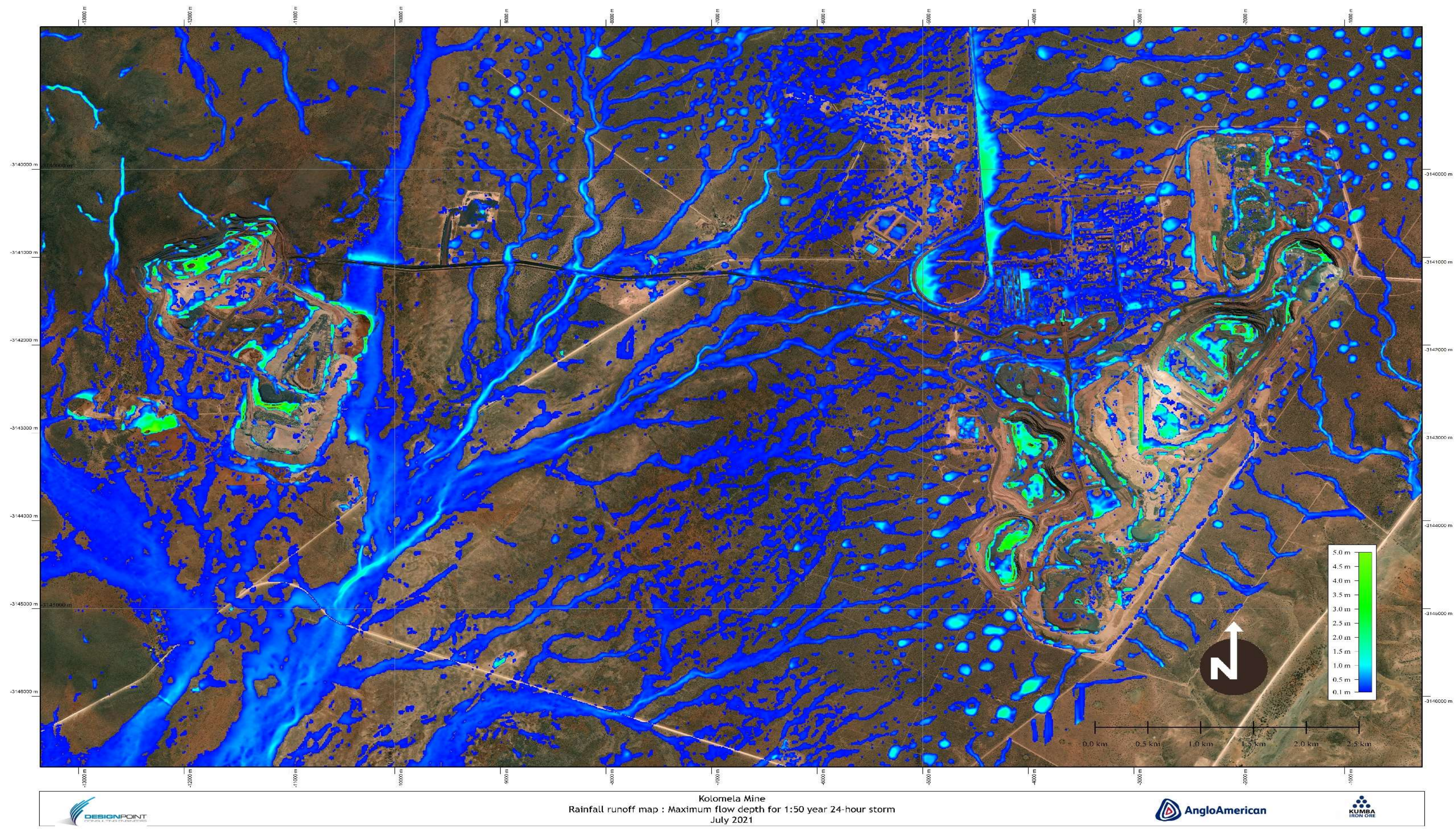


Figure 11 : Water depth , 1:50 year reccurance interval 24 hour storm.

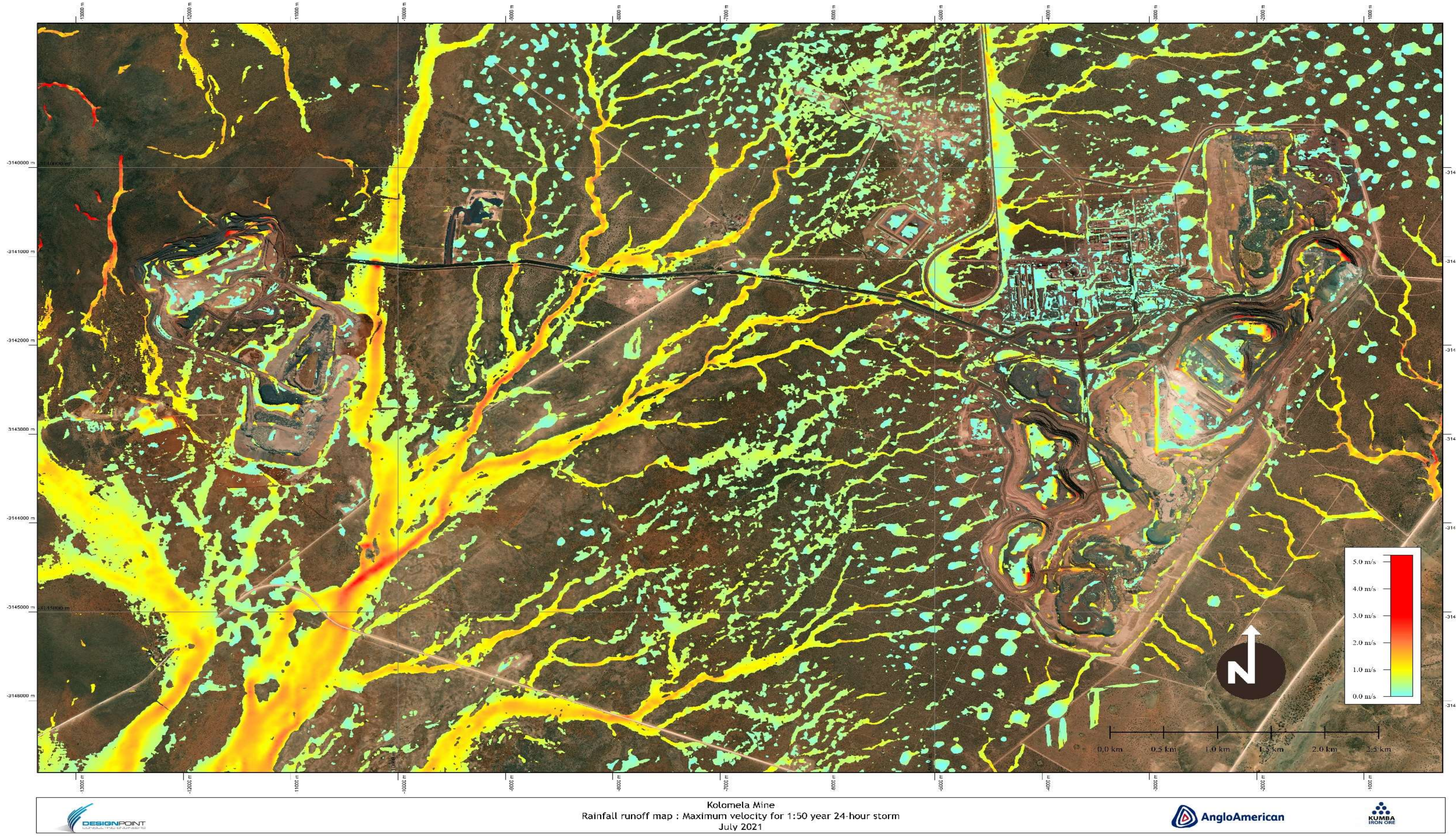


Figure 12 : Water velocity , 1:50 year reccurance interval 24 hour storm.

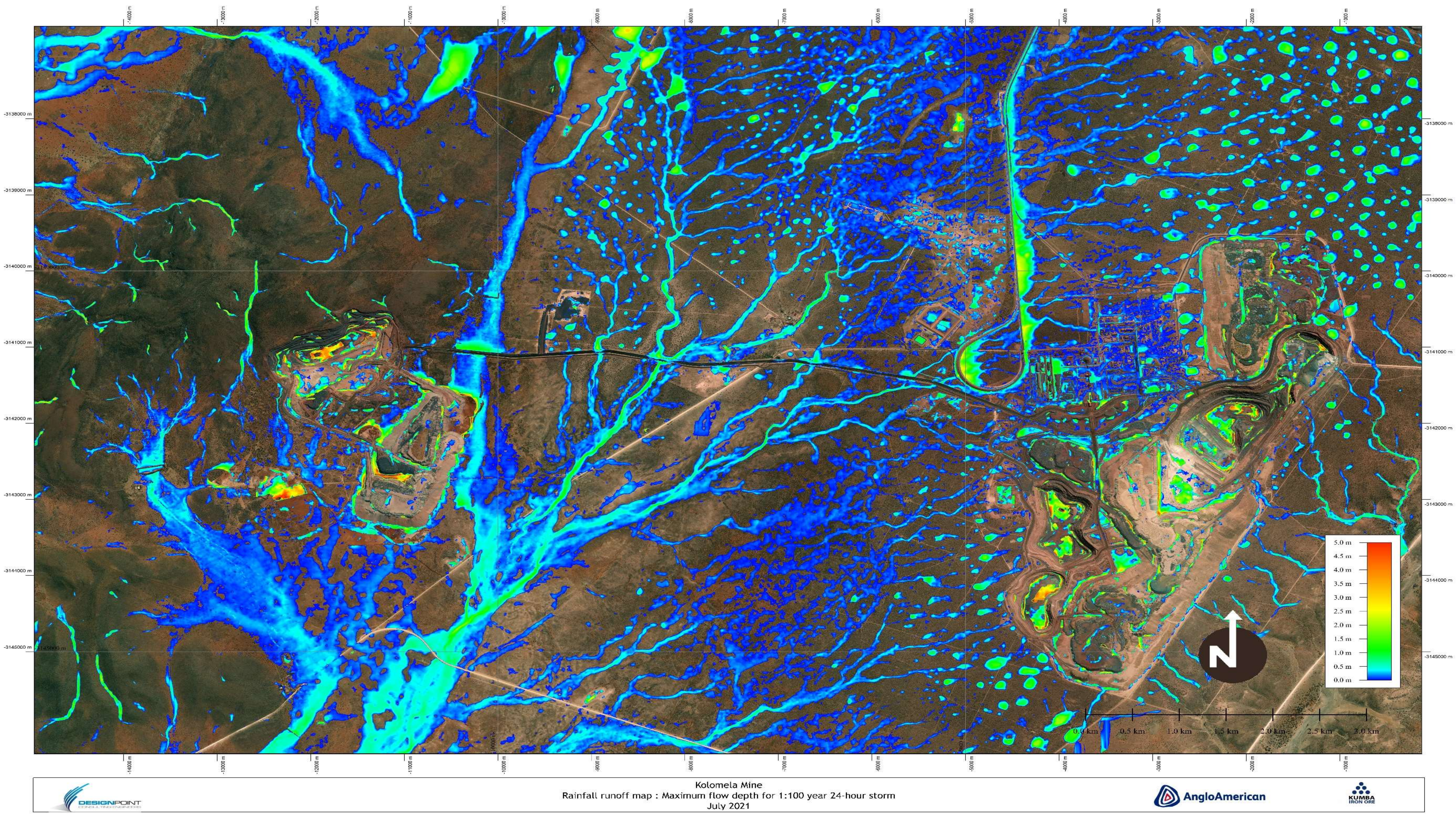


Figure 13 : Water depth , 1:100-year reccurance interval 24 hour storm.

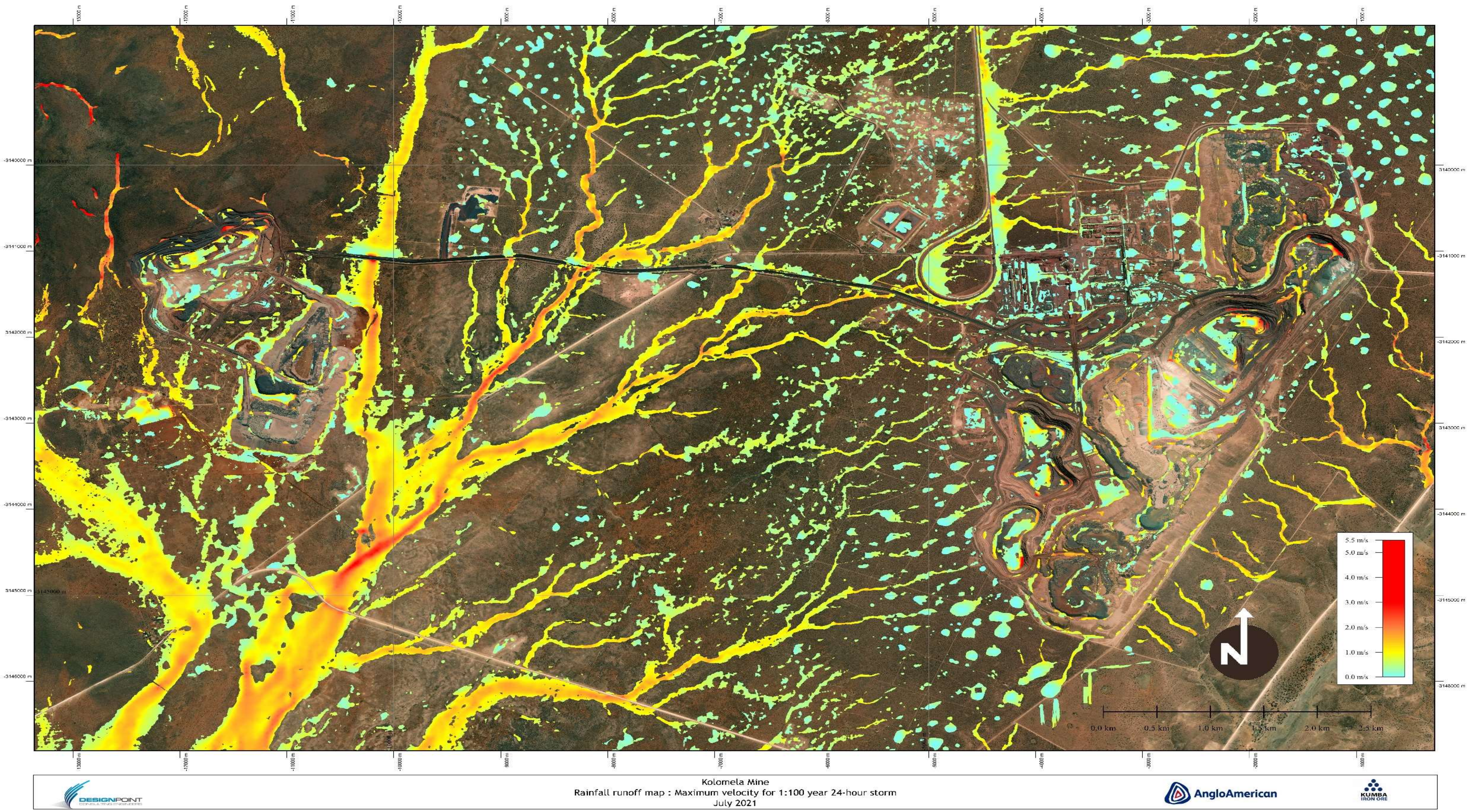


Figure 14 : Water velocity, 1:100-year recurrence interval 24-hour storm.

4.9 Floodline delineation

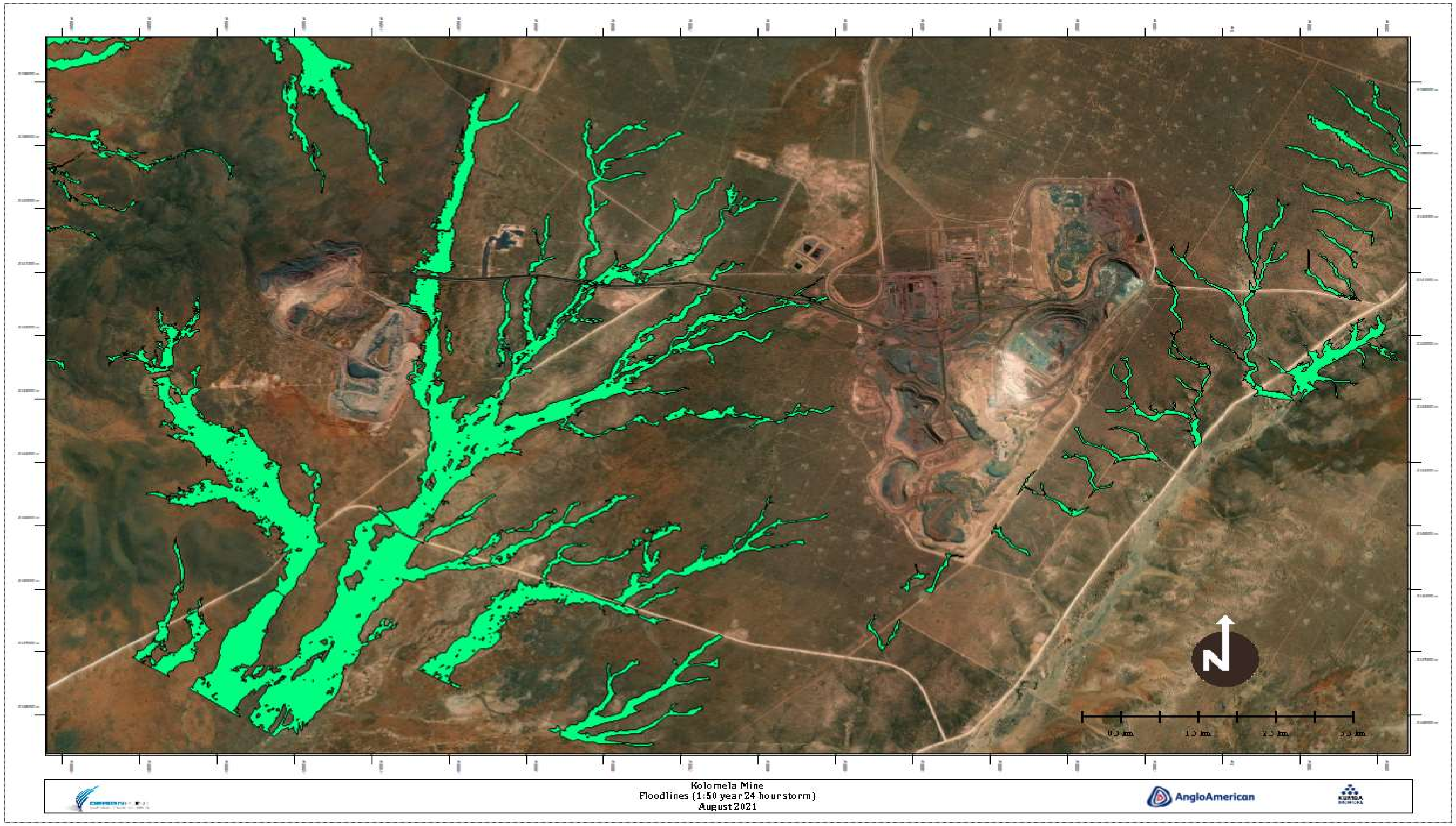


Figure 15 : Floodlines (1:50)

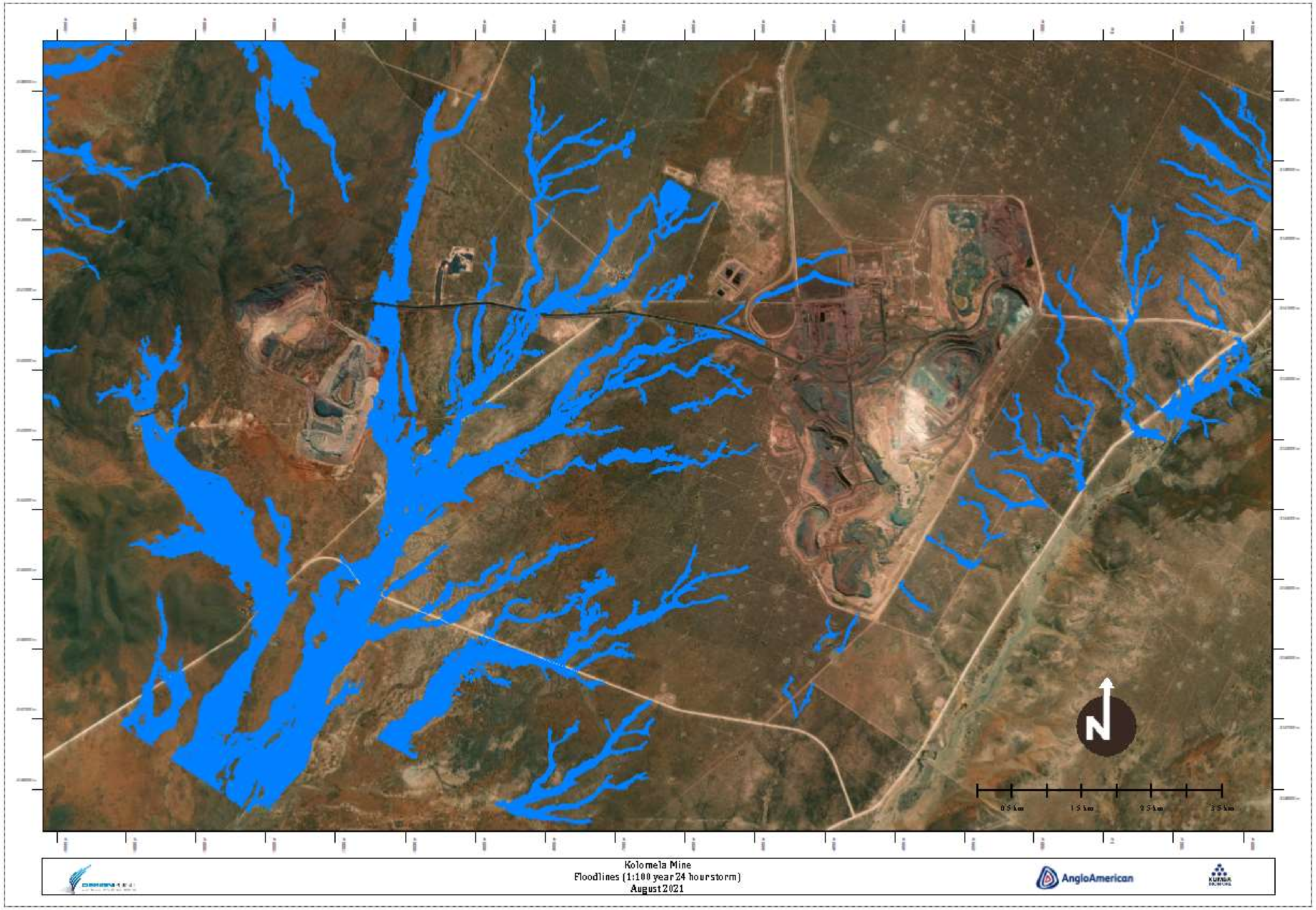


Figure 16 : Floodlines (1:100)

5 Flood Hazard identification

Furthermore, a hazard identification assessment was performed by establishing locations were a particular combination of flow depth and flow velocity falls within three ranges. The values used in establishing the ranges or, hazard identification keys, are presented in Figure 17, as low hazard (green), medium hazard(orange) and high hazard(red).

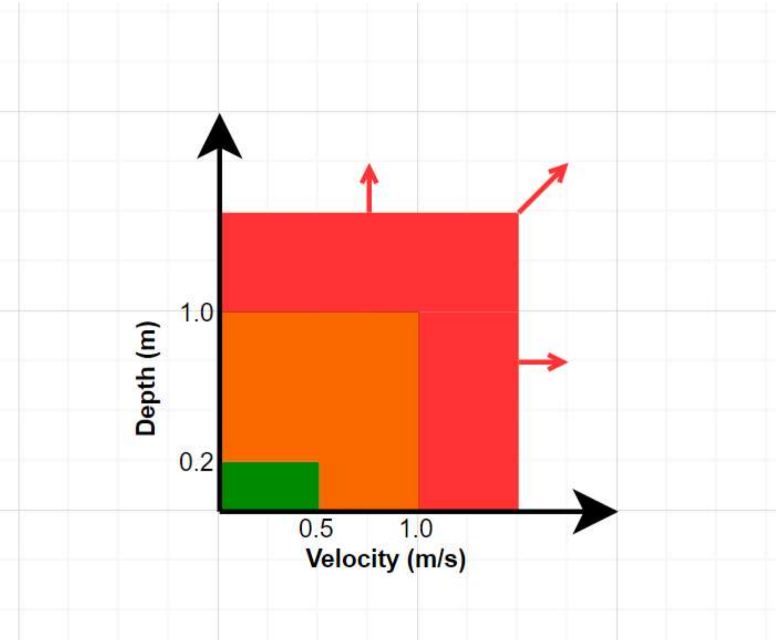


Figure 17 : Flood hazard key

Figure 18 below shows the flood Hazard Map, identifying higher risk areas in red and lower risk areas in green as described in Figure 17. The results and specific high-risk areas are described in Section 6.

