APPENDIX F: HYDROLOGY STUDY

JINDAL SURFACE WATER STUDY FOR THE ESIA

Melmoth

Prepared for: Jindal Iron Ore (Pty) Ltd

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EXECUTIVE SUMMARY

Introduction

SLR Consulting (South Africa) (Pty) Ltd, an independent firm of environmental consultants, has been appointed by Jindal Iron Ore (Pty) Ltd (Jindal) to undertake a Surface Water Impact Assessment study to support the Environmental and Social Impact Assessment (ESIA) and integrated authorisation application for the Jindal Melmoth Iron Ore Project.

The overall Jindal surface water study is a two-phased study. Phase 1, which was completed in 2022 covered the scoping phase, which included an assessment of existing studies, gap analysis, desktop hydrological assessment and broad identification of potential surface water impacts. Phase 2 includes a detailed hydrological assessment for the Environmental Impact Assessment (EIA) and Water Use License Application (WULA) purposes.

This report covers the Phase 2 Surface Water Study for the EIA and WULA for the mine. It encompasses the hydrological and floodline assessment, the stormwater management plan (SWMP) and the catchment and impact assessment.

Baseline Hydrology

Jindal's North and South blocks Mining Right Area (MRA) are both located within the upland region of the Mhlathuze Catchment. The Jindal's MRA, including both the North and South block, is influenced by three quaternary catchments (QC) W12B, W12C and W12D. They fall within the Usutu-Mhlatuze Water Management Area (WMA). QC W12B is drained by the perennial Mhlatuze, KwaMazula, Nyawushane and Mavungwini Rivers. QC W12C is drained by the Mfule River, Nhlozane and Mfulazane River and QC W12D is drained by the Mfule and Mhlatuze Rivers. The natural drainage systems flow in an eastern direction towards the Indian Ocean.

The site's Mean Annual Precipitation (MAP) and Mean Annual Evaporation (MAE) are 876 mm and 1 383 mm respectively. Evaporation data is based on Symonds Pan (S-Pan) data taken from the WR2012 Database (WRC, 2012) for the evaporation zone 22A, where the three QCs fall. S-Pan evaporation was converted to open water evaporation using evaporation coefficients from WR90 (WRC, 1990).

Flood Peaks and Floodlines Determination

Sub catchments (S) were delineated for modelling purposes for the streams that would be influenced by the proposed Jindal mining project.

The flood hydrology commenced with calculations of flood peaks for the delineated sub catchments. Six methods were used to determine design flood peaks namely, Rational Method (RM2), Rational Method Alternative 3 (RM3), Midgley and Pitman (MIPI), Standard Design Flood (SDF), the Unit Hydrograph Method (UH) and Social Conservation Services (SCS) Method. The peaks were used as the input into the hydraulic model Hydrological Engineering Centre – River Analysis System (HEC-RAS).

The topographical data forms the foundation for the HEC-RAS model and is used to extract elevation data for the river profiles together with the river cross-sections. The topographical data is also used to determine the positions at which the cross-sections are taken along the river profile, so that the watercourse can be accurately modelled.

Condition 4 of the GN704 indicates that no mining activity or associated infrastructure may be located or placed within the 1:100-year flood line or within a horizontal distance of 100 metres from any watercourse, whichever is greatest.

The proposed mine infrastructure WRD and the Pit is located within the 1:100-year floodlines and most of the infrastructure traverses watercourses.

Suitable flood protection measures (berms and diversions) are recommended to protect the infrastructure from being flooded. Maximum flood depths determined for the various streams must be considered during the design of flood protection berms, including relevant engineering freeboard. The flood protection berms will need to be relatively high along their full alignment in order to withstand the flood level and flood velocities. Several water courses will need to be diverted away from their natural courses to allow for the development of mine infrastructure.