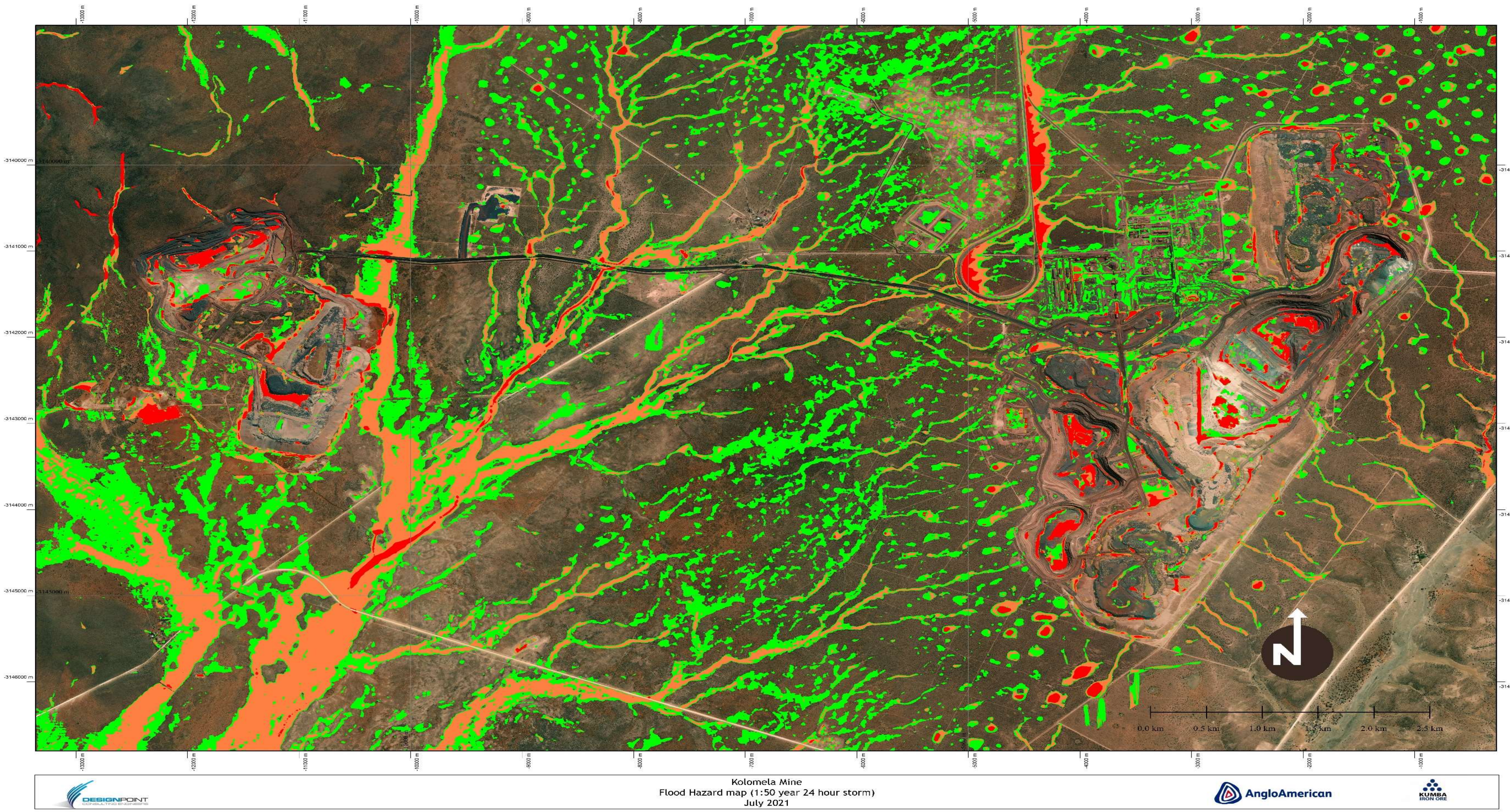


Figure 18 : Flood Hazard map 1:50

6 Flood risk identification & interventions

The purpose of this section is to highlight specific risk areas either in a clean or dirty water area. A stormwater master plan for Kolomela was compiled in 2020 and the risk identified in the following sections should be read in conjunction with the previous stormwater master plan.

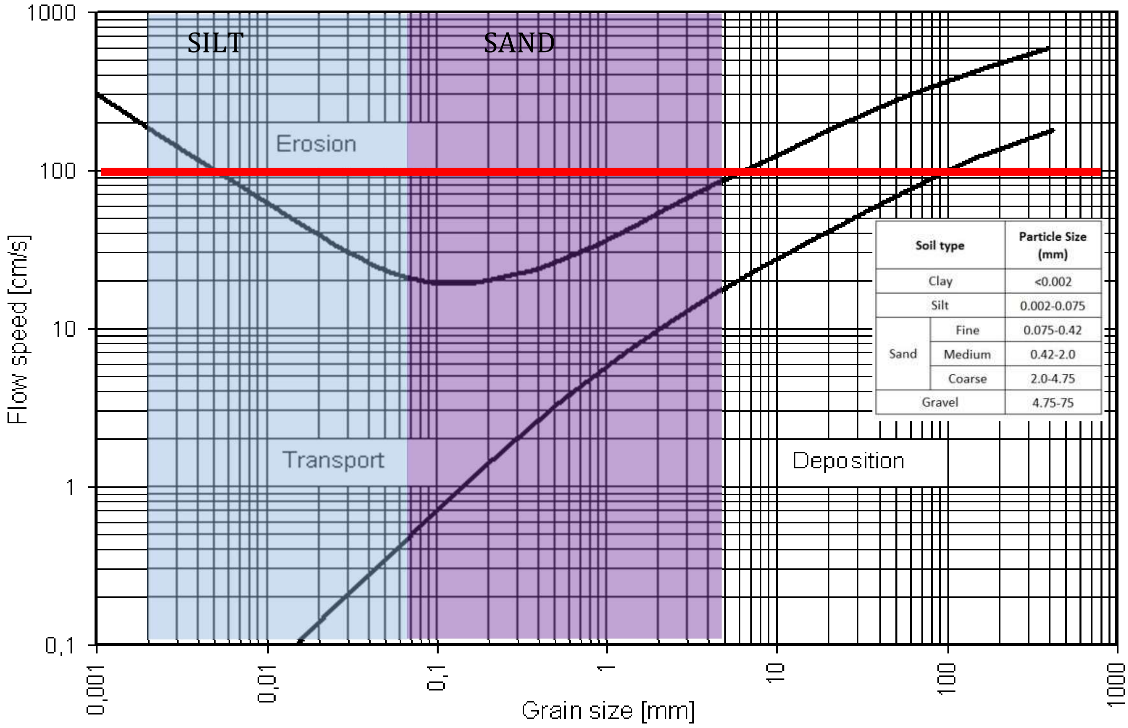
The hazard map forms an objective basis for the risk identification proses. Red zones are primary candidates for risk, followed by orange and green. Based on the risk areas that were identified in the existing stormwater master plan and our engineering judgement, the following areas are considered as risk areas.

6.1 Pit Area Sediment transport (in general)

The dynamic nature of the pit area is characterised by minimal formal stormwater conveyance and sedimentation infrastructure. Rainfall on and from areas surrounding pits naturally drain along the path of least resistance to either low points on embankments or ultimately to the low extremes in the pit, i.e., non-perennial dams. The excavation and filling operations naturally produces material that can be transported as sediment. Sediment transport and erosion will proceed along flow paths (kinetic energy dominates) and deposition will occur in relatively smooth areas where flow dissipates, and ponding establishes.

The mode of sediment conveyance can be characterised by soil particle size and the speed at which particles are transported. The scientific basis for the phenomena is well established and applied. The essentials of sediment transport can be summarised in the Hjulström curve.

The plot shows several key concepts about the relationships between erosion, transportation, and deposition. For particle sizes where friction is the dominating force preventing erosion, the curves follow each other closely and the required velocity increases with particle size. However, for cohesive sediment, mostly clay but also silt, the erosion velocity increases with decreasing grain size, as the cohesive forces are relatively more important when the particles get smaller. The critical velocity for deposition, on the other hand, depends on the settling velocity, and that decreases with decreasing grainsize. The Hjulström curve shows that sand particles of a size around 0.1 mm require the lowest stream velocity to erode.



Silt (blue) is fully transported at a velocity of 0.005 m/s and sand at 0.2 m/s. Stormwater runoff at 1 m/s has the capacity to transport and erode particles of up to 100 mm. Stormwater runoff into the pit can reach velocities more than 3 m/s.

Although the flooding is typically undertaken to establish water related risk, the impact of sediment deposition and erosion is often overlooked. This is especially significant in a pit, as erosion will be prominent on haul roads and steep inclines, with the resulting transported sediment being deposited in areas where velocities decrease, and water accumulates.

Haul roads typically act as paths of least resistance due to the relatively even surface boarded by safety berms. Flat areas in the pit typically act as platforms to provide dust suppression refilling infrastructure, parking facilities, booster pump station and foundations for ore conveyance infrastructure. Flooding and sedimentation deposition and erosion can lead to failures related to bearing of foundations, switch gear malfunction and even just buried infrastructure components. Reinstatement can be time consuming.

6.2 DMS

The current topography of the DMS area (indicated in red in Figure 19) and the activities in the area result in a natural ground surface that has a low gradient and prone to flooding.

Figure 19 : DMS location map

A half meter contour and elevation shade map of the area is shown in Figure 20. The map indicated a relatively flat area, although local depressions and high points will lead to ponded water during a rainfall event. Drainage from the area is constrain, due to non presents of natural sloped drainage causeways.

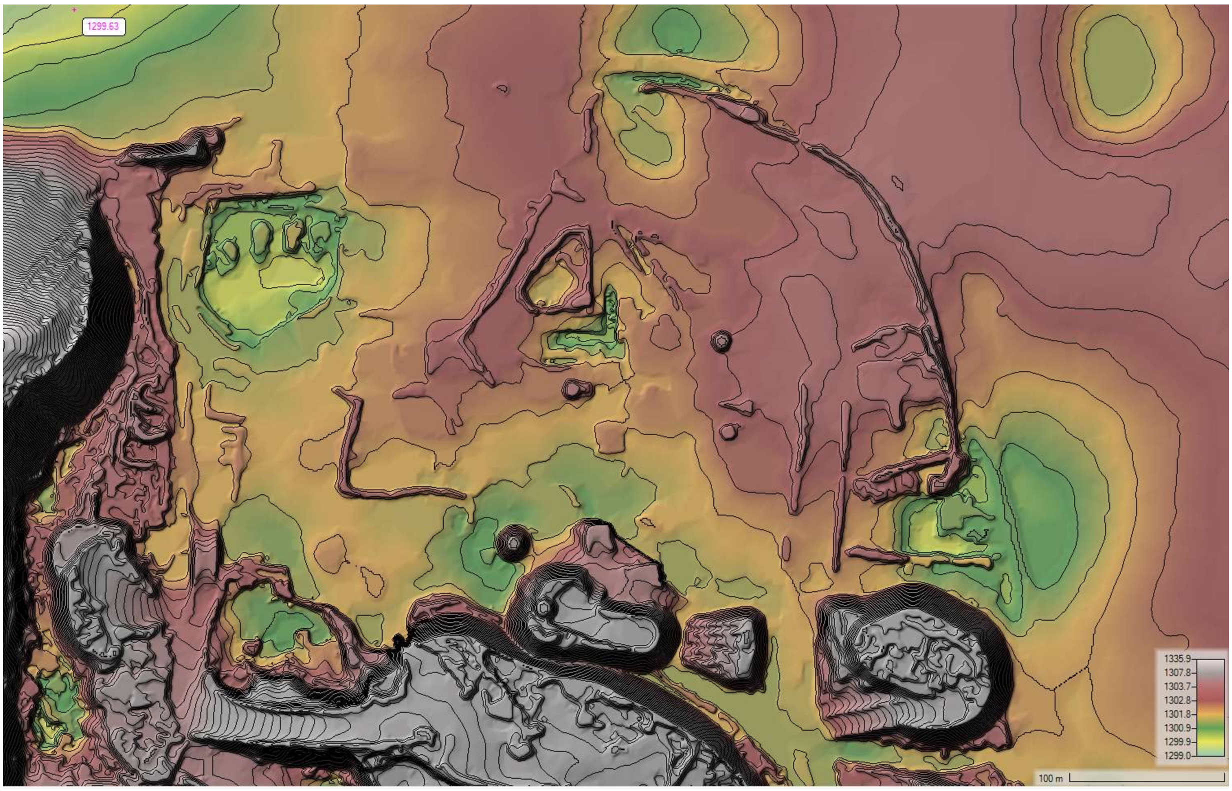


Figure 20 : DMS area contour map

The hazard map of the area (Figure 21) and feedback from the mine supports the flooding problem. A significant portion of the DMS area contains standing ponded water, during and after high rainfall events. Even though the depth and velocity of this area is not red as per hazard identification, standing water in this area affects proper functionality of the DMS plant and hence production.

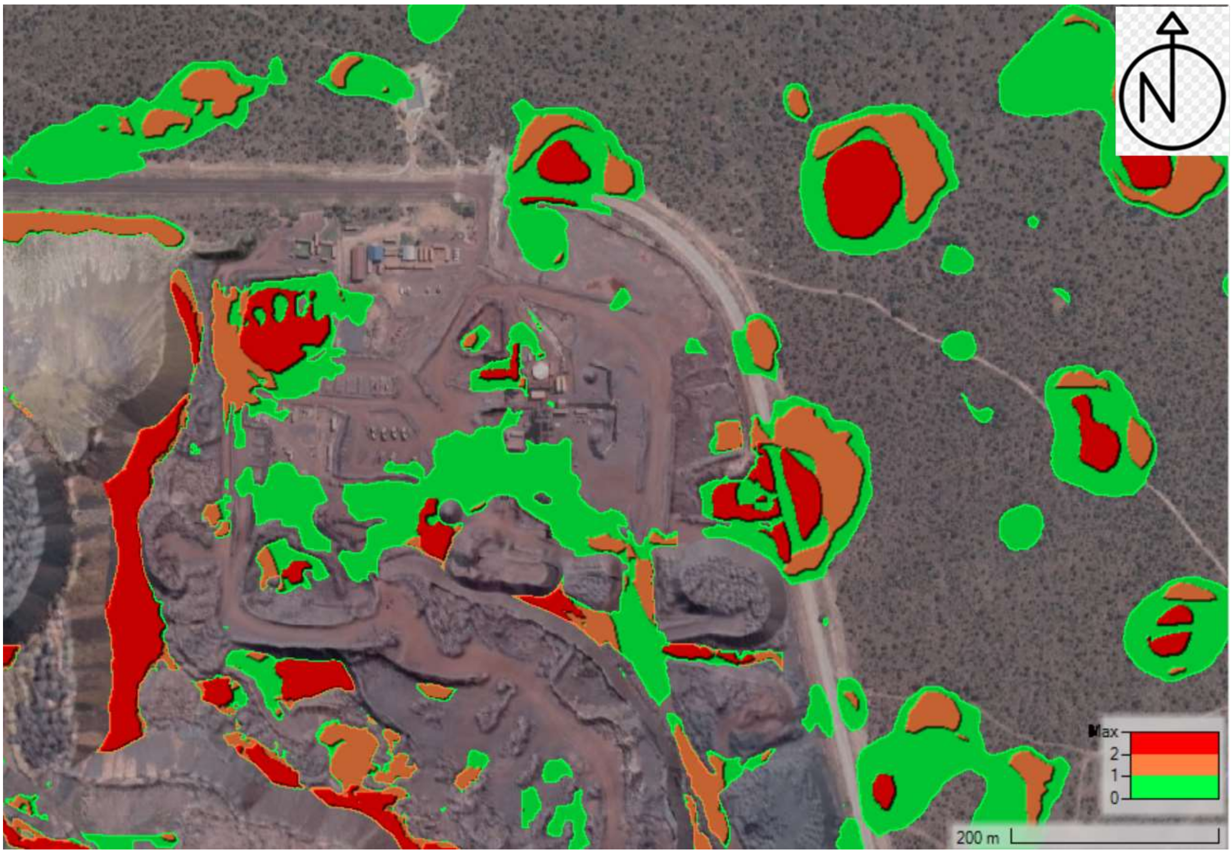


Figure 21 : DMS area hazard map

A possible solution to establish formal drainage in the area is to drain water to the new planned Return Water Dams. A sketch of the plan is shown in Figure 22. Drawings showing the concept design for the area is attached in Appendix D. The sizing of all channels was done using the hydrology study as described in Section 4.

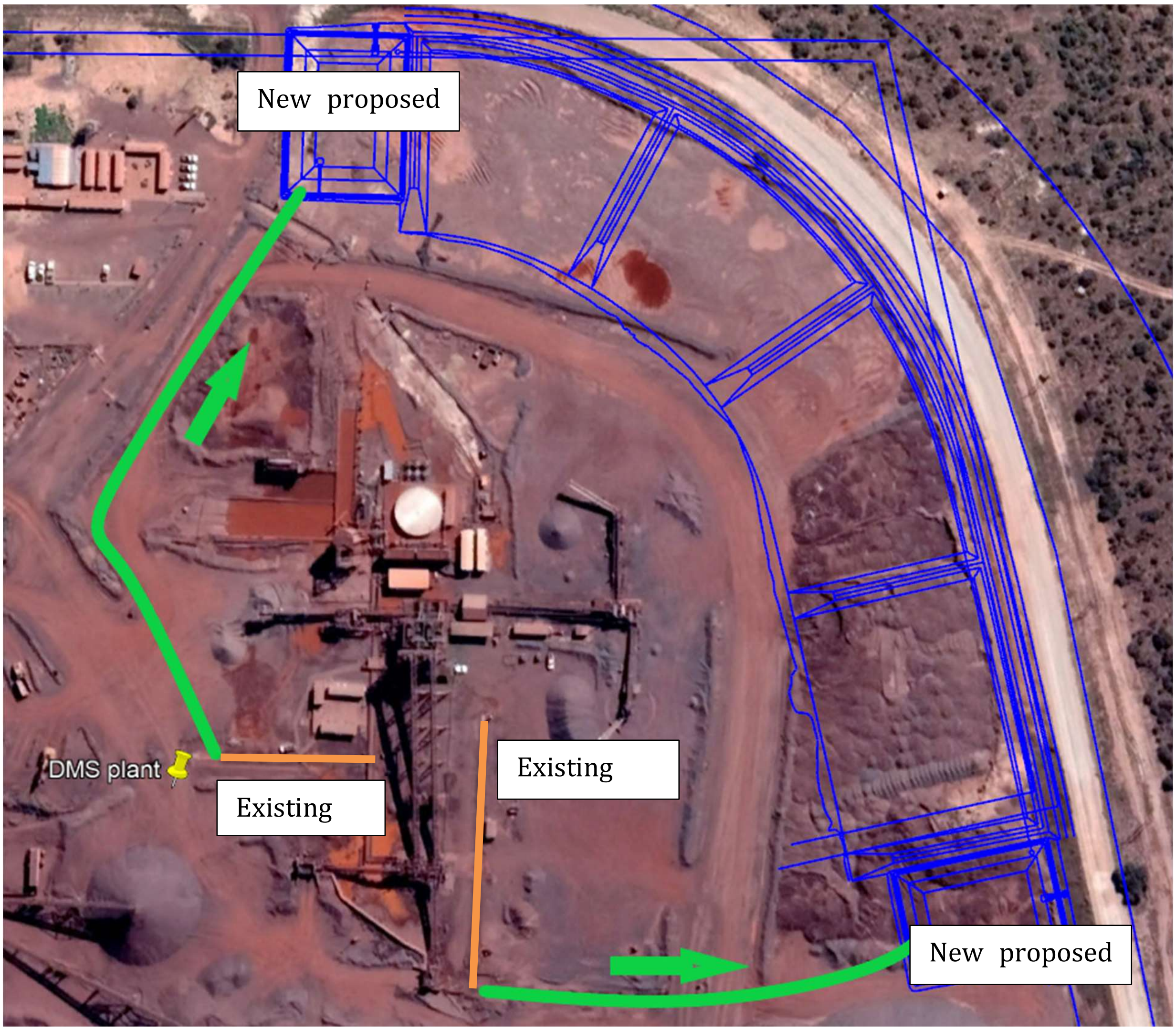


Figure 22: Proposed new channels to RWD areas

6.3 Plant Area

The hazard identification map for the 1:50 24-hour RI rainfall event in the plant area is shown in Figure 23. Three risk areas are identified namely Area A, Area B and Area C.

Figure 23 Plant area flood hazard map

Area A represent the channel leading up to and discharging into PCD1. Area B represent the discharge works and channel joining PCD1 and PCD3. The PCD1 system capacity is restrained by the hydraulic capacity of the channel that connect PCD1 and PCD3, resulting in the inlet channel flooding, and breach of PCD1. The same results and problems were identified in the Stormwater Master plan report.

The inlet-discharge arrangement of PCD1 will not support sedimentation action, due to the direct hydraulic link between the inlet and outlet. It is recommended to rearrange the inlet and/or outlet to ensure the longest hydraulic path possible. Two possible arrangements (blue and yellow) are presented in Figure 24.

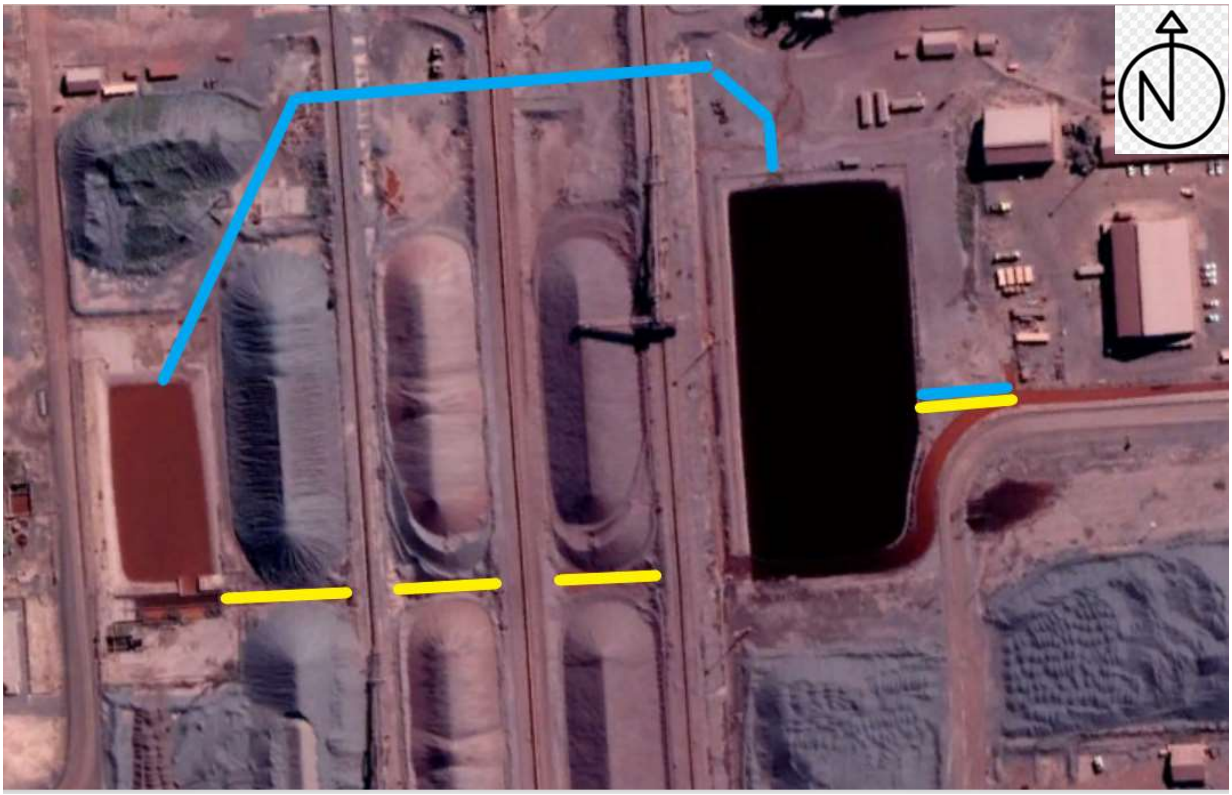


Figure 24 : Possible flood risk mediation measures.

Furthermore, it is proposed to provide a link between PCD3 and PCD2, to transfer overflow from PCD3 to PCD2. It is important that stormwater in this area is kept in a closed system as the area is identified as dirty water area and no spillage of these dams are allowed into the surrounding clean areas.

A summary of the risk and solutions to Area A is provided in Table 3.

Table 3 : Plant Area risk summary

Area	Area Description	Risk Description	Mediation
A	Channel and Inlet to PCD1	PCD1 breaching	Increase outlet capacity and realign inlet discharge to PCD1
B	Channel connecting PCD1 and PCD3	Hydraulic capacity of the channel is severely constrained	1. Modify channel cross section by providing retaining wall on either side of the channel.

Area	Area Description	Risk Description	Mediation
		by stacker reclaimer operations and sedimentation.	2. Re-alignment of the channel between PCD1 and PCD3 towards the northern side of PCD1

Area C refers to water accumulating at the Primary crusher conveyor incline area. From the flood maps this area has deep standing water and hence shown in red on Figure 23. During high stormwater flood events workers in this area are at high risk due to flood water entering the incline shaft.

It is important that this area is properly closed off with Bund walls to prevent water flowing into the area. The proposed location of the bund walls is shown in blue on Figure 25.Pumps should also be provided to pump water out as fast as possible. Two options are proposed for the pumping system and should be investigated. These are:

1. Pump stormwater to PCD2.
2. Pump water to Klinbankfontein evaporation dam.

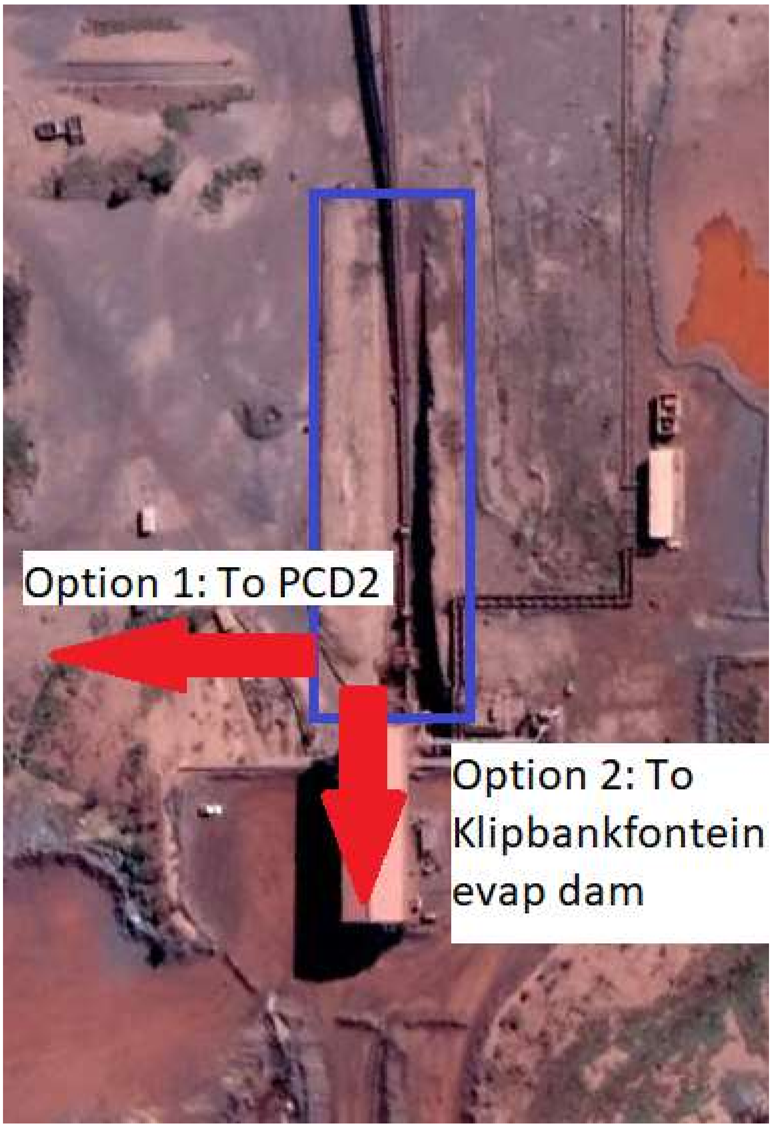


Figure 25: New bund walls around incline shaft and proposed pumping options

6.4 Rail and Rail loop

Flood waters build up next to the railway and in the railway loop was identified as a hazard as indicated in Figure 26. Although the depth of the water next to the railway line is more than 1 m, the depth is not sustained for long periods. Water is transferred through culverts and dissipates within 24 hours. This area has a service road and is therefore considered a risk. A possible mediation measure is warning signs at the entrances to the access roads or temporary closing access to the area during and after major rainfall events.

Two culvert arrangements are responsible for draining stormwater out of the railway loop. Both are two barrelled 1.5 x 1.5 m box sections, as indicated in Figure 27. The ponding is due to the relatively flat topography in the rail loop area, and the two discrete drainage locations. The more southernly located culvert transfers the majority of stormwater out of the railway loop area. The service road in the railway loop area therefore considered a risk. A possible mediation measure is warning signs at the access to the railway loop.

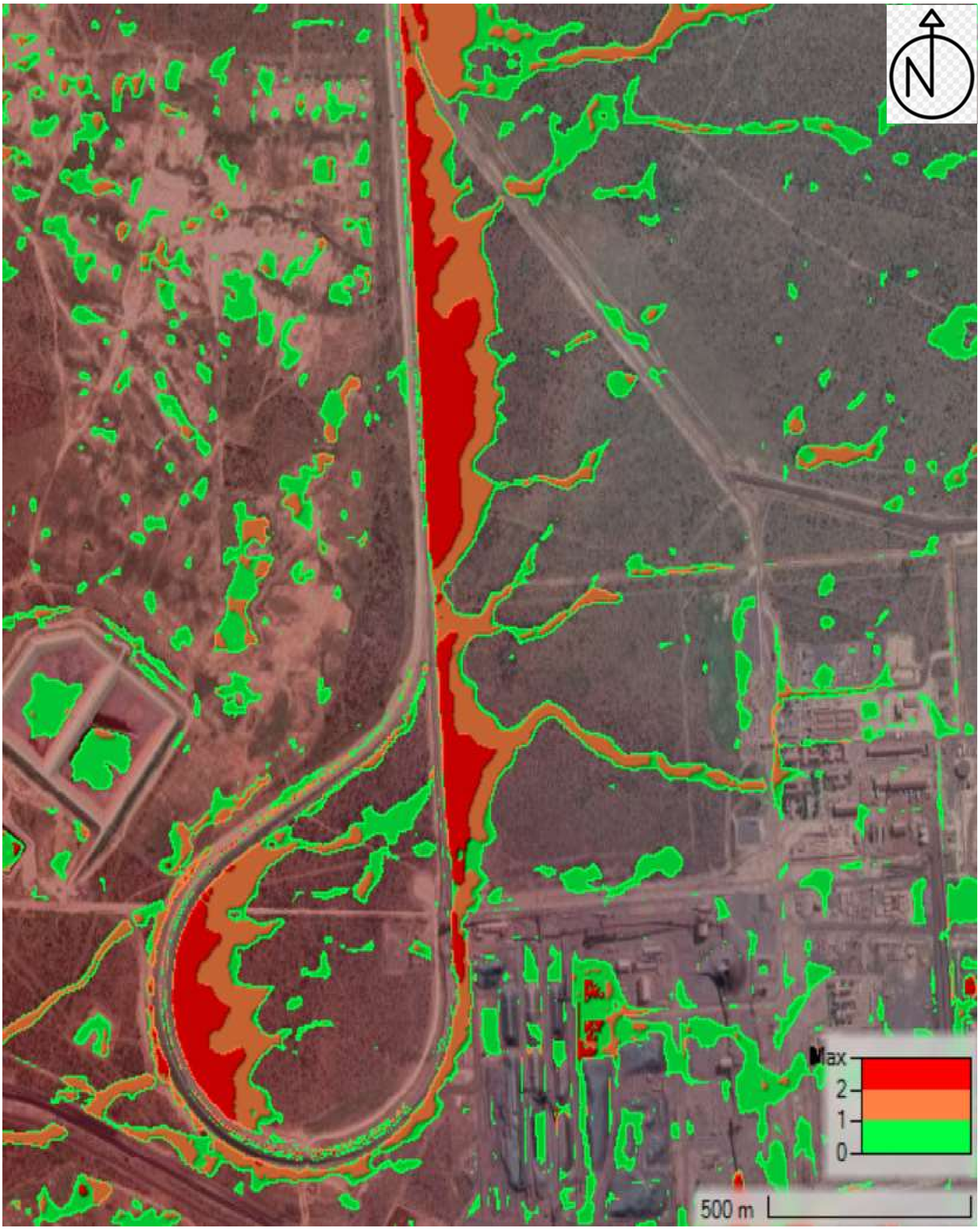


Figure 26 : Rail and Rail loop flood hazards

Figure 27 : Rail loop culvert

6.5 Haul road between Leeuwfontein and Kapstevel

The haul road between Leeuwfontein and Kapstevel was constructed with 10 culvert arrangements that convey stormwater from the north of the haul road to the south. Each of the culvert arrangements have a specific number (Between 1 and 7) of 1 x 1 m box sections (barrels). The elevated vertical profile of the haul road ensures that the culvert transfer stormwater before the haul road is breached. A typical arrangement is reflected in Figure 28.

Figure 28 : Haul Road, five-barrel culvert near Kapstevel

The simulation results, however, indicate that five of these culvert arrangements will be breached during the 1:50 24-hour recurrence interval storm. The location of the four culverts is indicated on the risk map in Figure 29. A site inspection of the culverts indicated that most of the culverts have downstream obstacles that will impede the natural flow of water. This includes vegetation growth and or haul road maintenance related wearing course material. It is recommended that regular maintenance and cleaning of the inlet approach and discharge side of the culverts to ensure optimum hydraulic conveyance capacity is available.

The main risks identified in the preceding sections as well as the proposed mitigation actions are summarised in Table 4.

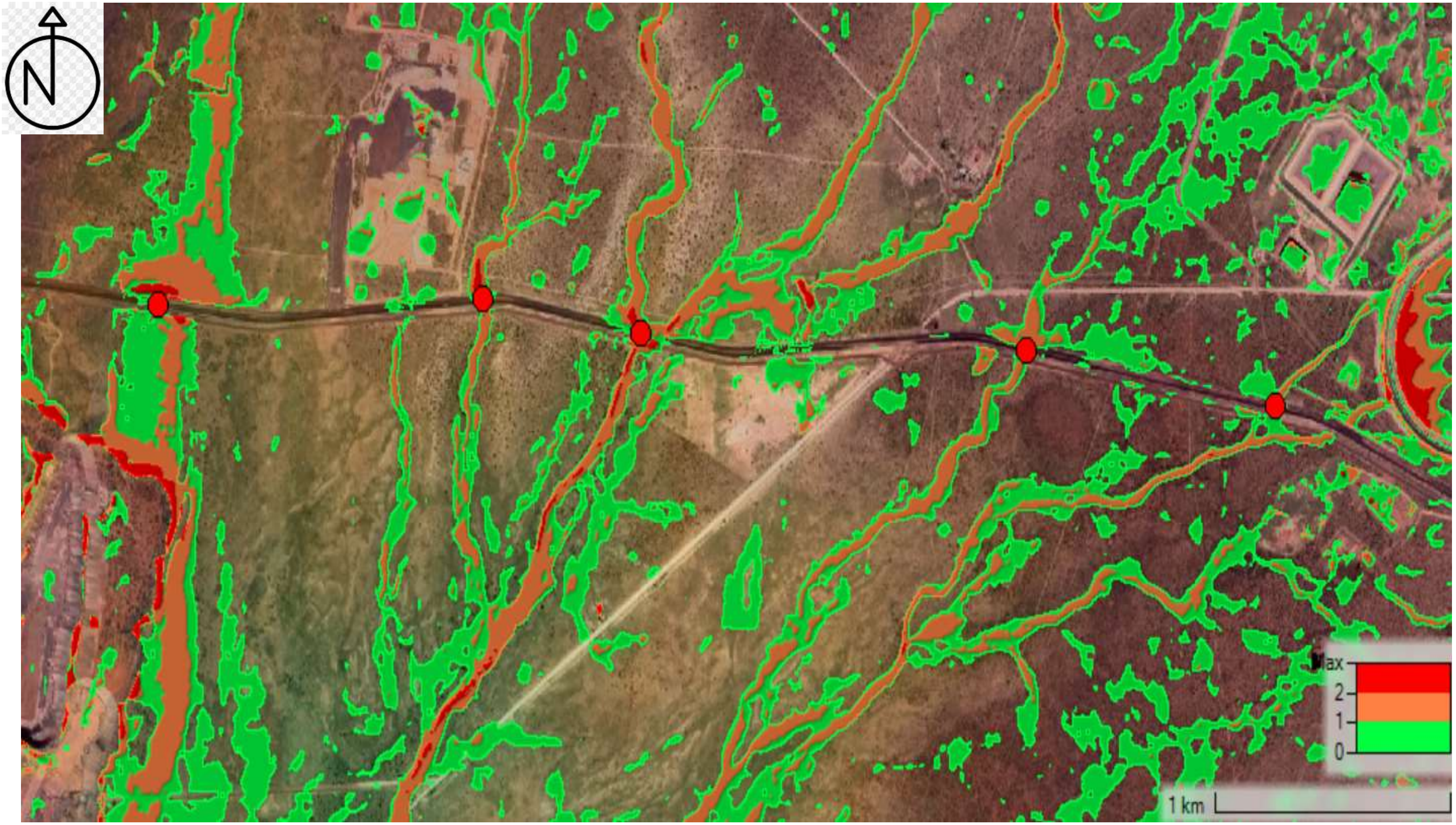


Figure 29 : Haul road culvert hazards

6.6 Risk and mitigation summary

The main risks identified in the preceding sections as well as the proposed mitigation actions are summarised in Table 4.

Table 4: Risks and mitigation measures

Risk Areas identified	Clean/ dirty water areas	Mitigation Actions
Leeuwfontein, Kapstevel and Klipbank fontein pit areas	Dirty water area	• Immediate evacuation of deepest pit areas • Develop an emergency flood procedure which must be distributed to all parties and updated on a regular basis as pit formation changes over time • In critical areas dewatering mobile pumps must be readily available to pump stormwater into evaporation ponds in shortest possible time • Identify temporary low risk low lying areas as stormwater storage ponds • Ensure that a lightning warning system is in place and procedures are followed accordingly.

Risk Areas identified	Clean/ dirty water areas	Mitigation Actions
Pit areas- sediment transport	Dirty water area	• All channels in and around the pit area should be serviced regularly to clean out sediment • Bund walls/ berms to be provided around in-pit pumps and infrastructure to prevent sedimentation and damage in and around infrastructure • Ensure haul road specifications adherence and maintenance on roads
DMS plant area	Dirty water area	• New channels to be constructed to convey runoff to the proposed RWD system • Connect existing stormwater infrastructure to the new proposed channels • Regular inspection, cleaning, and maintenance of conveyance infrastructure • Use stormwater that is collected in the sumps and dams around the DMS area in the plant processes.

Risk Areas identified	Clean/ dirty water areas	Mitigation Actions
		• It is not advised to pump excess water to Leeuwfontein evaporation dam as the dam needs to be kept empty as far as possible during rainy season.
DSO Plant area (Area A and B)	Dirty water area	• A new channel connecting PCD 1 and PCD3 is proposed as shown as shown in blue on Figure 24. • Option 2 is to provide retaining walls on both sides of the channel (in yellow on Figure 24) connecting PCD 1 and PCD3 • Increase the outlet capacity of PCD 1 • Provide a new connection from PCD3 to PCD2 to prevent flood water from PCD3 to return via the existing channel to PCD1
DSO Plant area (Area C)	Dirty water area	• Provide berms of approximately 1m high around the incline shaft. A typical detail of the bund wall is shown on drawings attached in Appendix D. • Mobile pumps should be available to pump water out of shaft area as fast as possible.

Risk Areas identified	Clean/ dirty water areas	Mitigation Actions
		• It is proposed that stormwater from the shaft area is pumped to PCD2 or to Klipbankfontein evaporation dam. From these dams stormwater can be re-used in plant area.
Rail loop area	Clean water area	• Ensure that the inlet and outlet side of culverts are kept clean and clear of obstacles. • Establish warning signs and access gate control traffic going into this area during a flood event
Culverts along Haul Road	Clean water area	• Ensure that the culvert inlet and outlets are kept clean and free of debris

7 Hydrological impacts of Kapstevel expansion

7.1 Non-Perennial streams

The non-perennial streams (stream A and B in Figure 30) that will flow during a rainfall event, and in particular during the 1:50 year 24-hour rainfall event, have an effect on the required stormwater related infrastructure associated with the Kapstevel expansions activities. The effects are evaluated from a volumetric flow point of view (hydrograph) and from a water quality (clean and dirty water) point of view.

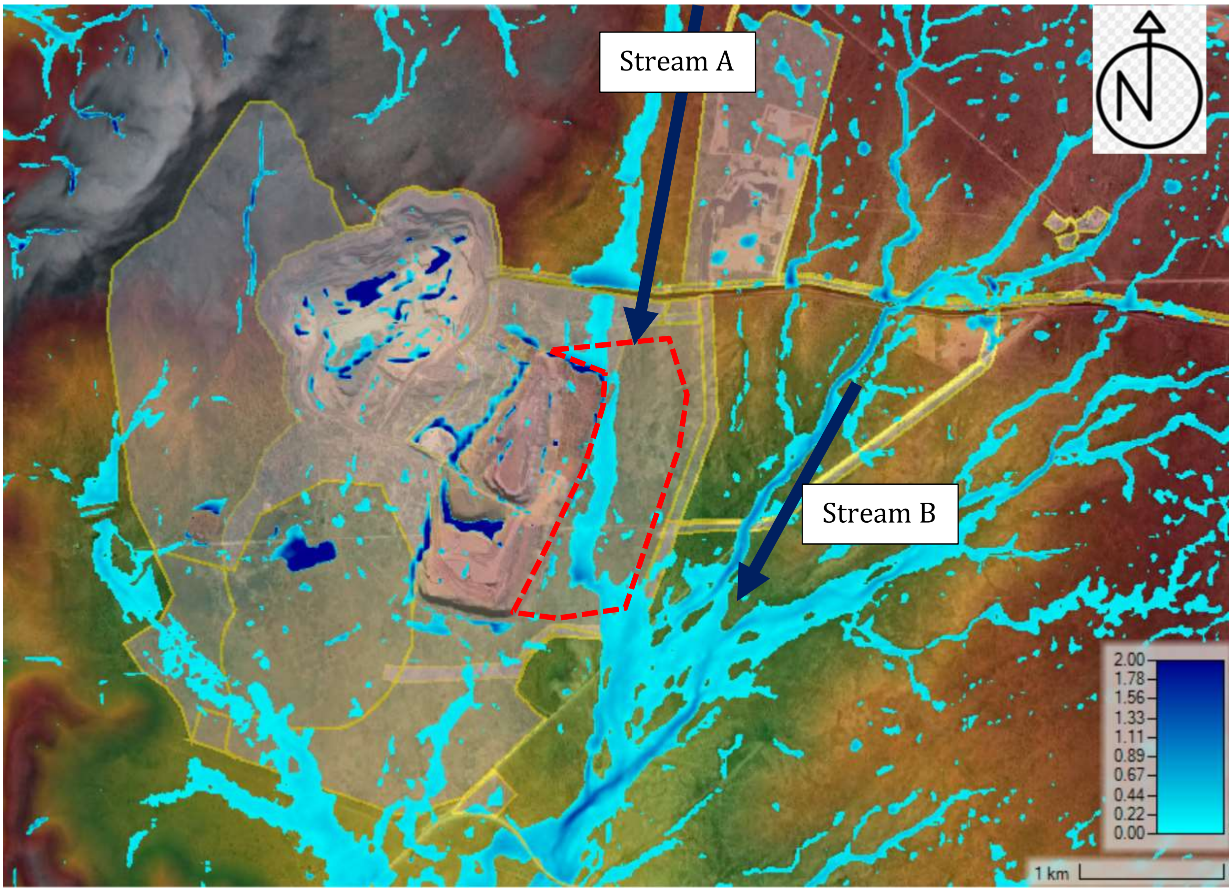


Figure 30 : Non-perenial streeams at Kapstevel pit arae (1:50 , 24 hour RI storm)

7.1.1 Stream A

Problem Statement: The locations of the current and proposed (indicated as a red dashed polygon in Figure 30) expansion of waste rock dumps are in the natural water course of stream

A. The current five-barrel culvert arrangement at this location (Figure 28) has a hydraulic capacity of approximately 22.5 m3/s. The 1:50 24-hour recurrence interval storm produces a flow of 55 m3/s at this location, refer to hydrograph in Figure 31. The haul road will therefore be breached for approximal 1.5 hours during the 1:50 24-hour rainfall event.

Proposed Solution: The culvert discharge and the breached flow will flow into the proposed rock dump area, blending water qualities and producing uncontrolled flow between the proposed rock dumps and the haul road. This situation can be addressed by diverting the stream with a berm and structured channel arrangement and ensuring that sufficient hydraulic capacity is provided with culverts during the doubling of the current haul road. The required volumetric flow that must be diverted and channel can be visually assessed by the hydrograph (1:50 RI rainfall) of stream A just before traversing the haul road, as presented in Figure 31.

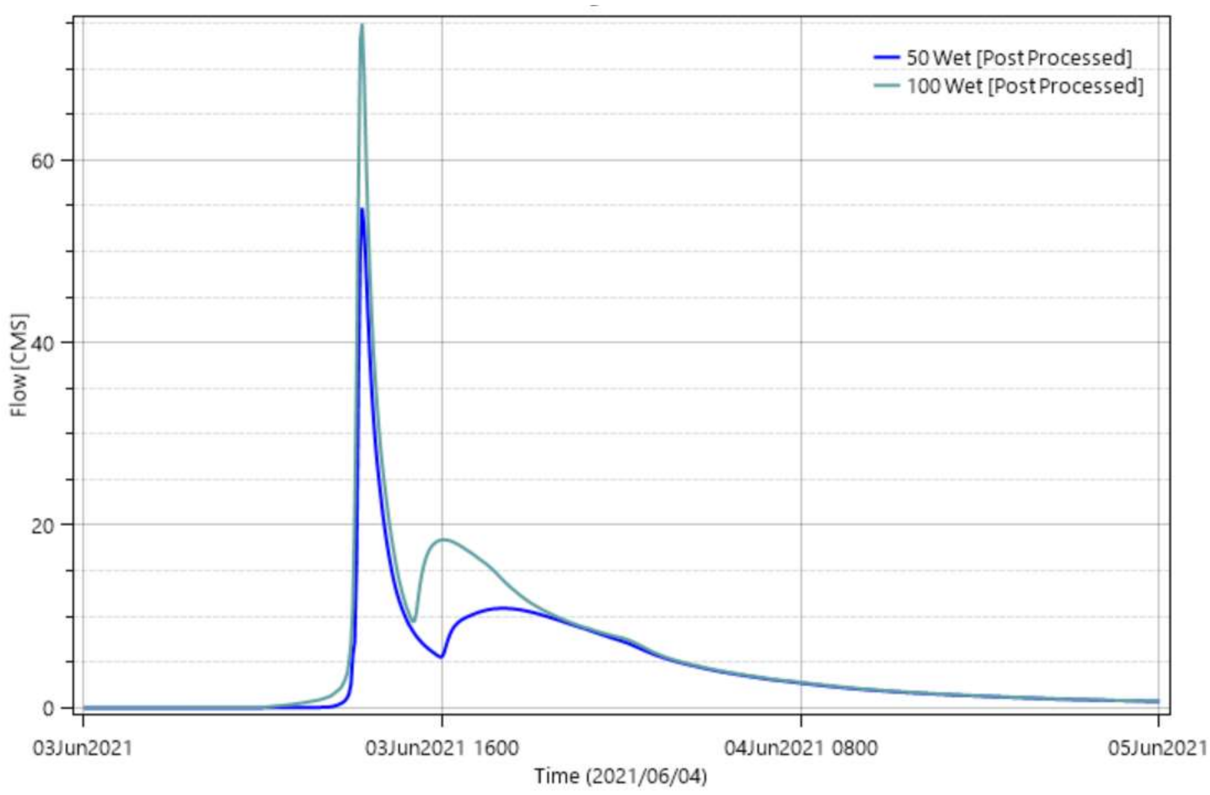


Figure 31 : Stream A, hydropgrapoh during the 1:50a nd 1:100 , 24-hour RI strom.

A stream diversion is implemented by alteration in flow direction and conveyance of stormwater away from the north of the rock dumps. A berm-and-channel arrangement south, next to the haul road can ensure direction change. A structure channel will then convey diverted water to a release point further down the catchment. A layout of the proposed stream diversion channel and the impact on the hydrology is presented Figure 32 (flow velocity) and Figure 33 (flow depth).