Baseline Water Quality

Surface water sampling was undertaken by a SLR hydrologist on the 14th of May 2021 from the proposed site of development. Six surface water quality samples were collected and analysed. Eight water monitoring points were also obtained from the Department of Water and Sanitation (DWS) water quality database. The water quality analysis results were compared against the Department of Water and Sanitation (DWS) guidelines for irrigation, livestock watering and aquatic ecosystems including the SANS241 guidelines for drinking water.

The water quality results were mostly within the water guidelines range except for a few exceedances. From the DWS Database exceedances have been recorded in pH, Electrical Conductivity (EC) and Total Cyanide in all monitoring points when compared to the Most Sensitive User (MSU) Guidelines.

Conceptual Stormwater Management Plan

Informed by the baseline hydrology of the site and the surroundings, a review of the proposed surface infrastructure has been undertaken, and a series of design guidelines for storm water management have been developed to ensure compliance with the requirements of Government Notice 704 (GN704).

A SWMP has been developed for the site where ‘dirty’ and ‘clean’ contributing catchments are discretised based on topography. Based on the discretised catchments, the required stormwater management drainage elements (including channels, pipes, berms, and pollution control dams) have been sized to ensure appropriate stormwater management according to the management principles outlined in the GN704 and Best Practise Guidelines (BPGs).

The concept of the proposed SWMP for Jindal South Block is to divert and allow clean water within the mine area to flow across the site as free surface flow. Dirty water runoff will be directed and discharged into lined conveyance and storage facilities.

Based on the proposed infrastructure design, the plant and processing areas (dirty water producing areas) are self-contained and have stormwater infrastructure (channels, berms and pollution control dams) built-in to these areas. Cut-off channels and culverts are proposed to divert clean water around proposed infrastructure and access routes. Further, earthen cut off/diversion channels and berms are proposed for construction around the project site and waste dumps. The cut-off channels will intercept and divert clean runoff from upstream catchments and contain dirty runoff within certain areas.

The concept design includes-:

- Conveyance infrastructure:
    - Diversion berm separating the project site and clean water catchment north of the South Block area
    - Waste Rock Dump (WRD) berms/paddocks to contain and prohibit the mixing of clean and dirty water
    - Clean water culverts to divert clean water and prevent damming behind the proposed processing areas which are designed to be built up on terraces.
    - Diversion berms around the plant/processing areas as well as at the edge of the pit.
    - A pumped pipeline system to pump pit water to the processing plant.
- Containment infrastructure: two Pollution Control Dams (PCDs) have been designed, one storing dirty water pumped from the pit and another to store dirty water runoff from the WRD.
- Pumping infrastructure: A pump and pipeline system is proposed to pump pit stormwater to the proposed and relevant PCD.

Site Water Balance

A daily timestep probabilistic Water Balance Model (WBM) has been developed, in accordance with the guidelines specified in the DWAF Best Practice Guideline G2: Water and Salt Balances (2006c), to assess the surface water management system over the entire Life of Mine (LOM). To evaluate the system response over the entire range of probable climate conditions, a stochastic rainfall generator was calibrated to the local historic rainfall record and 500 different sequences of rainfall for the full LOM were simulated.

The water balance predicts an average annual inflow rate of 16,896 ML/year to the site's integrated system. Of this, approximately 7,636 ML/year will need to be sourced from the external source (i.e., Goedertrouw Dam), the remainder will come from runoff, direct rainfall on the dams and feed material moisture.

Most of the water is expected to be lost via entrainment in the TSF (14,228 ML/year), with small volumes lost due to evaporation, dust suppression and via water content in the final product.

Average volumes in excess of 20,000 m^3 are expected to accumulate in the pit during the wet season. During significant wet events this may temporarily be as large as 400,000 m^3, when the pit footprint is fully developed. Periodic minor overtopping at the small PCD's, assuming the proposed arrangement, will likely take place. The current proposed Return Water Dam sizing (3,830,800m^3) and assumed operating principles resulted in a probable spill frequency of less than 1 in 500 years at this facility.

Potential Water Supply to the Proposed Mining Development

The proposed development includes processes that will require raw water. The supply of water has therefore been explored, including the potential abstraction of water from Goedertrouw Dam, and the detailed report on the assessment (Ward, 2022) is appended as Appendix G.

The Mhlathuze catchment (to which the Goedertrouw Dam contributes a significant portion) is overallocated and as such further interventions will be required to support the proposed mining development.

These potential interventions include the following. The Tugela Transfer Phase 2 was initiated because of the 2014 drought. After allowing for the current deficit, the requirement for the proposed mining development would take up over one third of this new supply.

The Mhlathuze weir ultimately provides water to Lake Nsezi. Spills from the Mhlathuze weir, during local rainstorms, have been in excess of what is required by Lake/Estuary, these spills may therefore be captured for use by Jindal.

Mhlathuze Water has already looked at duplicating the pipeline from the weir to the water treatment plant, which could provide an additional 24 Mm^3 per annum.

In addition, Jindal could appoint a professional service provider to develop operating rules to maximize the yield of the dam and minimize losses/spills during the wet seasons, and to convey these directly to the Dam operator. This could provide an additional 18 Mm^3 per annum.

Jindal is also exploring other options to secure a water allocation within the Mhlathuze catchment, which would need to follow the process of redistribution of water in the catchment. Details of these options are not currently available.

Goedertrouw and Neighbouring Catchments

The infrastructure proposed within the Mining Right Area (the WRD, South East Pit and Power Yard) all fall outside of the catchment area of the Goedertrouw Dam. The proposed development will therefore not impact on the runoff entering the Goedertrouw Dam.

The loss in area to the catchment directly downstream of the development is minimal. The proposed development is therefore expected to have minimal impact (if any) on the runoff to the catchments downstream of the proposed development.

All dirty water catchments within the area of the proposed development will be suitably cut-off from the clean water systems to ensure that dirty water is contained as per the regulations.

Jindal are exploring other options to secure water allocations from the catchment, on which there is no further details at this stage of study.

Impact Assessment

Informed by the site plan layout, baseline hydrology, design specifications for the storm water management system, and flood lines, the potential impacts of the proposed activities on surface water receptors are presented in this section along with a summary of mitigation measures.

Where possible impacts are assessed cumulatively as they relate directly to the currently impacted environment. The impacts of the proposed activities and the related infrastructure have been identified and then assessed based on the impact's magnitude, duration, probability, extent, severity and consequences and the receptor's sensitivity. This analysis then concludes in the determination of the impact significance which indicates the most important impacts and those that therefore require management.

The impact assessment is informed by the mine plan layout, baseline hydrology and design specifications for the storm water management measures, mainly to pinpoint the potential impacts of the proposed activities on surface water receptors. The impact rating for a construction, operational and closure phase is given in Section 8. Cumulative impacts on surface water quality and quantity were assessed to be low. A surface water monitoring plans has been proposed outline what needs to be monitored, the frequency of monitoring and responsible person implementation.

Recommendations

The following recommendations have been made:

- It is recommended that the findings of the baseline assessment and floodline modelling should be incorporated in the detailed design of the mine infrastructure and general layout.
- Several water courses will need to be diverted away from their natural courses to allow for the development of mine infrastructure. Floodlines have not been determined for these expected diversion channels as this will form part of engineering design which is outside the scope of this study. The channels will need to be designed and sized according to design criteria adopted by engineers to ensure they can accommodate design flood peaks.
- Maximum flood depths determined for the various streams must be considered during the design of flood protection berms, including relevant engineering freeboard. The flood protection berms will need to be relatively high along their full alignment in order to withstand the flood level and flood velocities.
- A SWMP has been conceptualized for the proposed plan layout of the South Block of the proposed Mining Right area to meet the applicable legislation. It is recommended that the proposed stormwater infrastructure be taken to preliminary and detailed design for implementation.
- Additional studies like geochemical waste assessments, geotechnical investigations and structural detailing may be required to further the conceptual stormwater management designs presented in this report.
- Recommended mitigation measures should be implemented and reviewed regularly as a best practice and compliance with various licenses issued on site by authorities. A surface water monitoring plan proposed should be reviewed periodically to ensure the appropriateness of sites and sampling frequency during operation.
- The cumulative impact of the proposed TSF to also be investigated in the upcoming studies.
- Should the need to abstract water from Geodertrouw Dam and importing water from the Tugela be identified monitoring of such an activity be conducted at appropriate frequency and form part of the surface water monitoring program.