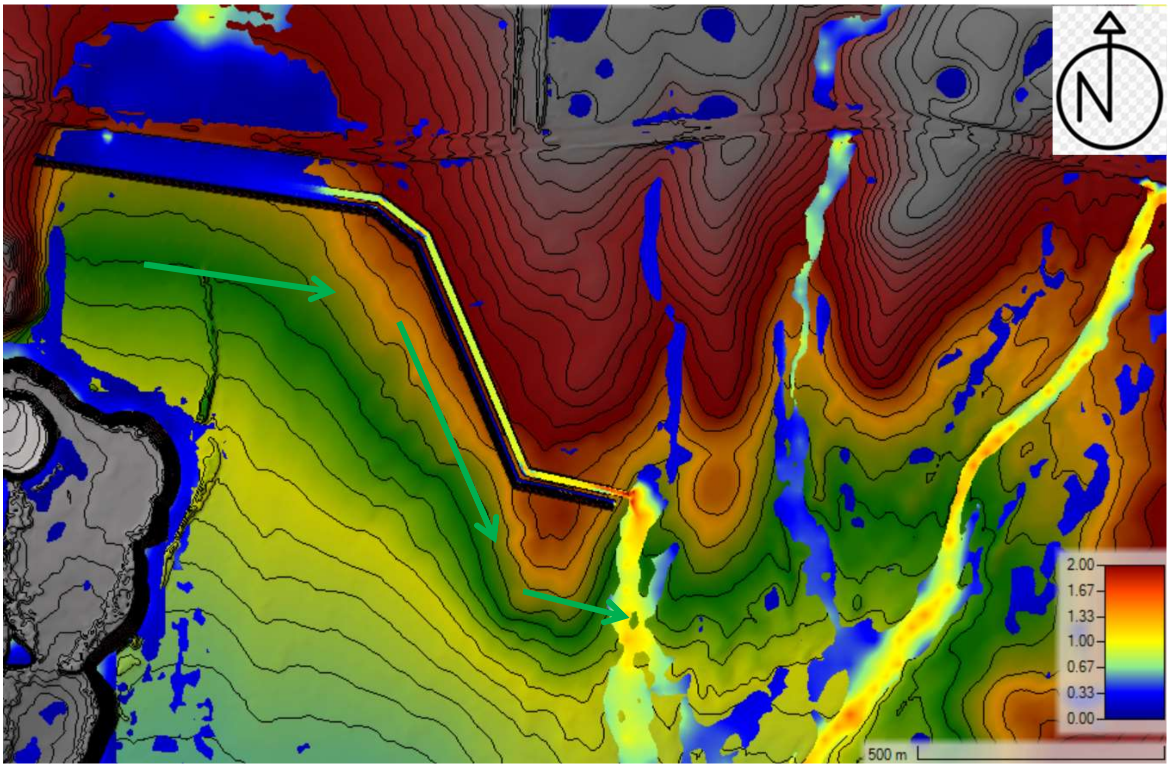


Figure 32 : Flow velcoity of proposed stream diversion of stream A.

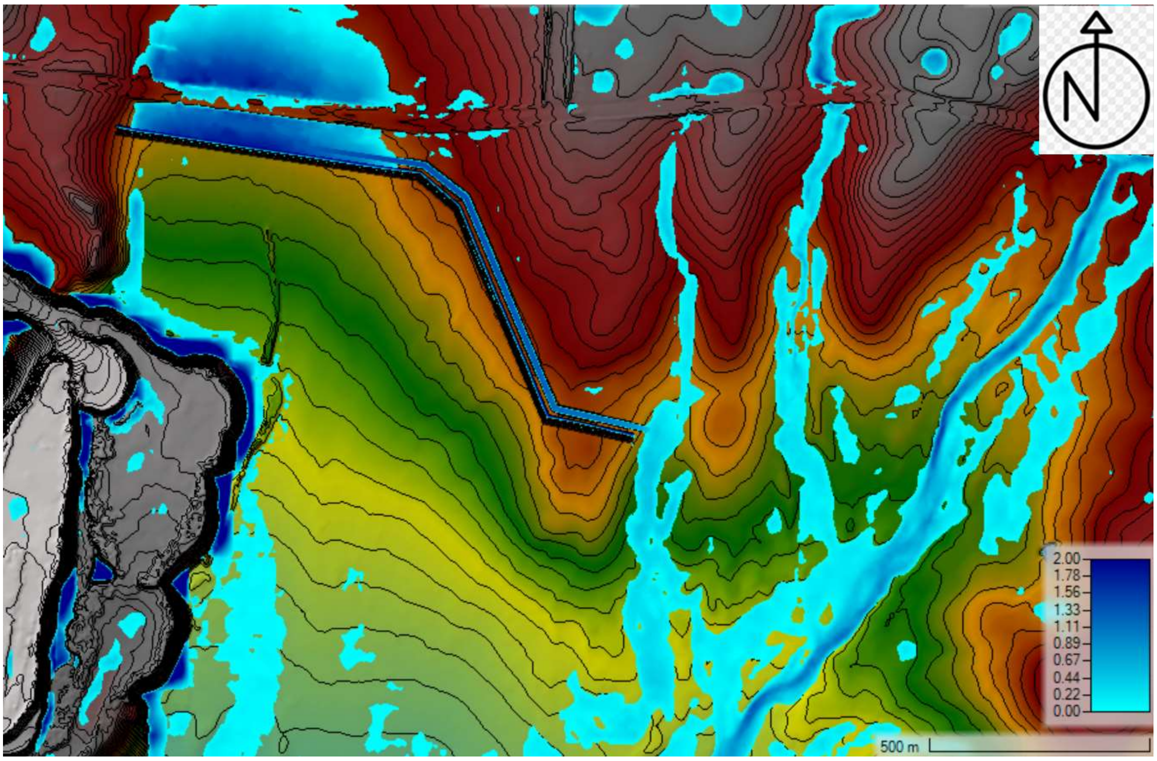


Figure 33 : Flow depth of proposed stream diversion of stream A.

The longitudinal profile of the proposed diversion channel is presented in Figure 34. Excavation depths will be up to 4 m.

Figure 34 : Logitudinal profiukle of Stream A diversion channel.

7.1.1.1 Diversion channel hydraulics

The proposed cross section of the diversion channel is presented in Figure 35. The compound channel consists of a trapezoidal shaped concrete lined primary conveyor and a rectangular shape secondary conveyor. The secondary conveyor is established by two "service roads" on either side of the channel, border by 2m heigh Gabion (or similar system) retaining system. The proposed channel section will establish structured drainage for flows of less than 30 m^3/s (primary channel) and contain and conveys the flow associated with the 1:50 and 1:100 24-hour rainfall event (primary and secondary channel). The secondary channel lining will be a waterproof cohesive n a compacted surface bed.

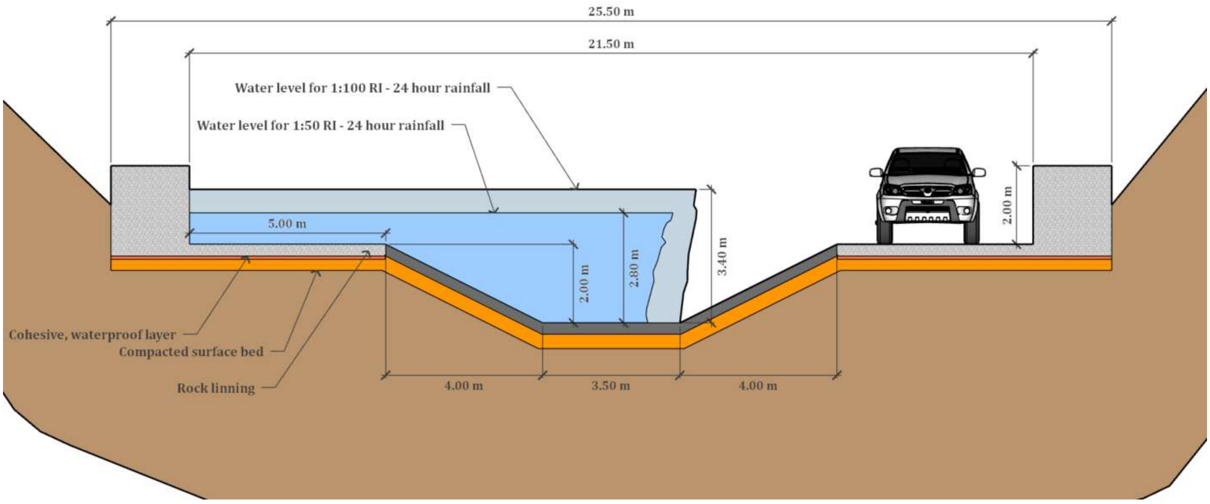


Figure 35 : Proppposed diversion channel cross section

The hydraulic performance of the proposed cross-section is presented in Figure 36. The flat longitudinal gradient (0.04%) of the channel lead to a maximum Froude number of 0.34, and a maximum flow velocity of 1.3 m/s for the 1:50 RI storm.

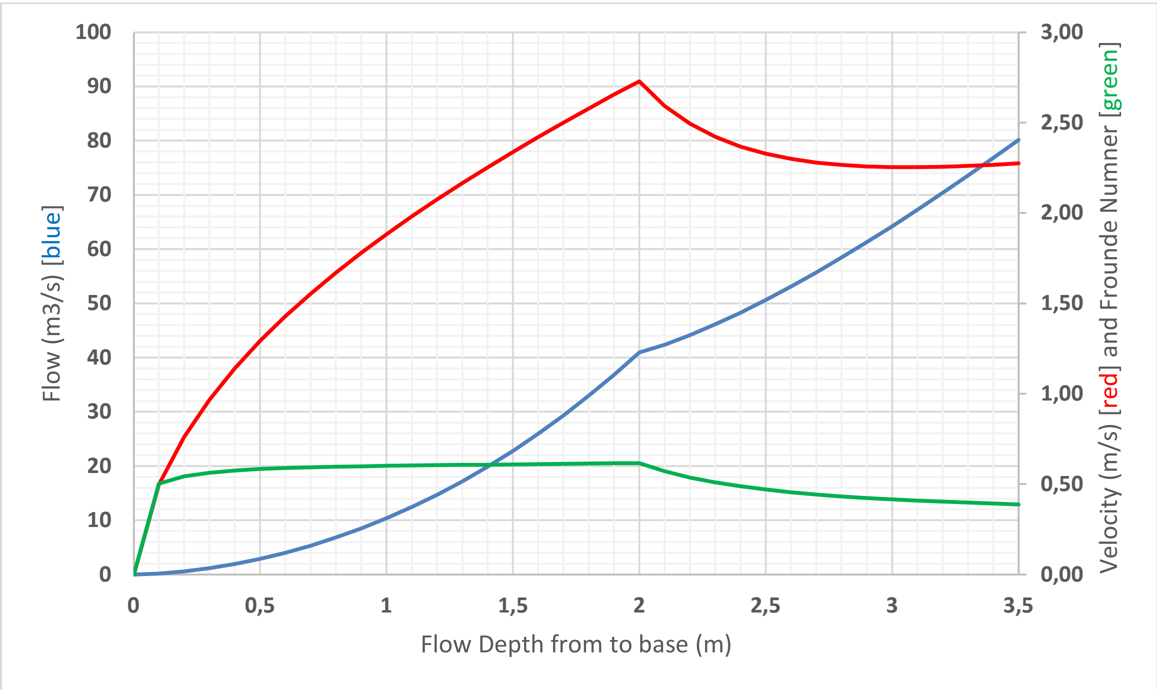


Figure 36 : Diversion Channel Depth-Flow and Depth Velocity relation

7.1.1.2 Energy dissipation

The final reach of channel discharge location is into a non-perennial stream that has a natural flow velocity of between 0.7 – 0.8 m/s. The maximum discharge velocity (Figure 32), are 2.6 m/s and a Froude number 1.02. The higher discharge velocity poses a risk of sedimentation at the discharge location and therefore justifies energy dissipation before water are released to the environment.

The Froude number of the discharge is insufficient to justify a hydraulic jump-based energy dissipation structure. The volumetric flow rate – channel width ratio ranges between 2.5 and 3.4 m^2/s, which is indicative of measurable but less severe downstream scour. A baffled chute is recommended in this application. One of the key characteristics of the baffled chute is that it is effective regardless of tailwater conditions, which is essential in this design context. A general arrangement of this type of energy dissipation structure is reflected in Figure 37 and the proposed arrangement in Figure 38.

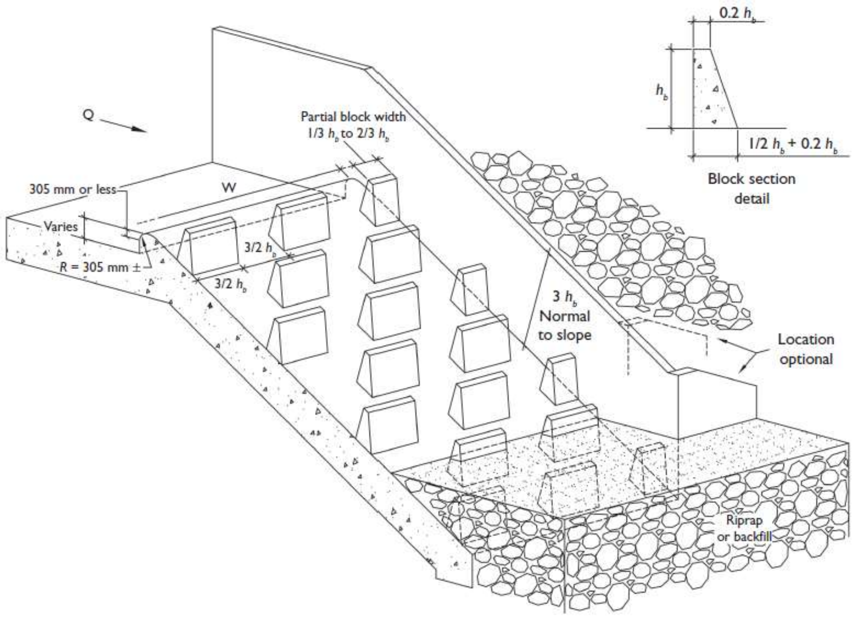


Figure 37 : Typical baffelked chute dicharge

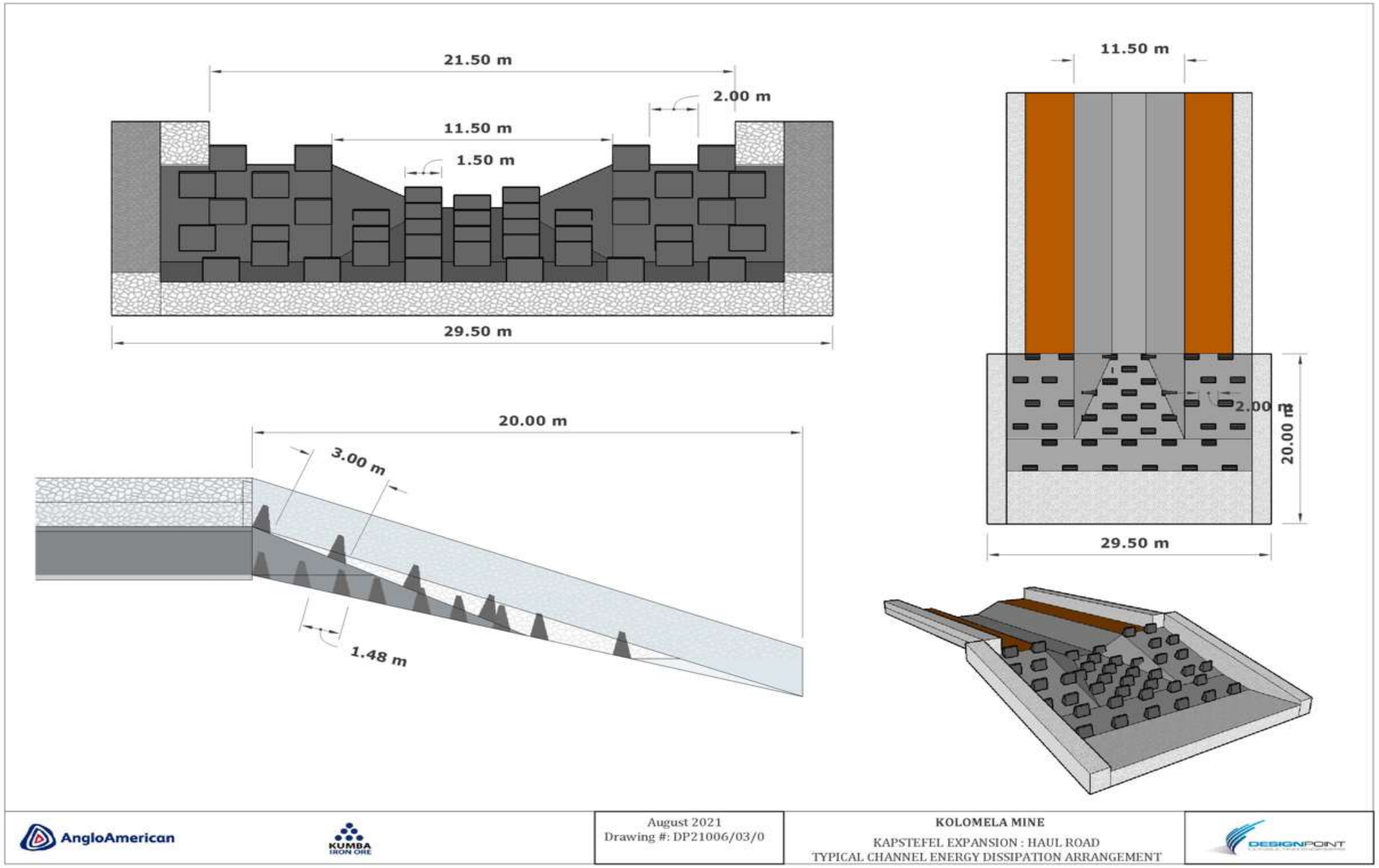


Figure 38 : Channel diversion channel dicharge - energy disapation concept

7.1.1.3 Diversion channel – New Haul Road

The proposed diversion channel will cross a section of a proposed new haul road in one location, indicated in Figure 39 . This crossing would require a culvert. The general arrangement of the proposed culvert is presented in Figure 40. The overall dimension of the culvert is 36 m long, 41 m wide and 7.5 m high.

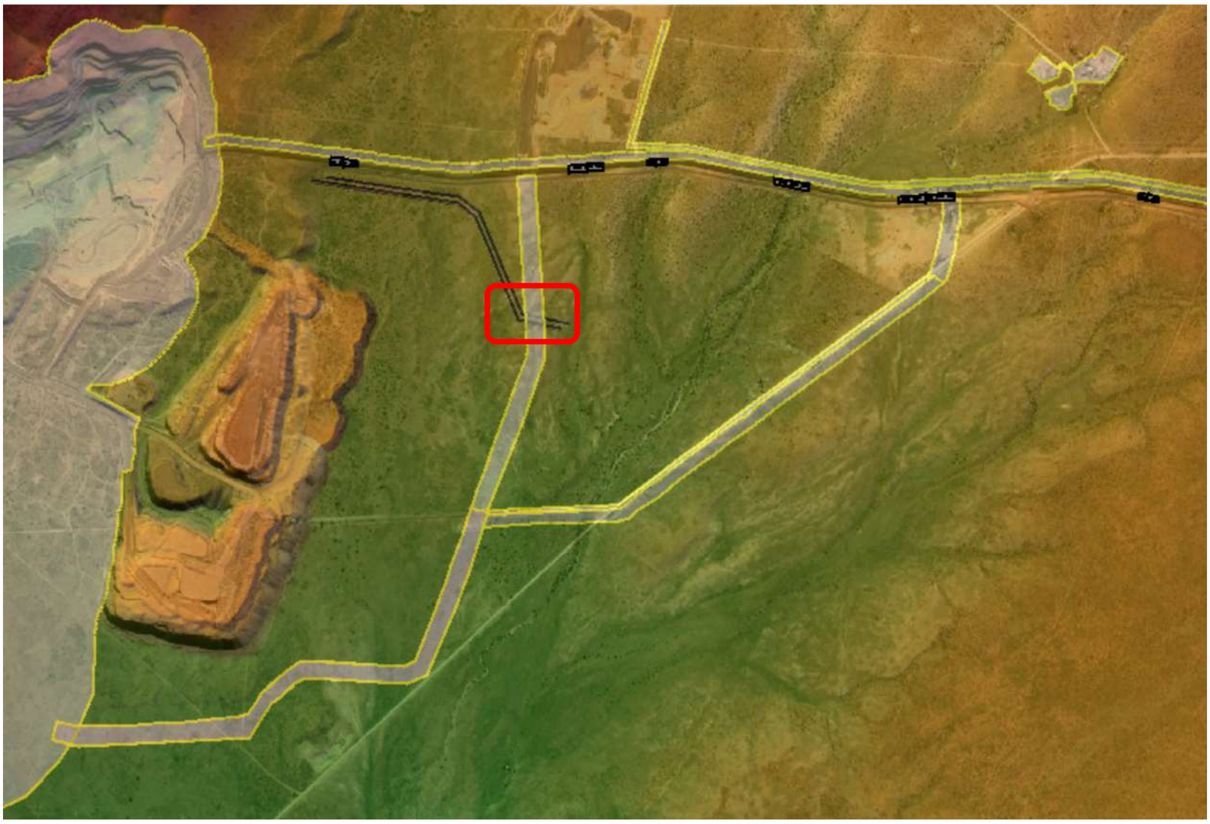


Figure 39 : Proippposed diversion channel – New Haul Road crossing

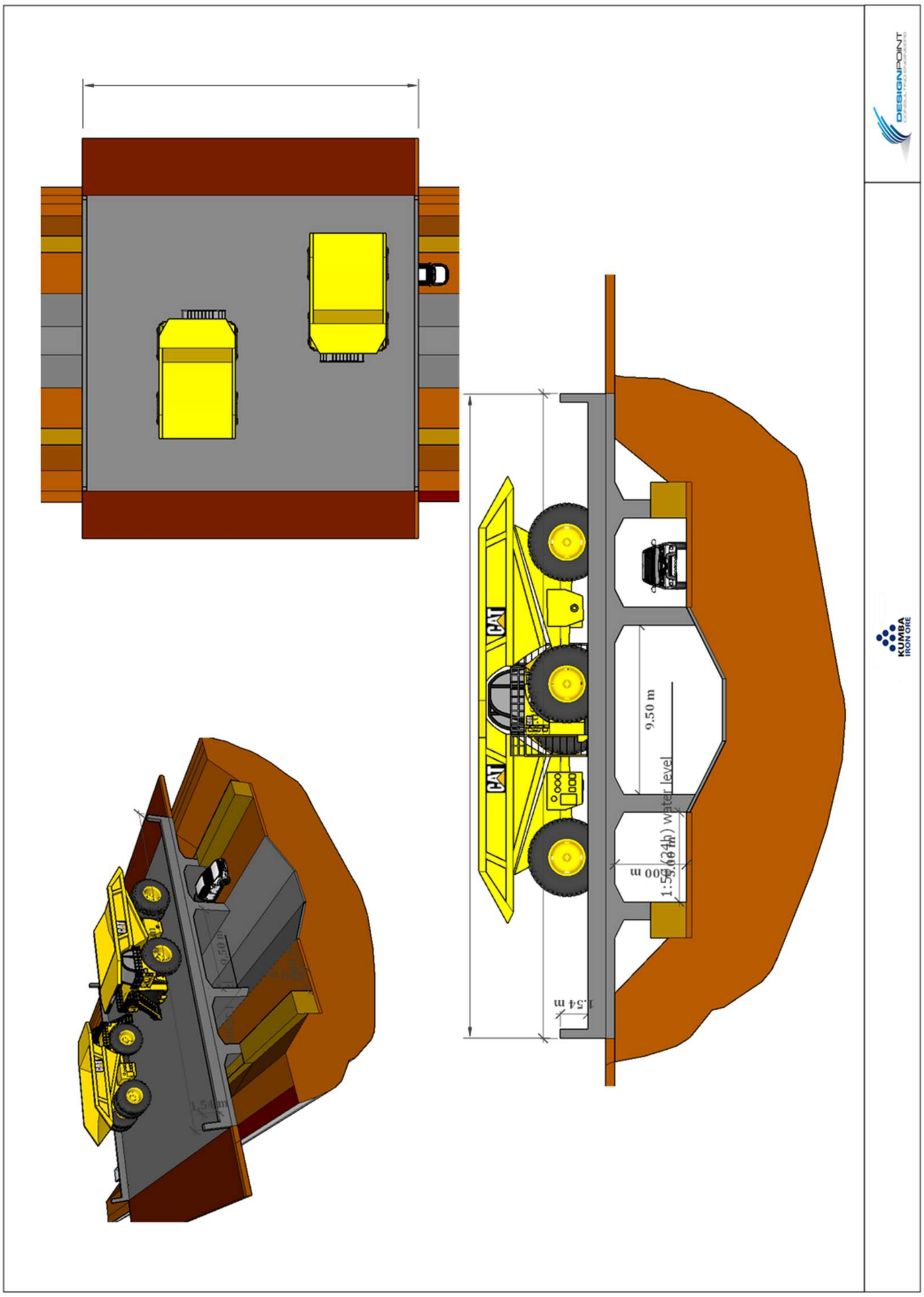


Figure 40 : Diversion channel, haul road crossingculvert profile

7.1.2 Stream B

Problem Statement: A section of the proposed haul road will cross stream B at Lat: -28.399141°, Long: 22.905887, indicated in Figure 41. A formal structure will have to be provided to ensure that stream B and the diverted water from stream A can be transferred underneath the proposed section of haul road. The hydrograph for this location in Stream B is reflected Figure 41.