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ACRONYMS AND ABBREVIATIONS

Acronym / Abbreviation	Definition
BPG	Best Practice Guidelines
DDF	Depth-Duration-Frequency
DEM	Digital Elevation Model
DMS	Dense Medium Separation
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EIA	Environmental Impact Assessment
ECO	Environmental Compliance Officer
RE	Resident Engineer
ETo	Evapotranspiration
GN704	General Notice 704
HDPE	High-Density Polyethylene
HEC-RAS	Hydrological Engineering Centre – River Analysis System
LOM	Life of Mine
MAE	Mean Annual Evaporation
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
mamsl	meters above mean sea level
MRA	Mining Right Area
PCD	Pollution Control Dam
PFD	Process Flow Diagram
RM3	Rational Method Alternative 3
ROM	Run of Mine
RWD	Return Water Dam
SDF	Standard Design Flood
SWD	Storm Water Dam
SWMP	Storm Water Management Plan
SWTP	Sewage Waste Treatment Plant
TPM	Tonnes per Month
TSF	Tailings Storage Facility

Acronym / Abbreviation	Definition
TSS	Total Suspended Solids
WBM	Water Balance Model
WMA	Water Management Area
WHO	Word Health Organisation
WR2012	South African Water Resources 2012 Study
WULA	Water Use Licence Application
WUL	Water Use Licence

Jindal Surface Water Study for the ESIA

1. INTRODUCTION

SLR Consulting (South Africa) (Pty) Ltd an independent firm of environmental consultants, has been appointed by Jindal Iron Ore (Pty) Ltd (Jindal) to undertake a Surface Water Impact Assessment study to support the Environmental and Social Impact Assessment (ESIA) and integrated authorisation application for the Jindal Melmoth Iron Ore Project.

The overall Jindal surface water study was a two-phased study. Phase 1 covers the scoping phase, which includes an assessment of existing studies, gap analysis, desktop hydrological assessment and broad identification of potential surface water impacts. Phase 1 has since been completed in the year 2022. Phase 2 involves a detailed hydrological assessment for Environmental Impact Assessment (EIA) and Water Use License Application (WULA) purposes.

Therefore, this report covers the Phase 2 Surface Water Study for the Water Use License for the proposed mine and its associated infrastructure. It should be noted that the impact assessment of the Tailings Storage Facility (TSF) for the mine will also be reported separately.

1.1 PROJECT BACKGROUND AND DESCRIPTION

The Melmoth Iron Ore Project (the Project) site is located 25 km southeast of Melmoth, within the Mthonjaneni Local Municipality in the KwaZulu-Natal Province.

Jindal Iron Ore (Pty) Ltd (Jindal), is owned by Jindal Steel and Power (Mauritius) Limited (74%) and South African BEE partner Mr. Thabang Khomo (Pty) Ltd (26%). Jindal holds two Prospecting Rights over the project site. The prospecting rights are referred to as North Block (PR 10644) and South Block (PR 10652) and have a total combined area of 20 170 ha.

In January 2021 Jindal appointed SLR Consulting South Africa as the independent Environmental Assessment Practitioner (EAP) to undertake a new ESIA and public participation process and prepare all documentation for a Mining Right Application (MRA).

Jindal's intent with this MRA is to consolidate the Prospecting Rights for the North and South blocks into a single Mining Right with development of the mine and mining infrastructure being undertaken in a phased approach. Mining is currently only proposed to be undertaken in the south-eastern section of the South Block, where the iron ore resource has been defined. Infrastructure would be developed to support this mining operation. The TSF is proposed to be off-site under a separate application.

An open cast mining operation is proposed to be developed in the south-east section of the South Block known as the South East Pit. Approximately 800 million tonnes of ore is expected to be mined from the pit over the Life of Mine (LOM) (approximately 25 years). Waste rock would be stripped from the pit at a ratio of approximately 0.5 tonnes of waste rock per one tonne of ore. The waste rock would be disposed of on a WRD within the mining right area. Drilling and blasting techniques would be used to excavate the iron ore (proposed to be 32 mtpa) which would then be loaded onto trucks and transported to the Run-of-Mine (ROM) ore stockpile area where it will be stored and subsequently transferred to the processing plant for milling and magnetic separation. The milling and magnetic separation processes are wet processes so that iron ore slurry can be easily handled by means of pumps and pipes and machinery designed for slurry processing. The concentrated iron ore now contains 67% iron compared to 30% iron in the mined ore. The concentrate is thickened and filtered to remove water which is recycled within the process. The processing plant would produce iron ore concentrate and a tailings slurry. The approximately 7.5 mtpa of iron ore concentrate would be transported 80 km to the Richards Bay Port by rail using the Nkwalini rail siding situated 4 km from the proposed Jindal MIOP (part of a separate application). The concentrate would be exported as there are limited local markets. The slurry would be disposed of to a TSF (separate application as discussed previously). Associated infrastructure to support the mine would include:

- a milling and processing plant;
- analytical laboratory;
- rail loading facility;
- access and haul roads;
- electrical transmission line and sub-stations;
- raw water abstraction and pipelines;
- stormwater management infrastructure;
- tailings pipelines;
- concentrate pipelines;
- offices;
- change house; and
- workshops and perimeter fencing (amongst others).

1.2 SCOPE OF WORK AND REPORT STRUCTURE

This Surface Water Study includes the following:

- Policy and Legislative Context-Section 2 presents a summary of the applicable legislation.
- Baseline Hydrology - Section 3 presents the baseline hydrology of the site and surroundings including climate, storm intensities, regional and local topography, watercourse and mean annual runoff.
- Surface Water Quality- Section 4 presents a review and analysis of available data and water quality collected by SLR to classify the baseline water quality;
- Flood Hydrology - Section 5 presents estimates of the flood hydrology of the selected rivers in the vicinity of the site including methodologies for peak flow estimation and results which will inform the floodline modelling.
- Hydraulic Flood modelling - Section 6 presents hydraulic flood modelling undertaken for the selected rives including methodology, software and 1:100-year flood-lines within the vicinity of the site.
- Conceptual Stormwater Management - Section 7 presents the recommended stormwater drainage measures to manage flood risks to the operation and minimise risks of polluting any water resources, including clean and dirty water catchment delineation, estimation of peak flows, channel routing and sizing, and sizing of pollution control dams.
- Goedertrouw Dam and Impact Downstream- Section 8 present the qualitative analysis of the proposed mine development on the Dam and agricultural users downstream.

- Impact Assessment-Section 9 presents a qualitative assessment of the significance of the impact of the project on the baseline surface water environment, a range of mitigation measures to minimise the impacts, and recommendations on the monitoring required;
- Conclusion and recommendations-Section 10, presents the overall study relevant actions to be considered and conclusion.
- References – Section 11 presents a list of the reference documents used for preparation of this report.

2. POLICY AND LEGISLATIVE CONTEXT

The following legislation was considered during this assessment:

2.1 THE NATIONAL WATER ACT (ACT 36 OF 1998)

Water resources management in South Africa is governed by the National Water Act (Act 36 of 1998) (NWA). The Department of Water and Sanitation (DWS) must, as custodians of water, ensure that resources are used, conserved, protected, developed, managed, and controlled in a sustainable manner for the benefit of all persons and the environment.