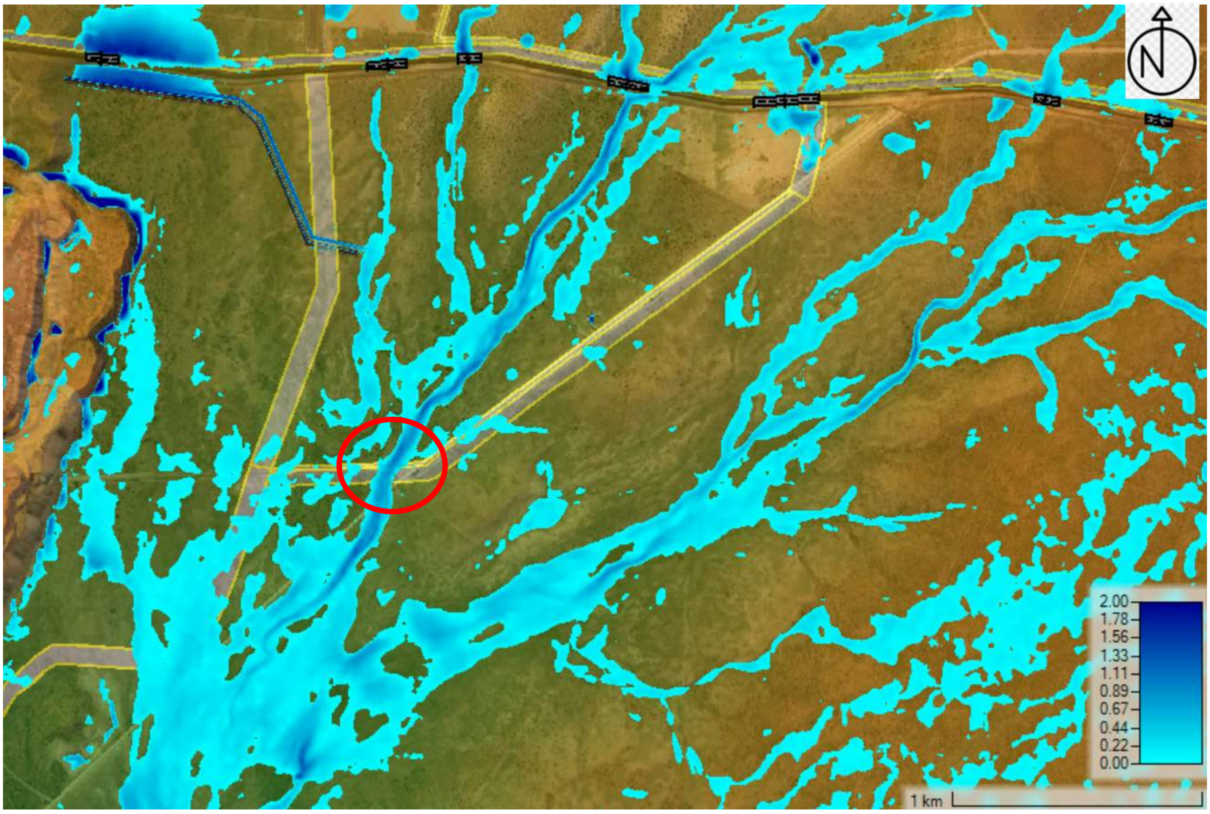


Figure 41 : Stream B interaction with haul road

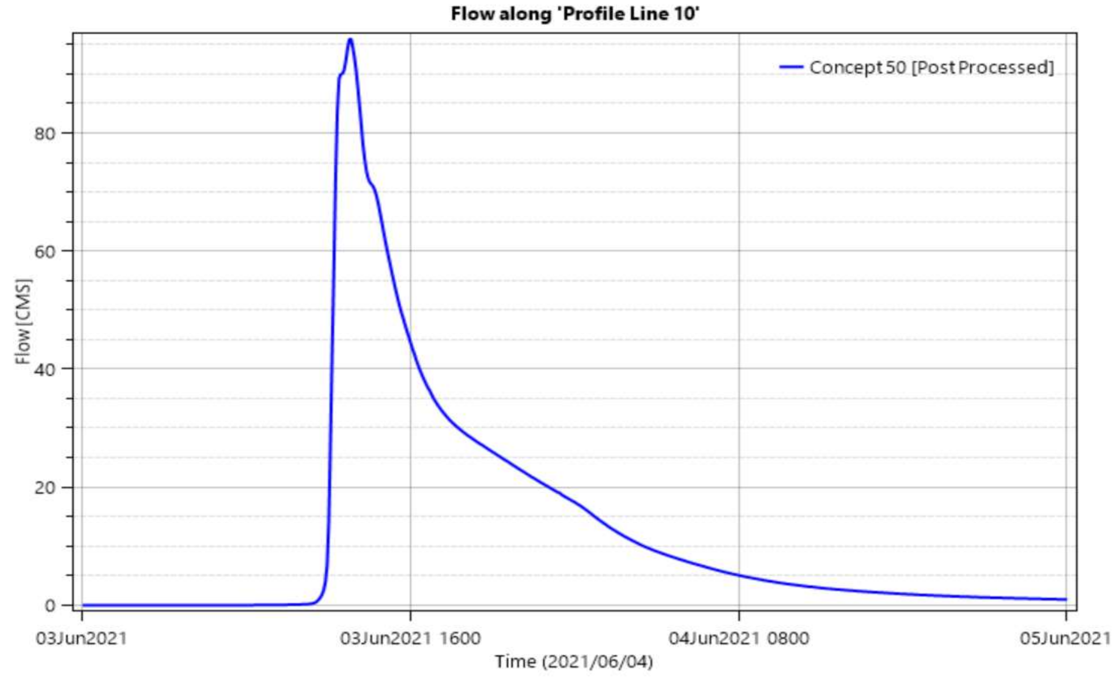


Figure 42 : Stream B – Haul road hydropgraph

Problem solution: A preliminary size of the culvert/bridge arrangement that will be required at this crossing can be established by a typical Culvert Monogram (Appendix A). A culvert arrangement of between 6 and 8 barrels, 3 x 2 m box culvert sections or a bridge will establish sufficient hydraulic capacity to transfer Stream B. The overall dimension (width x height x length) of the culvert arrangement will be 30 x 3 x 50 m.

7.2 Dump runoff – Proposed New Haul Road

Furthermore, two culverts will be required at the crossing of dump runoff over the planned haul road, as indicated in Figure 43. The toe line of the planned rock dumps will right be next to the haul road, so the actual flow paths will be different to the one indicated. The volume of water, however, will be order of magnitude similar, i.e., 20 m3/s. The overall dimension (width x height x length) of the culvert arrangement will be 10 x 2 x 50 m.

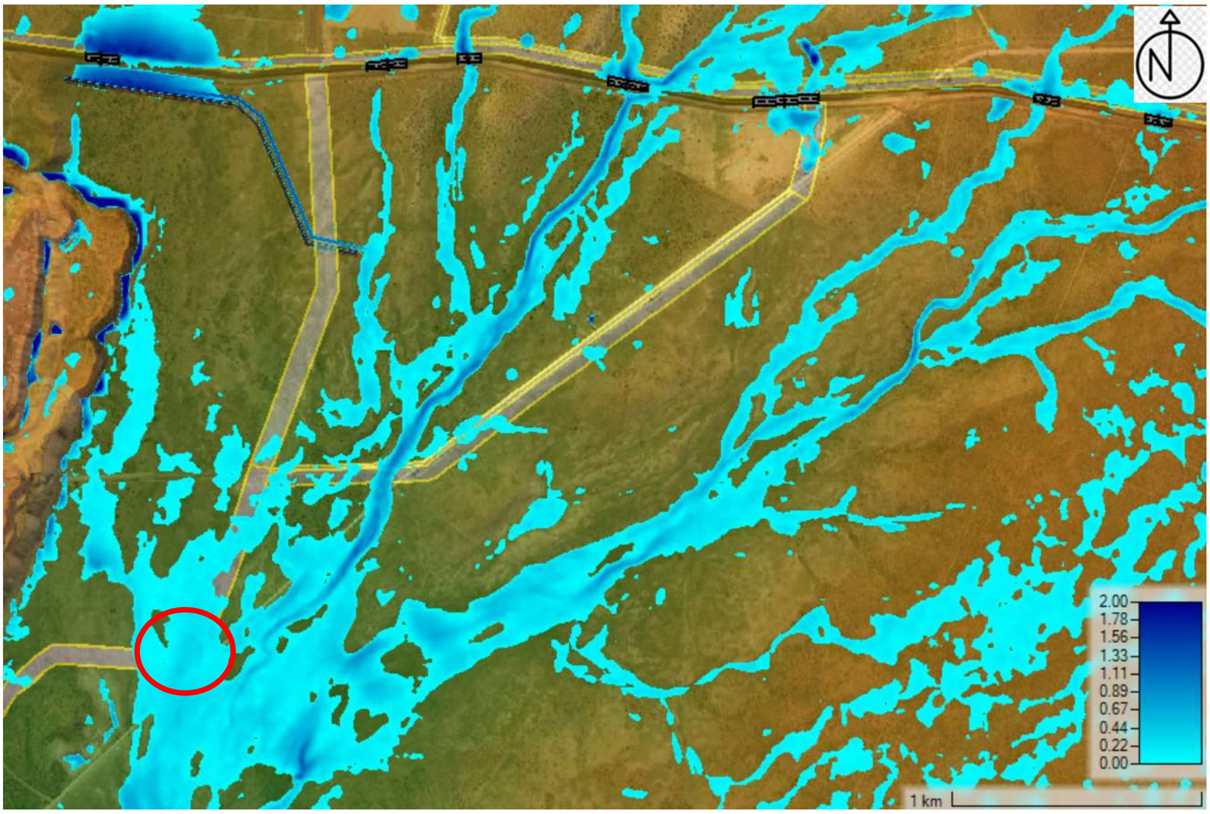


Figure 43 : Culvert location for rock dump runoff crossing planned haul road.

7.3 Existing Haul Road widening

Problem Statement: All the culverts under the existing haul road that joins the plant area with Kapstevel will have to be widened by approximately 40 m, refer to Figure 44. Furthermore, simulation results indicate that five of the current culverts were identified as not having sufficient capacity for the 1:50 year 24-hour recurrence rainfall event (refer to Figure 45).

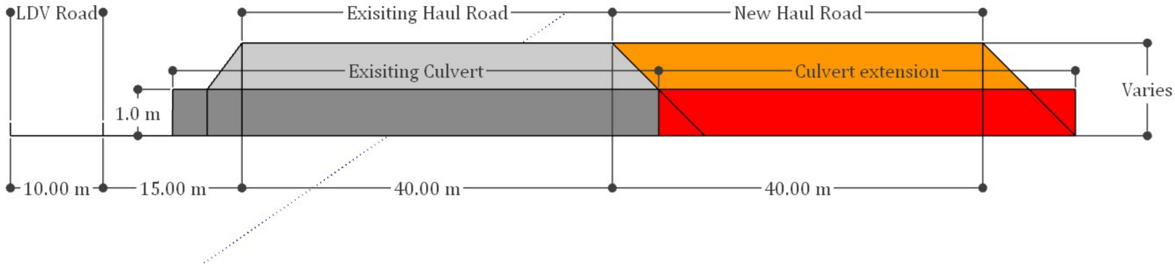


Figure 44 : Culvert extension concept design

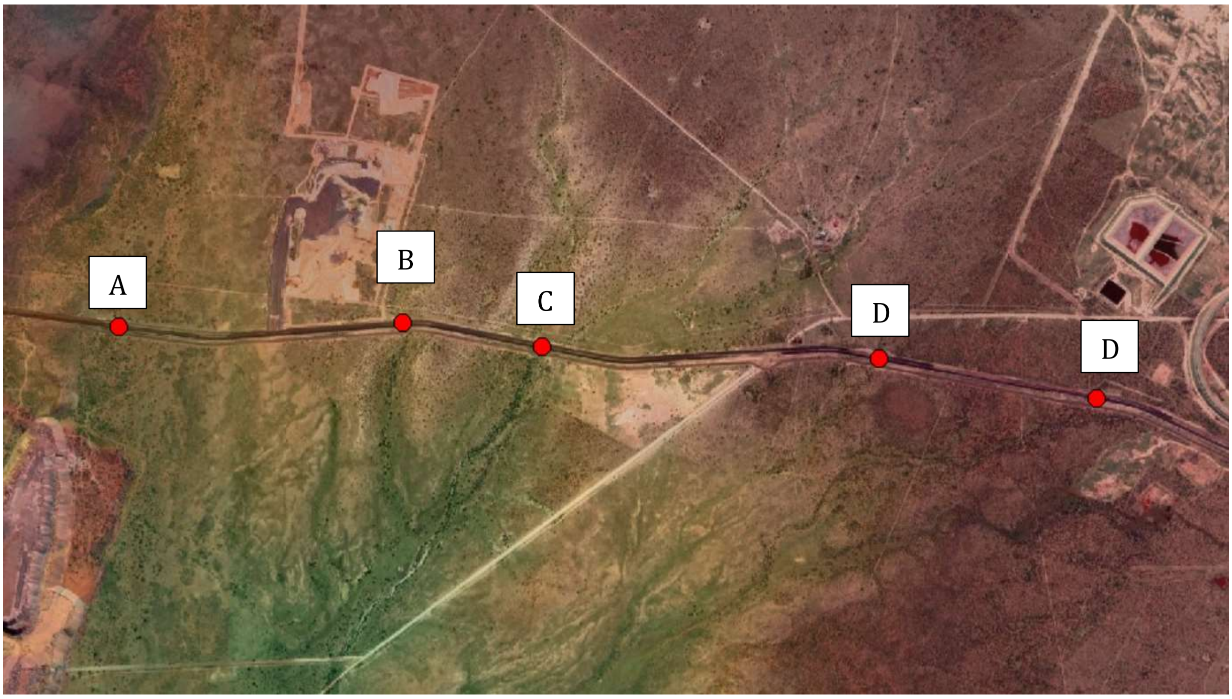


Figure 45 : Culvert identified for capacity increase upgrades

If the existing culvert barrels are lengthened by 40 m, the hydraulic capacity of current culverts arrangements will further decrease due to the increased frictional losses in the longer culverts. The planned haul road widening will aggravate the current lack of hydraulic capacity in the identified five culverts.

Problem solution: Concept sizing of the proposed culvert upgrade is indicated in Figure 46.

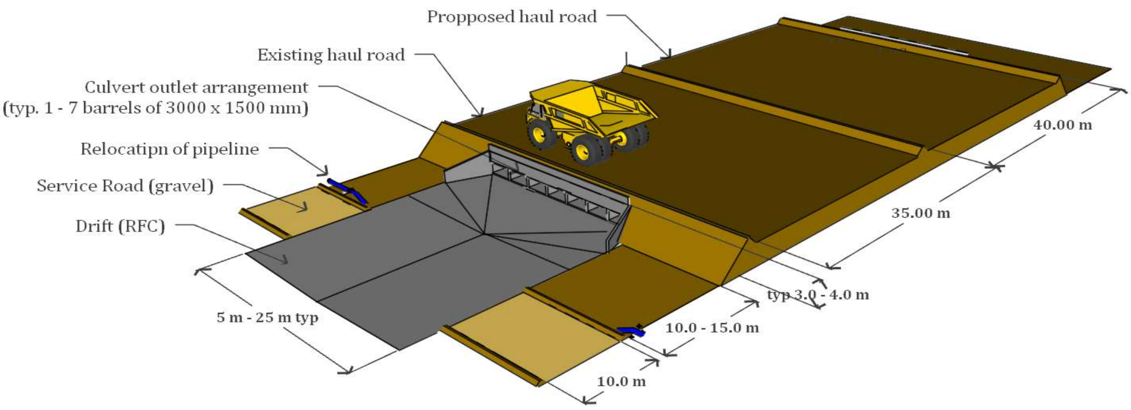


Figure 46 : Typical culvert capacity increasee arrangment sketch

The number of required barrels at each of the culverts and their approximate locations are presented in Table 5.

Table 5 : Culvert upograde requirements

Culvert Identifier	Design Flow (1:50 24h)	Number of barrels	Total width x height x length (m)	Latitude	Longitude
A	54	6	20 x 2 x 90	-28.384539°	22.894225°
B	12	2	15 x 2 x 90	-28.384490°	22.909067°
C	67	7	25 x 2 x 90	-28.385479°	22.915587°
D	6	1	2 x 2 x 90	-28.386026°	22.932631°
E	7	1	2 x 2 x 90	-28.387762°	22.943146°

A concept layout drawing is provided in Figure 47, and a typical concrete drawing for a seven-barrel arrangement in Appendix B.

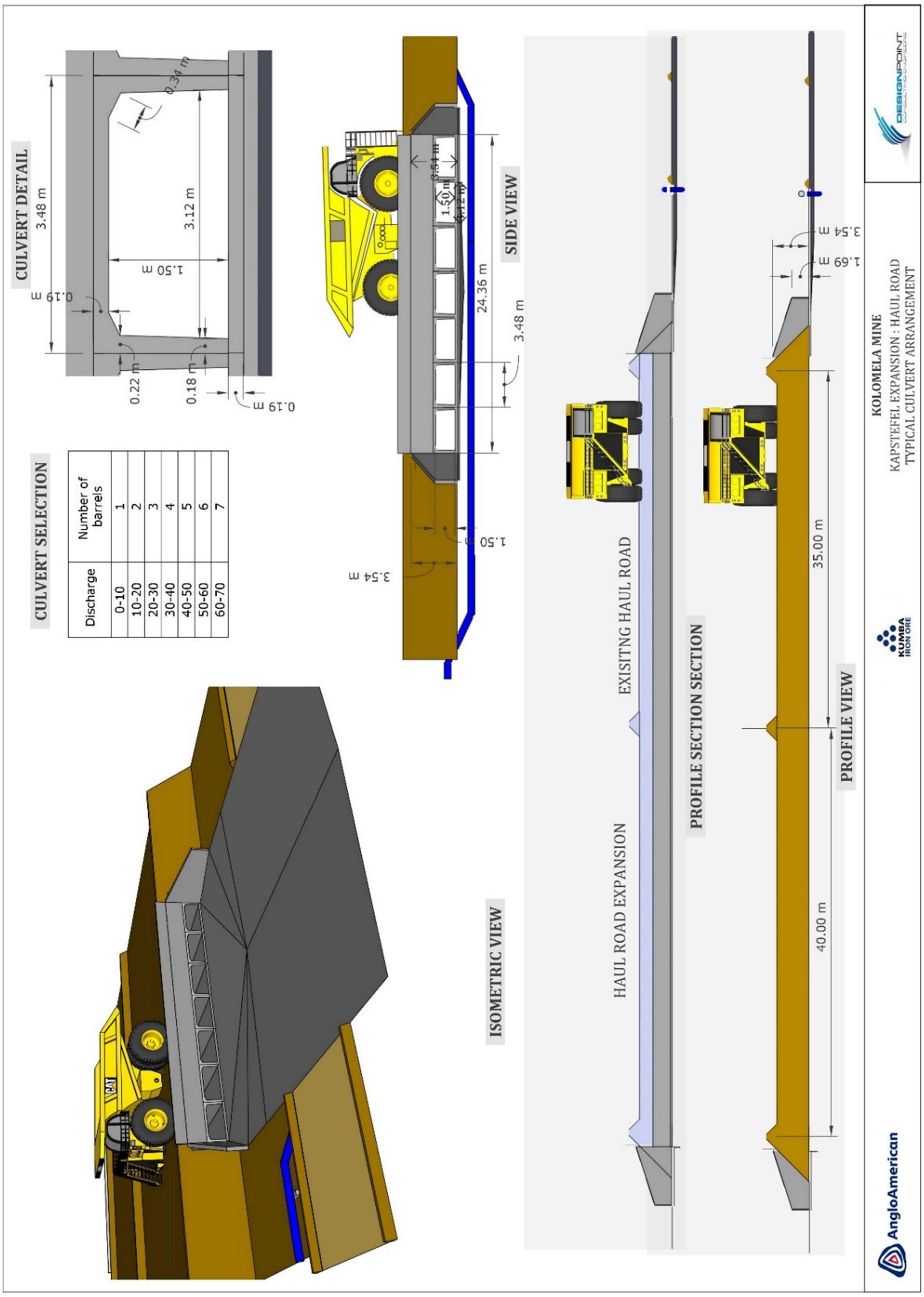


Figure 47 : Concept culvert general arrangement.

7.4 Rail loop stockpile area

Problem statement: A low-grade stockpile area is planned in the rail loop. A stockpile in the rail loop dam will change the overland flow regime that are reflected in Figure 26. The impact of this must be investigated further and might include formal directed drainage out of the rail loop through existing culverts.

Problem solution: If the concept is approved to build a new stockpile area inside the rail loop it is proposed to add a formal earth lined stormwater channel inside the loop to take stormwater to the existing culverts.

7.5 Proposed railway line

Problem statement: The planned rail expansion is superimposed on the 1:50 year 24-hour depth map and presented in Figure 48 in red. Ponding occurs at the new railway tie-off point.

Problem Solution: Structured drainage (culverts) at the tie-off from the current railway line and in the DMS area will be essential to ensure that ponding of stormwater do not affect railway geotechnical related foundation aspects. Possible new culverts are indicated in yellow on Figure 48 with estimated sizes given in Table 6.

Table 6: Estimated culvert sizes for new railway loop

Culvert Identifier	Design Flow (1:50 24h)	Number of barrels	Total width x height x length (m)
A	30	3	3 x 1.5 x 20
B, C, D	-	1	3 x 1.5 x 20

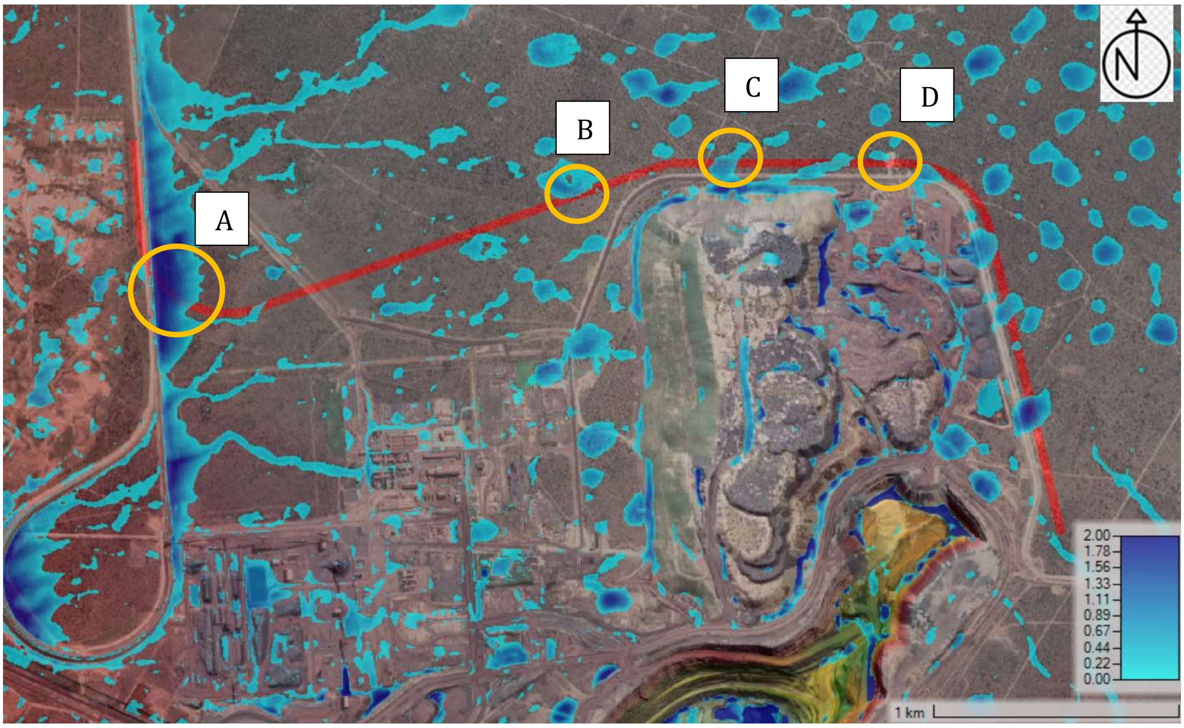


Figure 48 : Planned railway expansion

7.6 Solar farm

Problem statement: Culverts underneath the railway line and access road to the mine, convey stormwater from an eastern to western direction through a series of existing culverts. These discrete drainage locations release stormwater into the area earmarked for a solar farm, shown in Figure 49.

Problem solution: Current culvert discharge location can possibly be channel through the area, and act as formal drainage system inside the area. The possible location of three channels is indicated in Figure 49. A formal stormwater management plan needs to be developed for the solar farm once the design of the facility has been finalised. The plan must take into consideration water runoff from maintenance activities.

Figure 49 :Solar farm area

7.7 Kapstevel pit stormwater berm on western side

Problem statement: Runoff drains past the western side of the Kapstevel pit expansion area, as reflected in Figure 50. App 300 000 m3 of water are transferred through the area during the 1:50 RI rainfall event. This water will have an impact on the proposed activities in the expansion area.

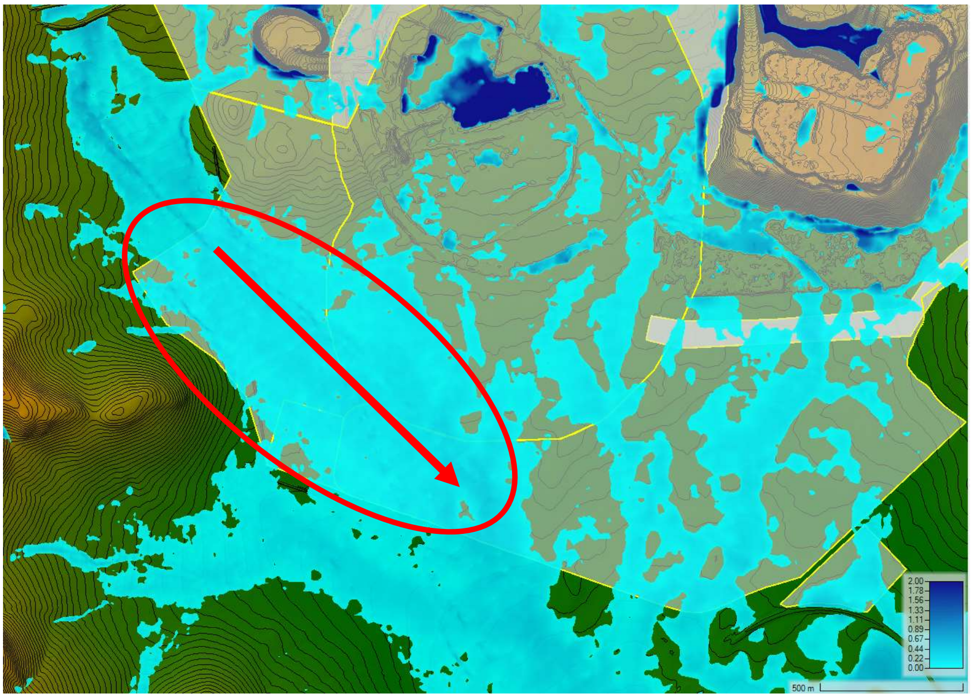


Figure 50 : Kapstevel western stromwater drainage

Problem solution: The effect of a proposed diversion berm located on the western side of the Kapstevel expansion area is reflected in Figure 51. The berm is approximately 1400 m in length with a height of 1.5 m.

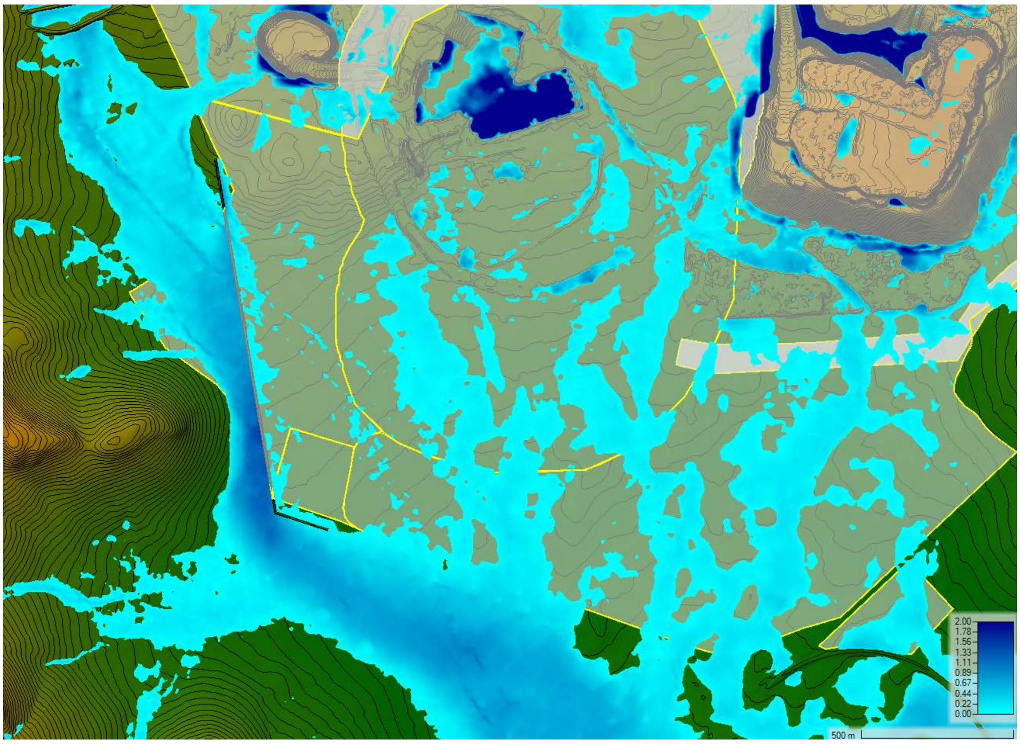


Figure 51 : Ka[pstevel western side stormwater runoff diversion berm location

7.8 Kapstevel at pit facility

Problem Statement: A new office area is proposed to the Northen side of the Kapstevel pit. The area will include offices, workshops and haul truck access.

Problem solution: The area is classified as dirty and clean stormwater run-off from the North should be diverted around the facility. Figure 52 shows the proposed berm of 1.5m high.

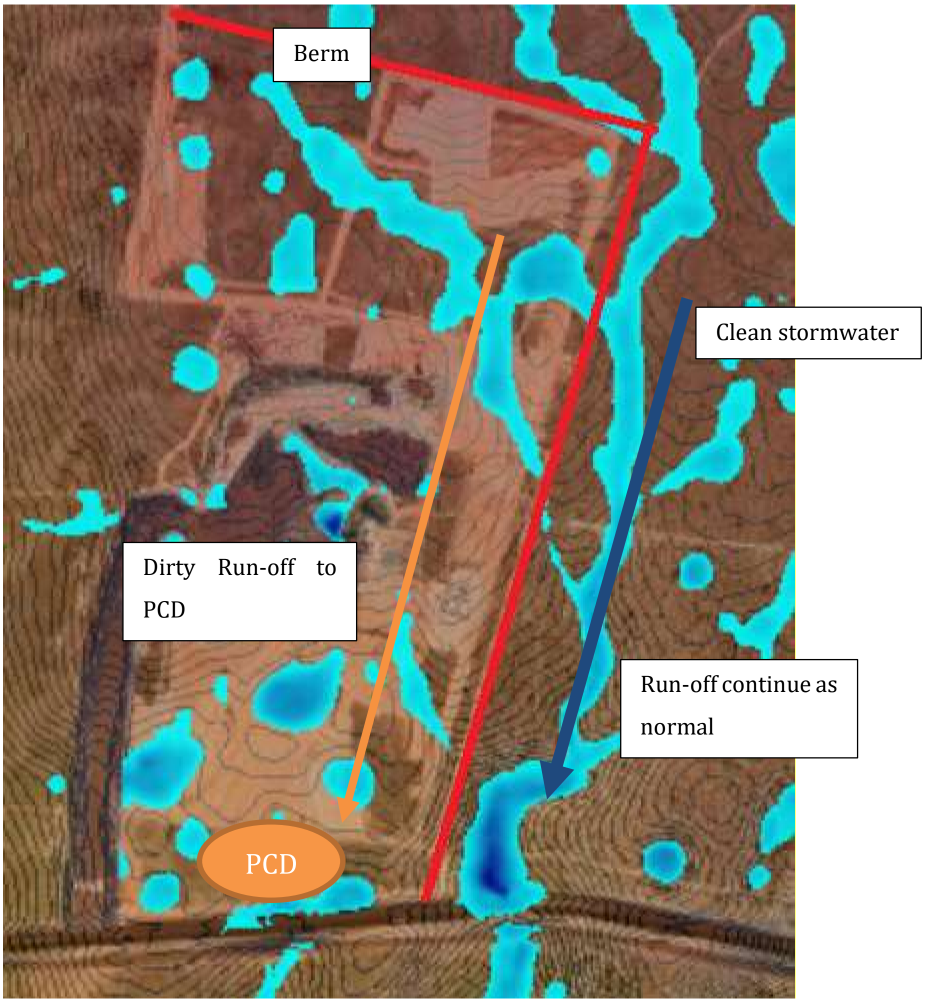


Figure 52: Kapstevel at pit facility clean and dirty water separation

The stormwater inside the area which is classified as dirty will flow to a proposed new pollution control dam. The dam and internal stormwater designs are done by others.

7.9 Outlet at Leeuwfontein pit

Problem Statement: Silt particles are readily transported in stormwater runoff. In the case of the selected area on the eastern side of the Leeufontein pit, runoff sediment causes "red" water that has a negative downstream effect. The problem area is shown in Figure 53 below:

Figure 53: Location of sediment problem at leeuwfontein pit

Problem solution: Silt sedimentation can be induced by the provision of a sediment berm located perpendicular to the flow direction. A typical cross section of the proposed berm is shown in Figure 54. The proposed location for the silt berm is shown in Figure 55.

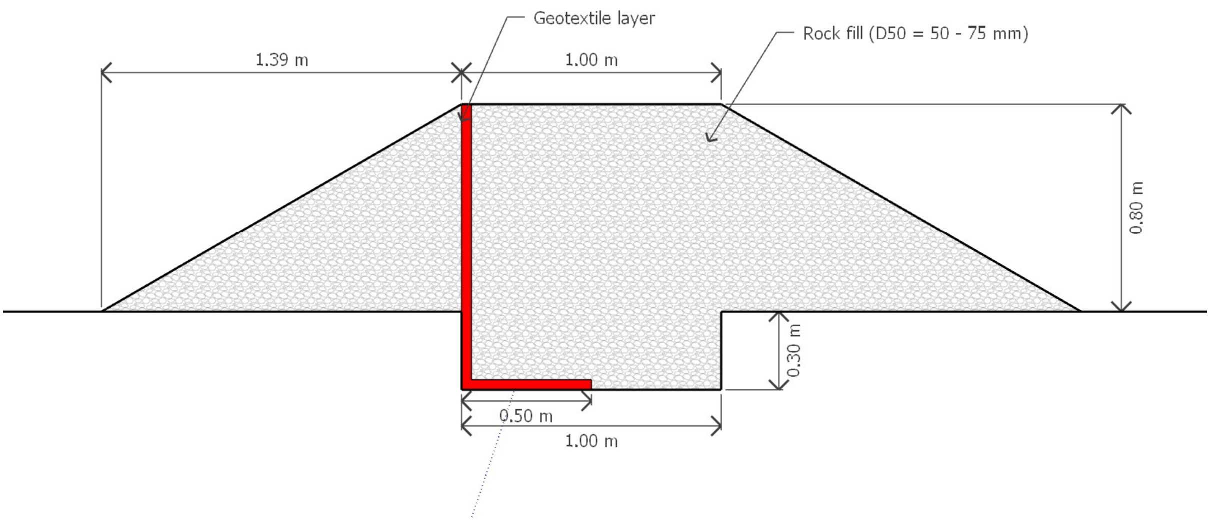


Figure 54: Silt berm cross section

Figure 55: Proposed silt berm location

7.10 Waste rock dumps

Waste rock dump areas are classified as clean. For this reason, it is not required to catch or diverted stormwater run-off from these dumps. It is however proposed to have a 1.5m High berm next to the dumps to prevent sedimentation into surrounding areas.

7.11 Clean and dirty water areas

Clean and dirty water areas for the future expansions on the mine was done according to General Notice 704 of the National Water Act (36 of 1998).

The catchment areas were developed based on lidar survey (contours) of the existing infrastructure at Kolomela mine. The delineation of the clean and dirty water catchments was based on land use and topography.

The focus of this section was to identify areas where clean water systems should be upgraded to prevent clean and dirty water contamination (Refer to Section 7.1 to 7.3). The results of the upgraded clean and dirty water catchment areas for the future developments are shown in Appendix D.

7.12 Risk and mitigation action for future developments

The main risks identified in the Section 7 as well as the proposed mitigation actions are summarised

Risk Areas identified	Clean/ dirty water areas	Mitigation Actions
Non-perennial stream: Stream A	Clean	• Stream diversion with a new channel and berm conveying water around rock dumps • New culvert at haul road crossing shown in Figure 39 • New energy dissipating structure at the end of the diversion channel to prevent erosion in natural environment
Non-perennial stream: Stream B	Clean	• New culvert to be designed at culvert crossing where Stream A and Stream B joins
Haul road widening	Clean	• Proposed to upgrade the culvert sizes and number of culverts as per Table 5.

Risk Areas identified	Clean/ dirty water areas	Mitigation Actions
Rail loop stockpile area	Dirty	• Option 1: Avoid building stockpile inside loop area otherwise area will be classified as dirty water area and stormwater will then need to be contained
New railway line	Clean	• Allow for new culverts at tie-off from the existing railway line to allow free flowing of water from eastern to western side • Depending on future RWD developments at the DMS plant area, any overflow from channels or dams should allow for proper culverts underneath railway line.
Solar farm	Clean	• Three possible solutions are proposed: • A) Stormwater from outside catchment can be diverted around the facility from the North • B) Existing stormwater infrastructure can be used to divert clean run-off through the facility and into the natural environment • C) Catching all run-off within the facility with a new channel and berm at the southern end of the facility

Risk Areas identified	Clean/ dirty water areas	Mitigation Actions
		• Internal stormwater plan for the facility should be devlopmed during the design phases of the Solar plant.
Kapstevel western berm	Clean/dirty	• Flooding of the most western side of the new Kapstevel South facility can be prevented by adding a berm • Proposed berm height 1.5m • Water will be diverted around the new pit and truck parking area. Refer to Figure 51
Kapstevel at pit facility	Dirty	• Berm and channel to the Northern side to separate the clean and dirty water.
Leeuwfontein area	Clean	• Stormwater run-off from site contains high silt particles and should be contained • A silt berm or fence is proposed perpendicular to the flow

8 Conclusion

The Hydrological parameters used for the simulation and establishment of flood hazards and flood risks was developed as part of this study. The study is based on the effects of a 1:50 and 1:100 recurrence interval 24-hour rainfall event on existing and proposed infrastructure at Kolomela mine. The identified hazards that are classified as risks for the current topography are identified and include the following items:

- All open pit areas
- The broader areas around PCD1 and PCD3 in the plant
- DMS area
- Primary crusher conveyor belt incline
- Culverts under the haul road between Leeuwfontein and Kapstevel
- Pooling east of the railway line and in the rail loop

The identified hydrological impacts associated with the planned expansion of Kapstevel area are identified and include the following items

- Stormwater diversion north of the haul road leading to Kapstevel area
- Haul road crossing over the non-perennial stream east of the proposed Kapstevel expansion
- Possible PCD facilities to manage runoff from proposed Kapstevel rock dumps
- Cut off berm southwest of the Kapstevel area

Identified hydrological impacts associated with the planned expansion activities at the Leeuwfontein and Plant area include the following items

- Drainage underneath the planned railway line
- Drainage through the planned solar farm
- Pooling of water in rail loop can impact the operations of the proposed stockpile in the area.

9 Section B: Water balance

9.1 Objective

The objective of this report is to present the Water Balance for Kolomela mine. This report focuses on the current water related situation and practices at the mine. The report is based on information and data supplied to Design Point for the year 2020. This section focusses on describing the flow of water from the pit dewatering start point all the way to mine users and third-party exports.

Future scenarios are currently planned on Kolomela mine with an expansion of the Kapstevel pit and increase production at the DMS plant. This is described in Section 9.9.

9.2 Brief Overview

Kolomela mine is a water positive mine. This means that more water enters the system than what leaves the system. Water is abstracted from the pit areas at an average rate of 1500m^3/hr. In order to maintain a dry pit for safe mining conditions, groundwater is abstracted from boreholes located around the pit shoulder/boundaries. This groundwater is pumped to a ring main which then distributes the water for either onsite use within the pit (drilling, dust suppression), to the DSO and DMS plants for beneficiation, or if surplus exists, to 3rd party users (Sedibeng Water Scheme) outside the mine.

The following sections provides an outline of the water balance on Kolomela mine. The overall Kolomela site is shown in Figure 56.

Figure 56: Kolomela layout

9.3 Kolomela pit area water

9.3.1 Overview

The mine currently consists of three pit areas namely, Kapstevel pit, Leeuwfontein Pit and Klipbankfontein pit. The pit boreholes dewater at a rate of approximately 1500 m^3/hr to keep the pit dry. Water is firstly distributed to the filling points where it is used for dust suppression on haul roads, dumps, stockpiles and Light Delivery Vehicles (LDV) roads.

Water is then distributed further throughout the mine via a ring main pipeline around the pit areas. The ring main pipeline constitutes a spinal pipeline and has three primary distribution points for conveying water out of the mining area and distributing it further:

1. Export reservoir - Water is pumped into the export reservoir from where it is distributed as potable water use in the mine. Most of the water from this reservoir is exported to the Sedibeng reservoir outside the mine close to Postmasburg.
2. Water is pumped directly to filling points from the ring main. At the filling points water is used for dust suppression across all mine haul rounds and Light Delivery Vehicle (LDV) routes, dumps and stockpiles.
3. Kolomela mine also recharges aquifers with water from the dewatering activities. The discharge areas are located to the Southeast of the mine. As Kolomela mine is a water positive mine meaning that more water is abstracted than what is used, the mine can recharge aquifers and re-establish the water table outside the mining area.

The pit areas are shown in Figure 57 . Each pit area has an evaporation dam where rainwater is pumped to/collected during the rainy season to keep the pit dry. These are also shown in Figure 57. Although the dams do not influence the mine water use balance, they are included to show the entire scope. Currently no water is used from these dams and proposals for improvement are made in Section 9.8.

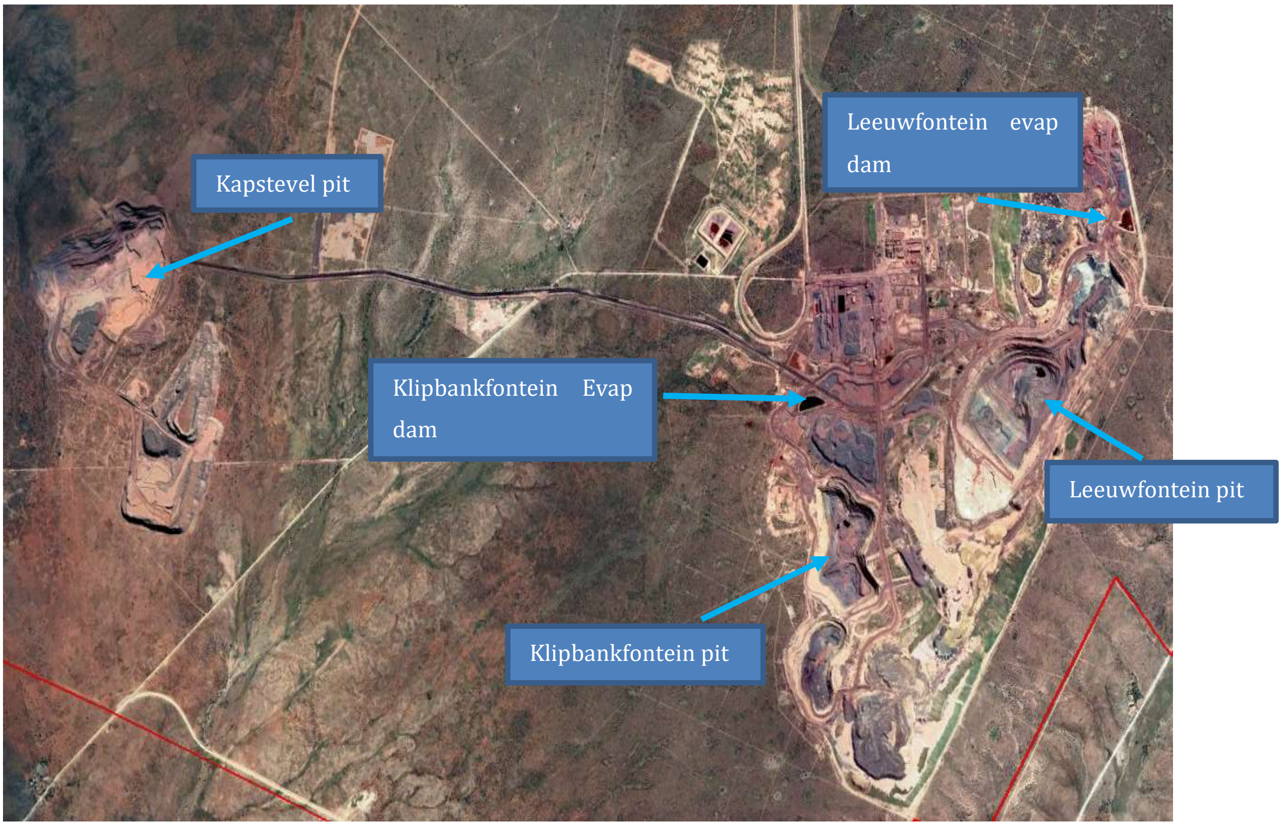


Figure 57: Locality plan of the three pit areas at Kolomela

9.4 Outside pit water use

9.4.1 DSO and DMS plants

Kolomela mine consists of two plants namely the DSO and DMS plant. Water to each plant consists of various water sources on the mine. Ground water is always seen as a last resort and only used as make-up water in the plants. Re-use water from various stores is discussed in Section 9.5. The average ground water use from the plants is 130m^3/hr.

Figure 58 shows the in and out flows from each plant on average for 2020.

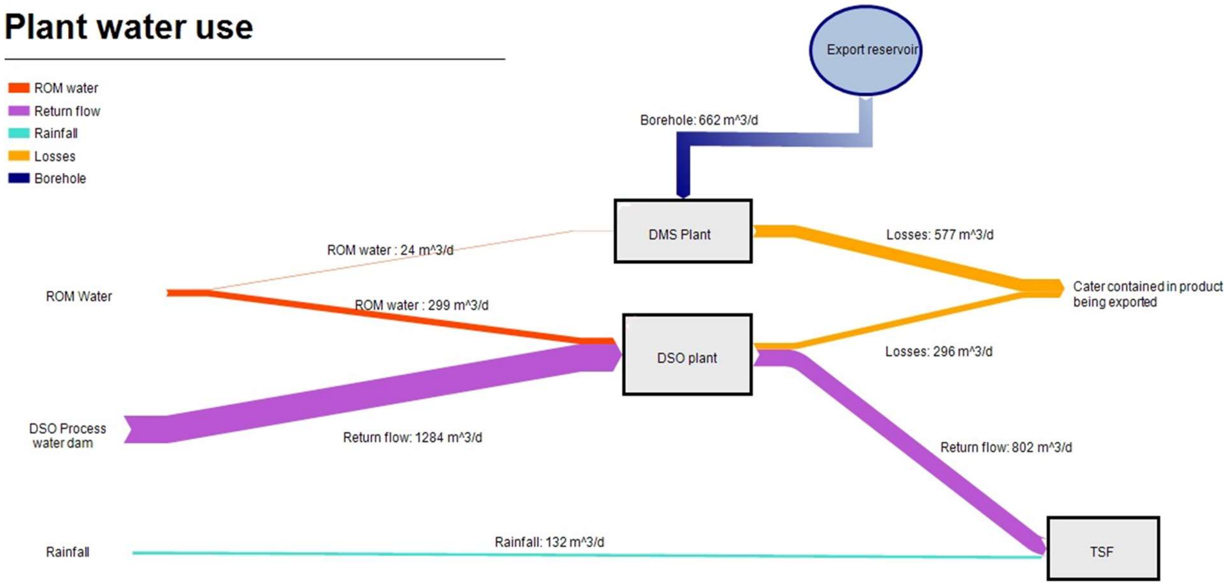


Figure 58: Plant water flow diagram

Water losses from product are due to the moisture content and general losses around the plant areas. These losses are based on the amount of product produced at each plant and does not significantly increase or decrease due to environmental changes.

9.4.2 Potable water use

Potable water is required at workshops, crushers and offices. The water that is dewatered at Kolomela is of good drinking quality and is distributed to various offices and workshops for consumptions, washing and cleaning. The export reservoir and potable water tank is the main distribution point for potable water at Kolomela. Figure *59* shows the water network from each of these tanks and reservoirs.

The dewatering rate shown in Figure 59 includes water from all three active pit areas at Kolomela which includes Leeuwfontein pit, Kapstevel pit and Klipbankfontein pit.

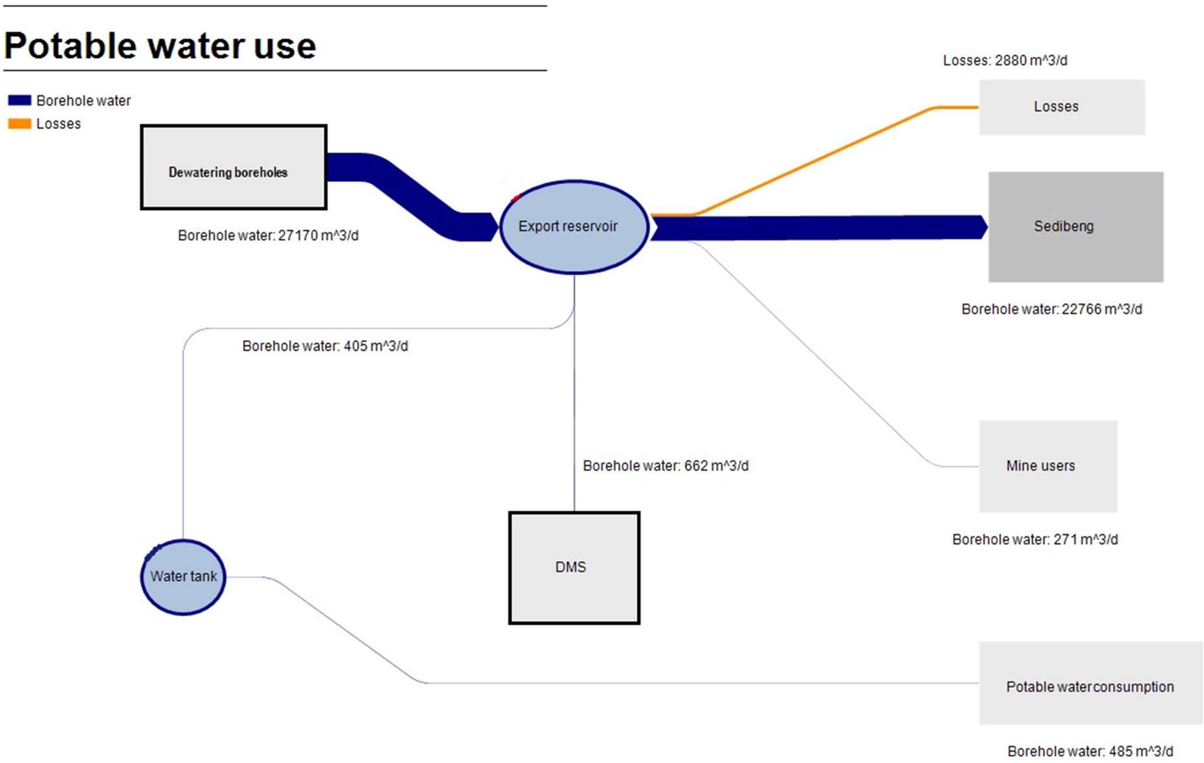


Figure 59: Potable water use flow diagram

Potable water uses on the mine together with workshops services average at approximately 50 m^3/hr. The majority (84 %) of the water from the pit areas is distributed to third parties and is further described in Section 9.6.

9.5 Water re-use

Kolomela has various water reuse points. This reduces the environmental footprint and groundwater use on the mine. It also allows the mine to export water to surrounding communities (Sedibeng) for potable water use. The following reuse areas exists:

- Water that collects on the TSF (rainfall and water from plants) are recovered through the Return Water Dam (RWD) and is pumped to the plants.
- Two water treatment facilities are located on the mining premises.
  - One - the Bioremediation treatment plant and sewer water is treated and pumped back into the Return water sump.

- ➢ Two - The temporary sewerage treatment plant treats sewerage and this is pumped into PCD 3. From PCD 3 it is further distributed.
- Water is collected and recovered in 3 pollution control dams. Namely PCD 1,2 and 3. At each dams run-off are collected from each surrounding catchment. PCD1 also receives water from an oil water separator and treated sewerage as per previous point.

The re-use line diagram is shown in Figure 60. The volume of water being re-used is shown in purple.

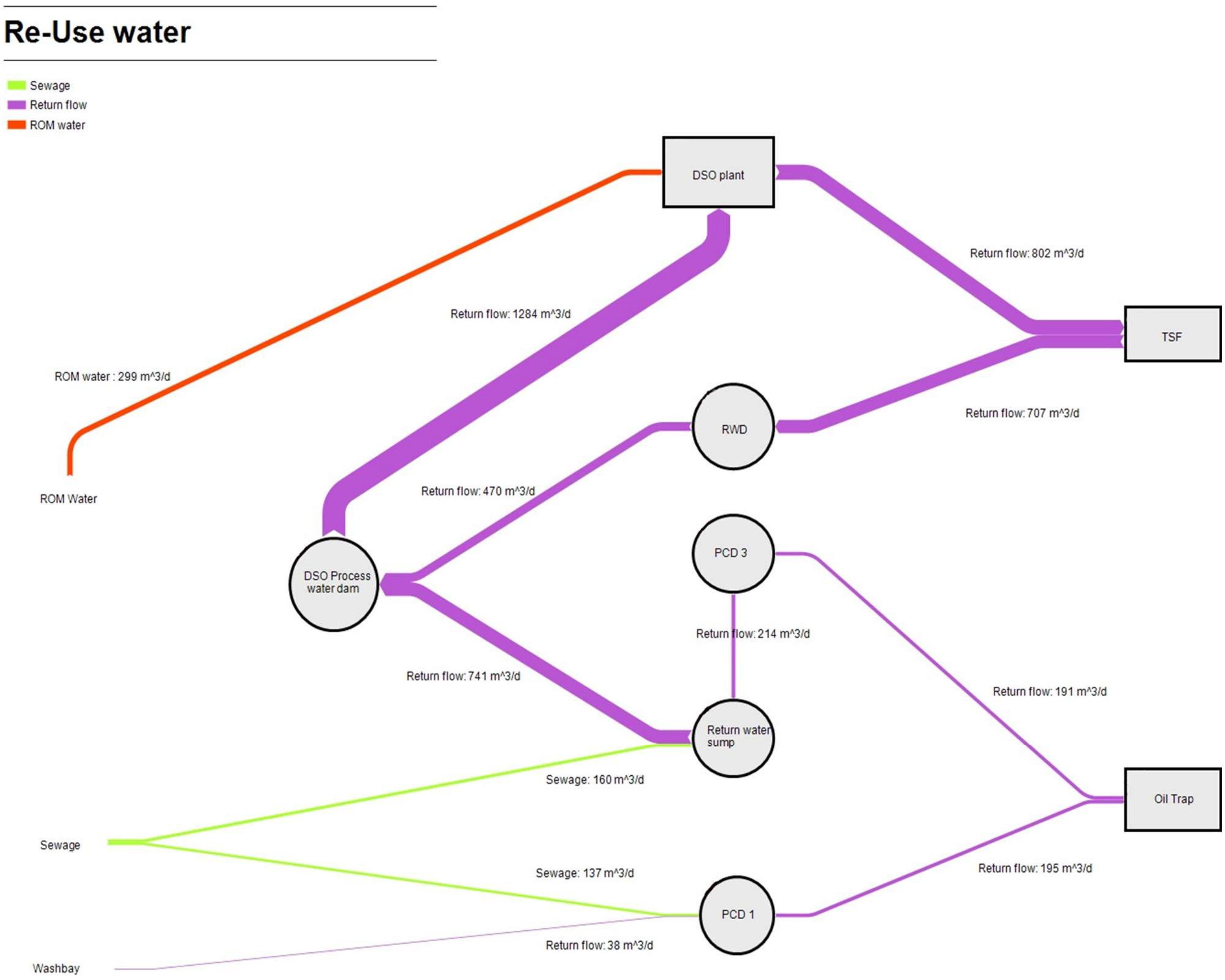


Figure 60: Water Re-use diagram

9.6 Third party export water

80% of the ground water at Kolomela is exported to Sedibeng via the Beeshoek reservoir. From the Beeshoek pumpstation water is distributed to Potsmasburg and into the Vaal-Gamagara pipeline.

Water is also pumped into aquifer recharge points. On average 780m^3/d of water is pumped into the recharge points. The aquifer recharge area is shown in Figure 61 and Figure 62.

Figure 61: Aquifer recharge area location

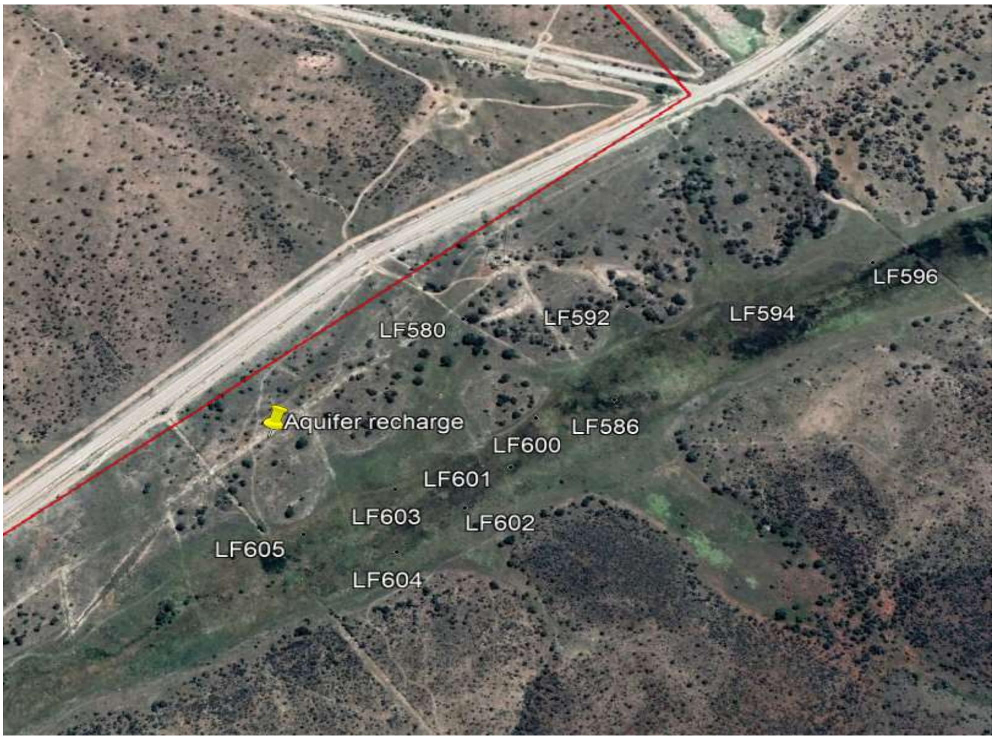


Figure 62: Aquifer recharge points

Figure 63 shows the line diagram with water that is exported to Sedibeng and for aquifer recharge.

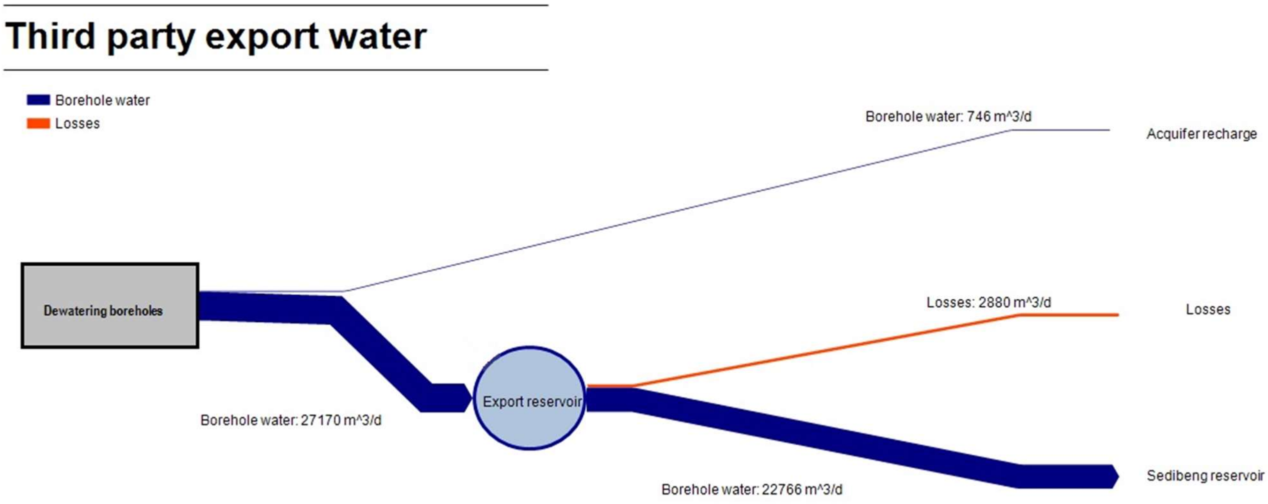


Figure 63: Third party export water

9.7 Overall water balance

The overall water balance which includes all sections as per above is shown in Figure 64.

The overall water balance is dependent on the total volume of water coming into the mine and the total volume of water leaving the mine. From Figure 64 the total inflows on the left of the diagram and the total water on the right of the diagram is summed in Table 7.

Table 7: Overall Kolomela water balance

	Inflow (m^3/day)			Outflow (m^3/day)
Borehole water	35 040		Losses form pipelines	8 736
ROM water	321		Dust suppression	1 068

	Inflow (m^3/day)			Outflow (m^3/day)
Total rainfall and runoff.	381		Aquifer recharge	746
Total sewage in	332		Discharge	0
Evaporation dams inflow (rainfall and run-off)	620		In-pit use	178
			Workshops	429
			Sedibeng export	22 766
			Product losses	472
			Total evaporation and seepage.	514
			General losses	39
			Potable water use	60
			Leeuwfontein evap dam (from DSM)	415
			Evaporation dams evaporation and seepage	620
Total	36 694 m^3/d		Total	36 043 m^3/d

The difference between the inflows and outflows is 1.8%. This means that there is a 1.8% imbalance in the Kolomela water balance.

This is an extremely low values and shows how well the mine are currently managing their water use.

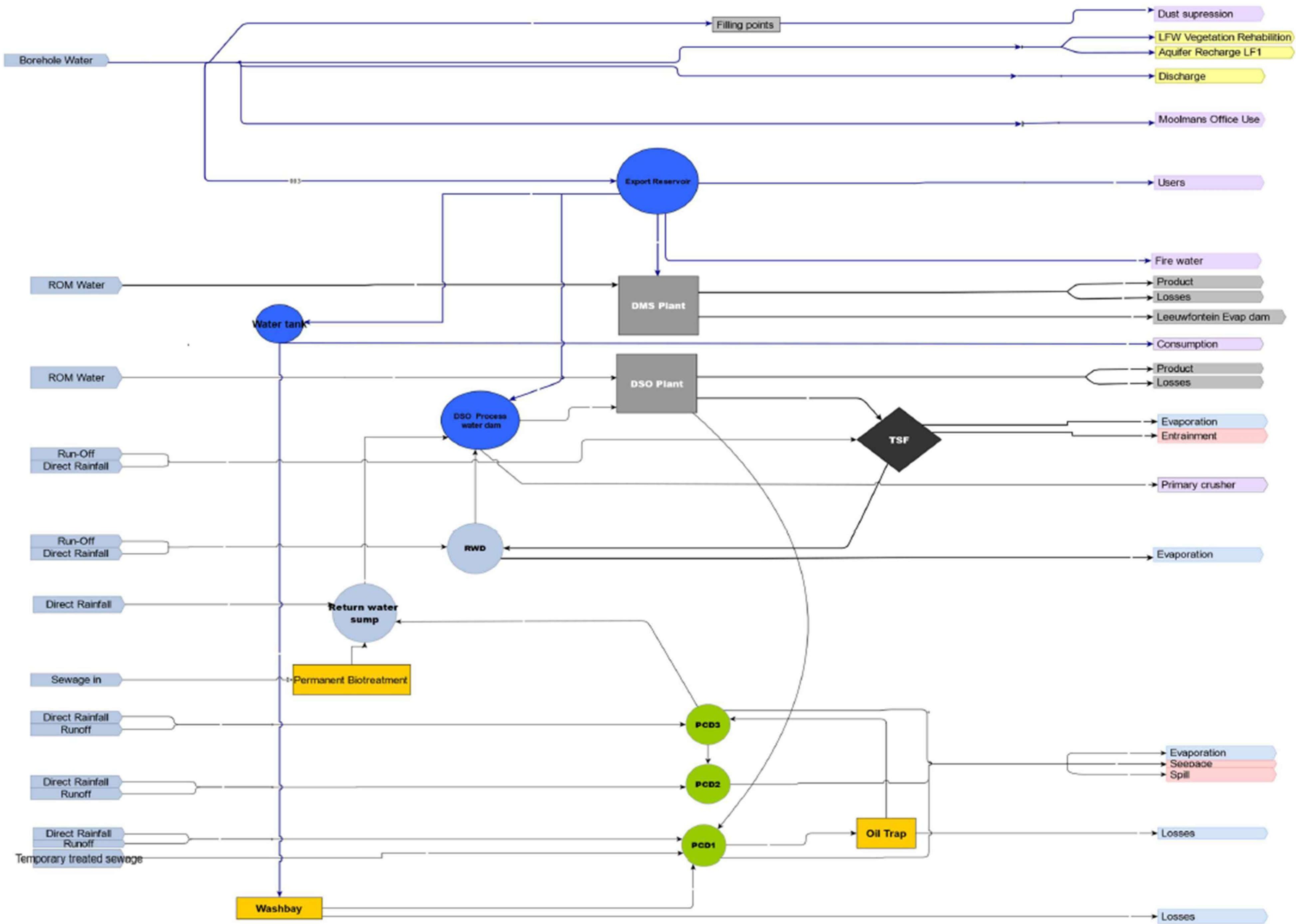


Figure 64: Overall site water balance

9.8 Points of improvement

As in all water entities, water savings is always top priority. Kolomela is located in a water scarce area and optimum water use affects the mine and the surrounding community. As Kumba Iron Ore Kolomela exports around 80% of their ground water to Sedibeng, the 20% remaining ground water used for potable water can be optimized.

Although the scope of this report does not include the assessment of possible water savings on the overall water balance the possibility exists for the mine to reduce their ground water (fresh water) use by:

- Fixing any leaking pipes or pumps around the ring main.
- Fixing any leaks along the export pipeline.
- Reusing the stormwater that is collected in each pit. This can either be pumped to the plants or to filling points for dust suppression.
- Optimising filling of water bowsers at filling points to prevent spillage

The effect of each of these scenarios can reduce the groundwater use of the mine but should be investigated after water use licence approvals

9.9 Future scenarios

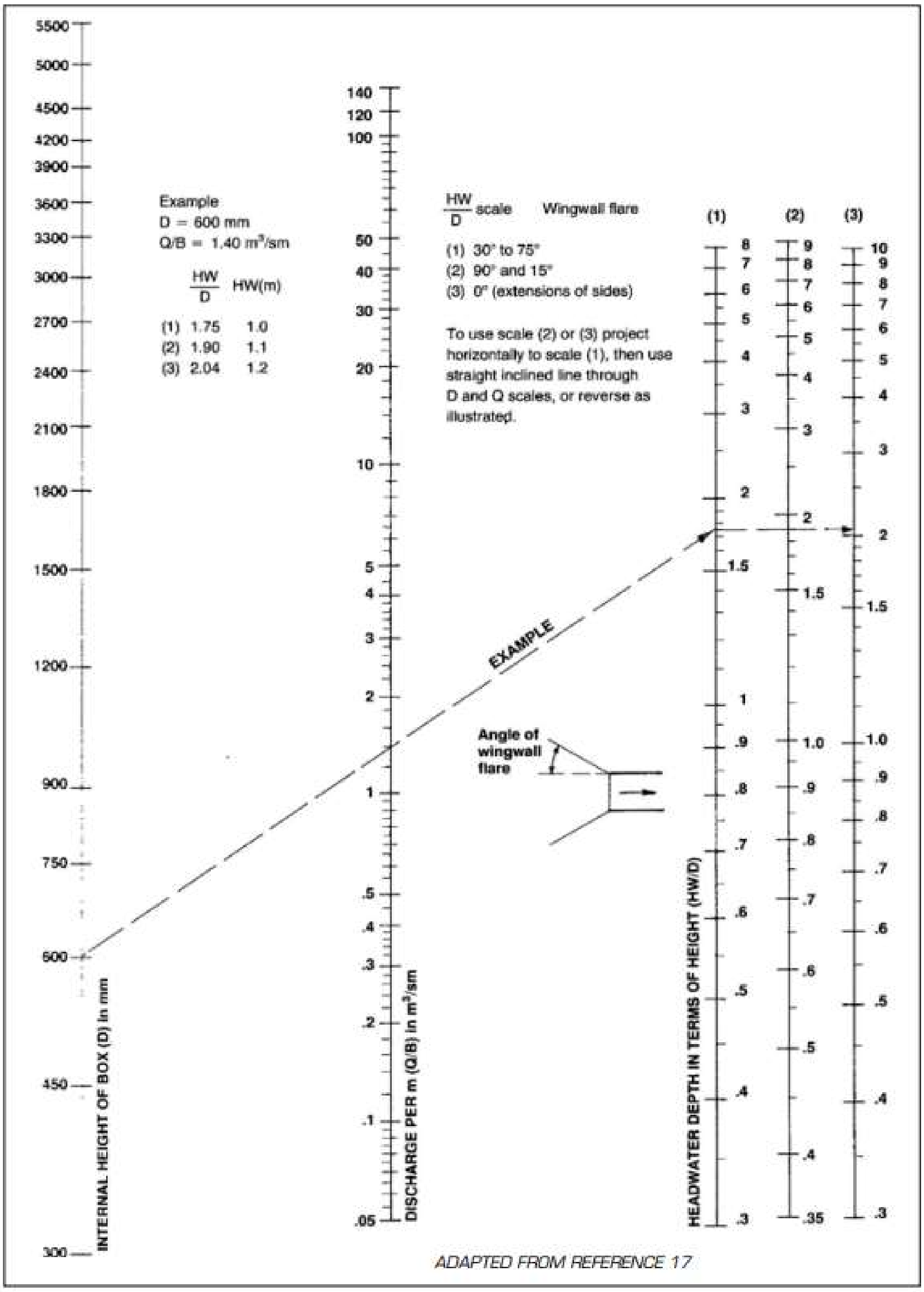
A couple of future scenarios are currently investigated by Kolomela which can affect the water balance. These scenarios are:

- Expansion of the Kapstevel pit.
- DMS plant expansion to increase production tonnes.
- New tailings facility for handling of DMS plant tailings product.
- New Return Water Dams.
- New evaporation dams at the expansion of Kapstevel South.
- New at pit facilities at Kapstevel

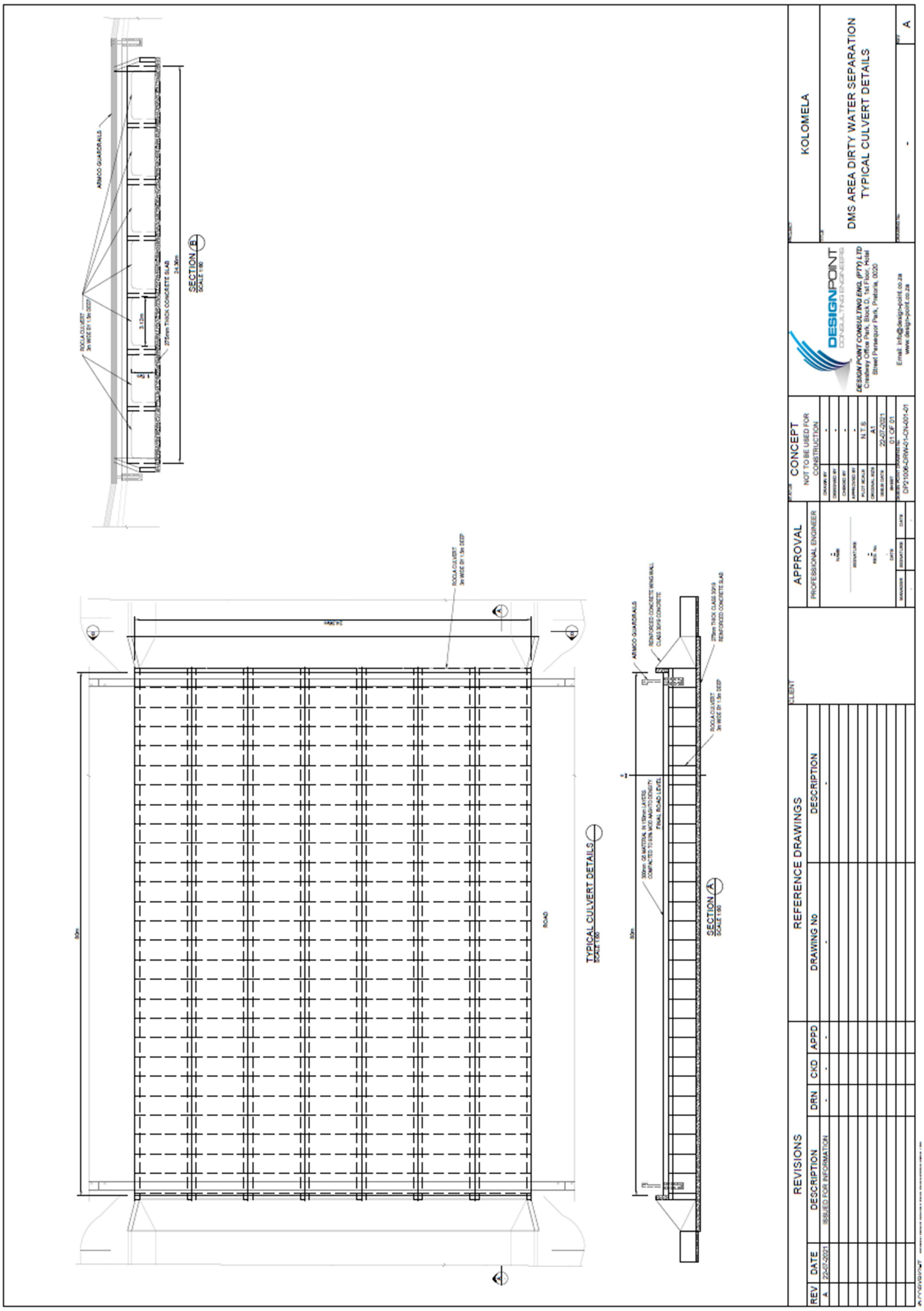
Each of these can either increase or decrease the groundwater use on the mine. It is therefore important that the re-use on the mine is improved even further (as suggested in Section 9.8) by using water collected in the stormwater dams.

As shown in Table 7 approximately 620 m^3/d on average water will be available during the rainy season for use. This means that expansions on the plant can possibly use stormwater instead of groundwater. It is therefore proposed that a thorough study on water demand should be done once the expansions on the mine has been approved.

10 Appendix A



11 Appendix B



12 Appendix C: Kolomela DMS Concept designs

13 Appendix D: Dirty and clean water areas (Future)

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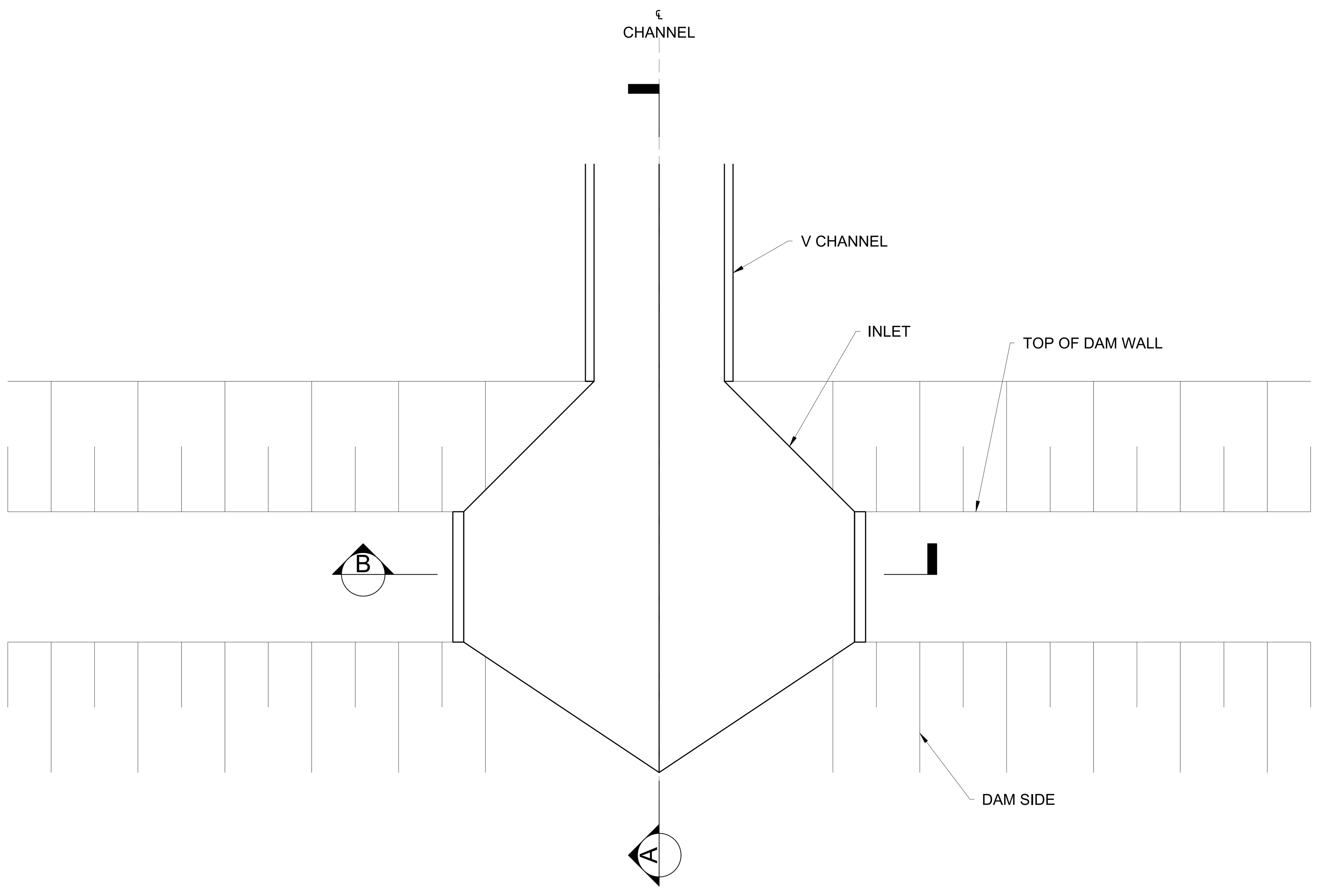

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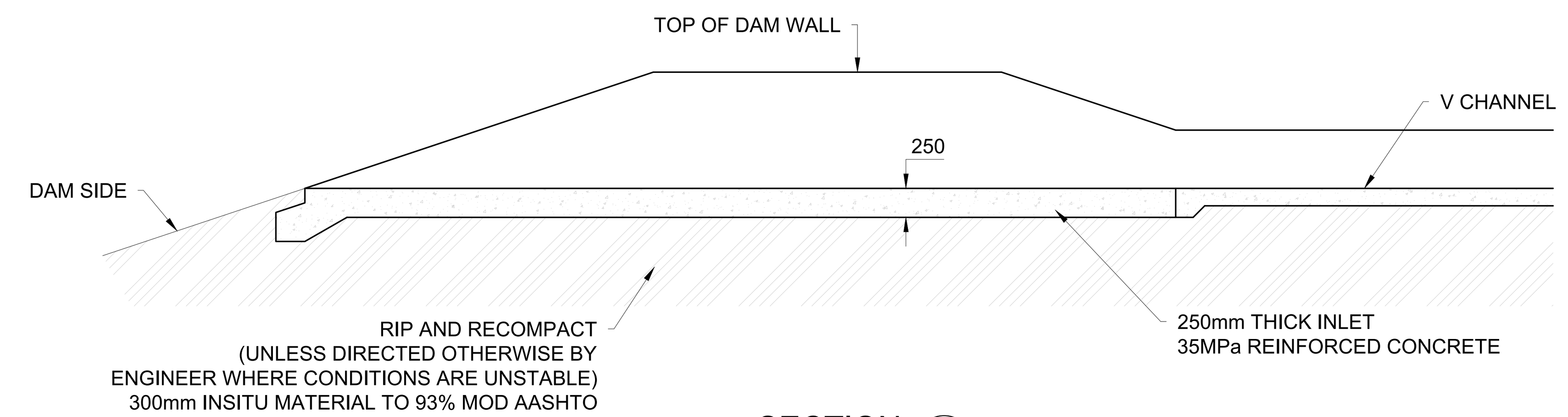

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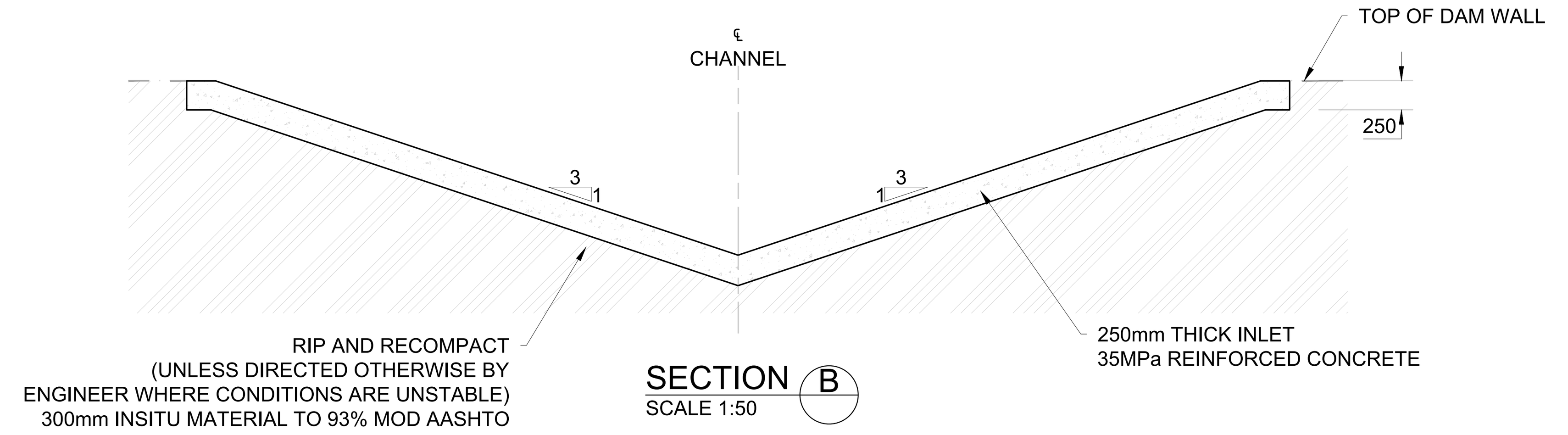

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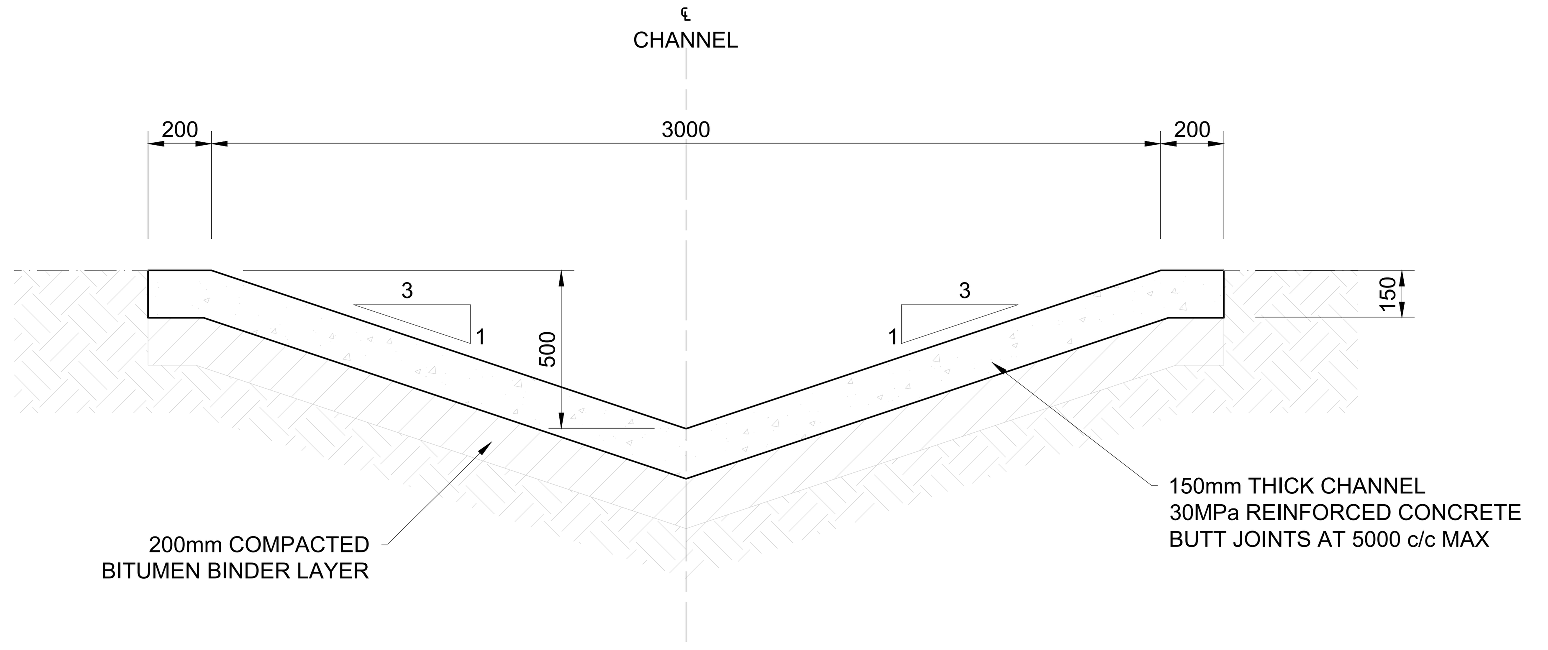

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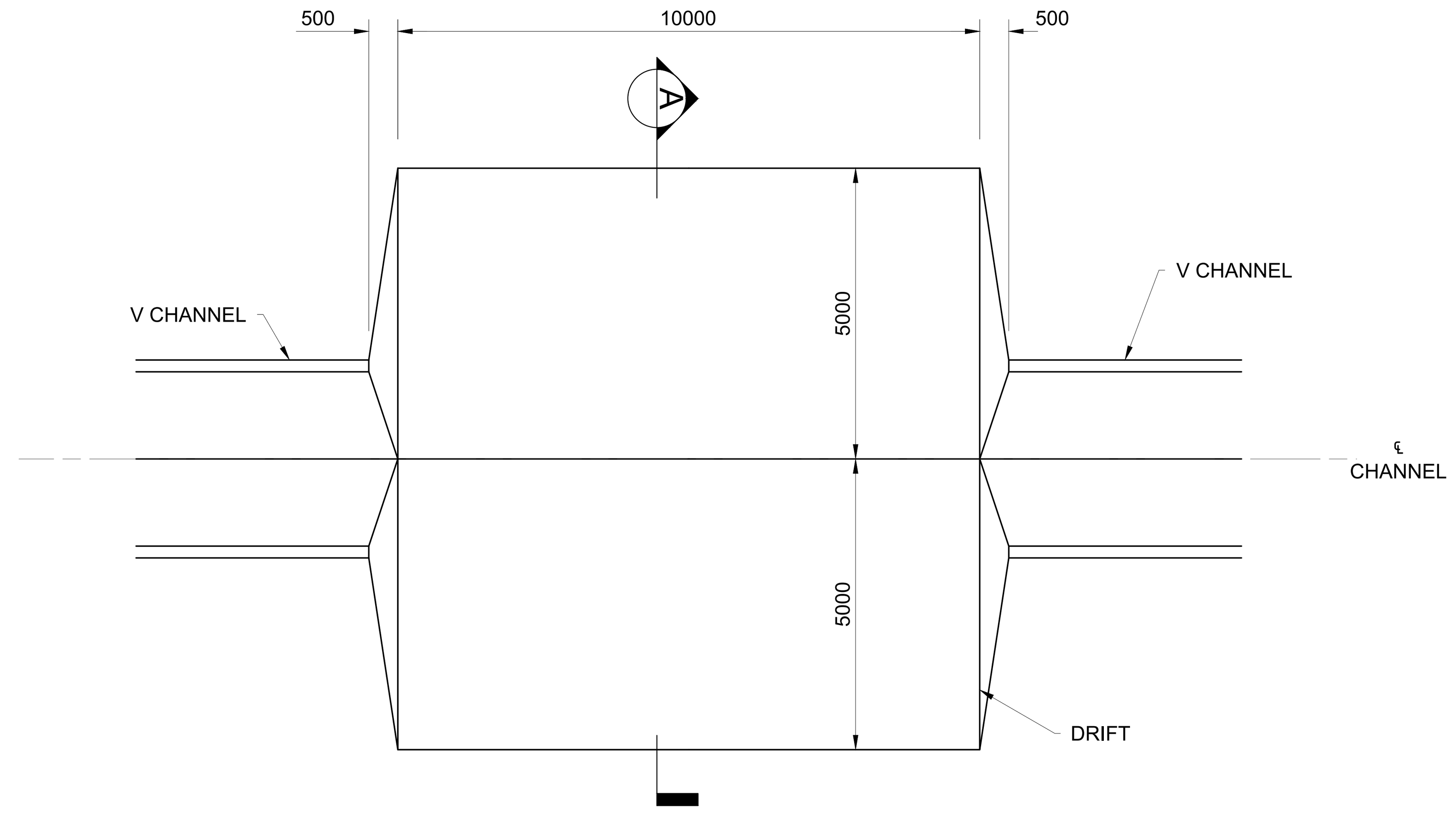

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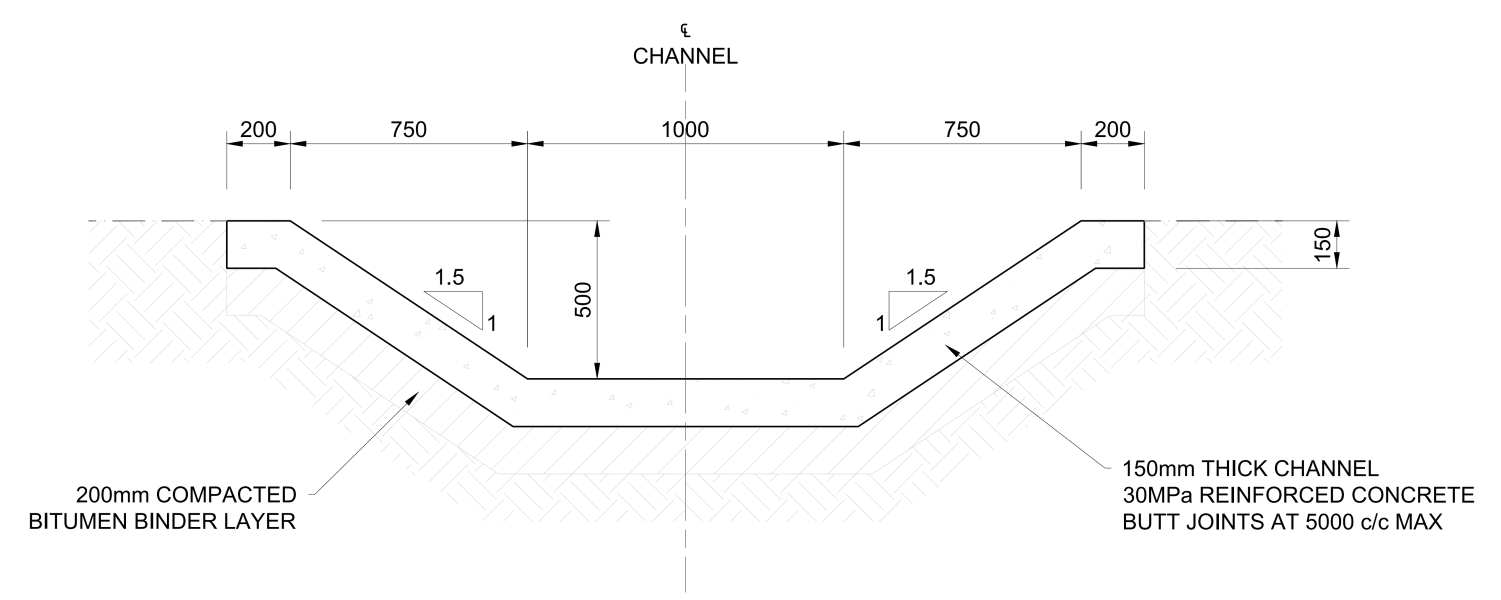

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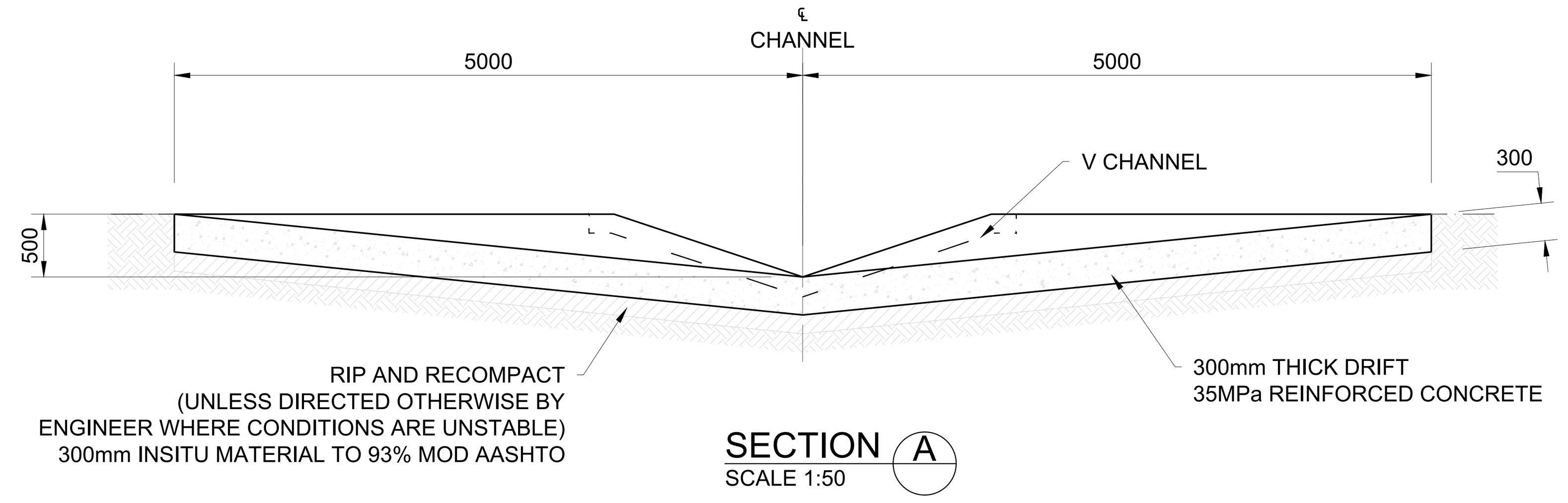

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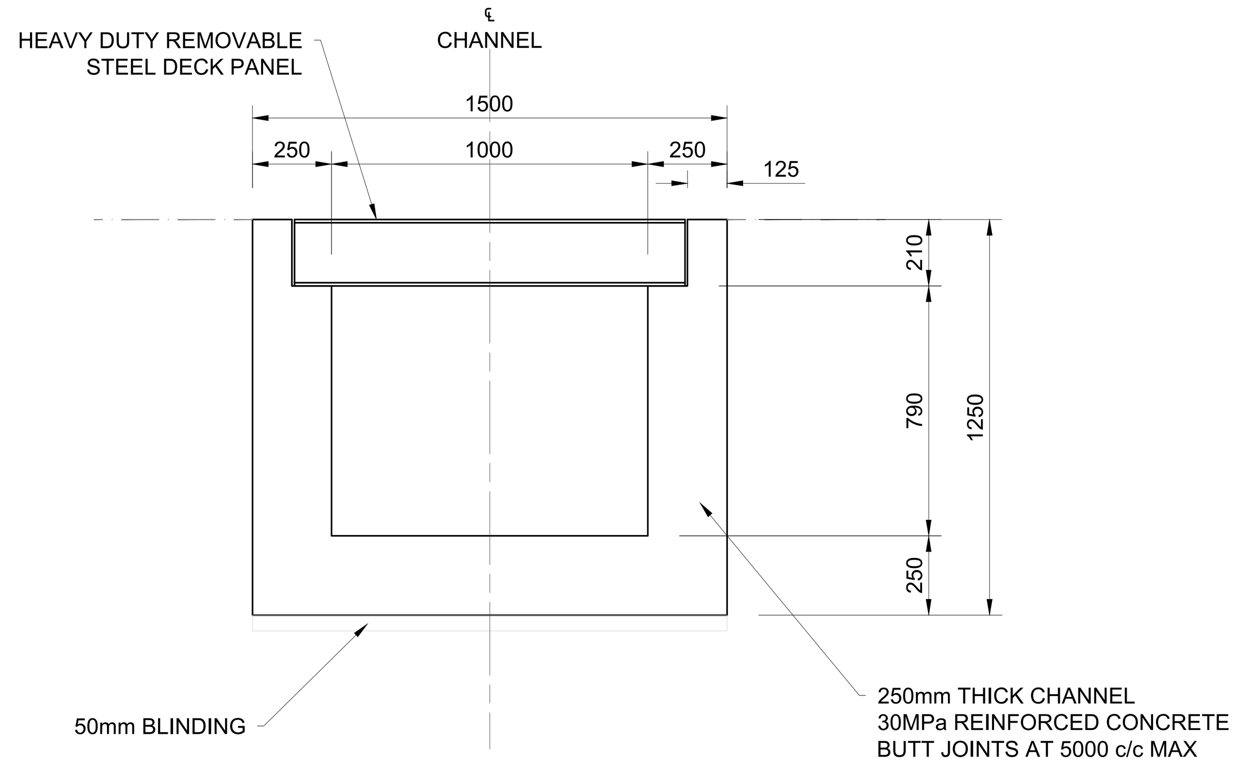

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