2.2 REGULATIONS ON THE USE OF WATER FOR MINING AND RELATED ACTIVITIES

Government Notice 704 (Government Gazette 20119 of June 1999) (hereafter referred to as GN704), was established to provide regulations on the use of water for mining and related activities aimed at the protection of water resources. The three main conditions of GN704 applicable to this project are:

- Condition 4 – indicates that no person in control of a mine or activity may locate or place any residue deposit, dam, reservoir, together with any structure of other facility within the 1:100-year flood line or within a horizontal distance of 100 metre from any watercourse.
- Condition 5 - 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 - 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 the flow of a 1:50-year recurrence interval storm event. Clean and dirty water systems should therefore not spill into each other more frequently than once in 50 years. Any dirty water dams should also have a minimum freeboard of 0.8m above full supply level.
- Condition 7 - 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 clean water resource (by spillage, seepage, erosion etc.) and it should be ensured that water used in any process is recycled as far as practicable.

2.3 BEST PRACTISE GUIDELINES

In addition to GN704, the DWS (previously Department of Water Affairs and Forestry) has developed several Best Practice Guidelines (BPGs) for the mining industry. These include:

- BPG A4 for Pollution Control Dams (PCDs) defines the allowable PCDs spillage frequency as being one spill in every 50 years on average. This is equivalent to stating that an RWD or PCD should be designed with an annual spillage probability of 1:50 (2%) or less. In addition to this, BPG A4 recommends that the final design criteria should be determined through the use of a long-term continuous simulation water balance model, modelled at an appropriate time step (preferably daily), where:
    - “The definition of an event is defined as a sequence of continuous spill days occurring during a 30-day window”.
    - “The spillage frequency depends on the size of the dam (capacity) and the abstraction and re-use rate.”

    - "Confirmation of the dam sizing (based on spillage frequency), by means of continuous modelling."
    - "It is important to consider the loss of storage due to sediment build up in the PCD when sizing the dam."
    - "The PCD water balance will be used to specify a minimum storage level. This ensures that adequate freeboard is maintained so that the storm water inflow can be accommodated, and the spillage frequency met. The management of the PCD should be according to this minimum level. The dam volume should be reduced to this minimum level as soon as possible after storm events."
    - "It is important to consider that, in general, it is not the single events that result in spillage, but rather prolonged wet conditions."

- BPG G1 Storm Water Management, which defines a methodology of planning, designing and implementing storm water management measures to ensure separation of clean and dirty water and provides guidelines to ensure sustainability over the mine's life cycle. It also offers guidelines for the following:
    - Classification of clean and dirty areas.
    - Conceptual designs and review, "The designer has to balance the need to obtain preliminary sizes so that water conveyance systems and retention structures can be provisionally sized, without undertaking a detailed design that may have to be discarded due to inadequacies in the storm water management plan (SWMP), or changes in the conceptual design."
    - Assess the Suitability of the existing infrastructure and define infrastructure changes required.
    - Design of required infrastructure informed by all prior steps.
- BPG G2: Water and Salt Balances, which defines a methodology of planning, designing and implementing water balance objectives to ensure suitable water management strategies and provides guidelines to ensure sustainability over the mine's life cycle.

- BPG G3: Water Monitoring Systems.
    - Water monitoring is a legal requirement and can be used in negotiations with authorities for permits and authorizations.
    - Monitoring on a mine consists of various components. It must be recognised and understood that the successful development and implementation of an appropriate, accurate and reliable monitoring programme requires that a defined structured procedure be followed. Furthermore, it is important that this is done by a suitably qualified person.
    - Monitoring programmes can be developed to support various management actions that have different primary objectives. The detailed features of monitoring programmes tend to be very site-specific. As a result, there is no single uniform procedure that can be followed when defining and implementing a monitoring programme. However, there are a number of general principles that need to be followed when developing these site-specific monitoring programmes to ensure that the data and information that are collected are appropriate and reliable.

- Interested and affected parties should be consulted at the appropriate time during the development of the monitoring programme. The monitoring programme should be able to address their concerns and provide answers to their questions; and
- The objectives of the management actions that drive the monitoring programme must be clearly defined, together with the data and information requirements that support these objectives.
- The most common environmental management actions require data and thus the objectives of water monitoring include the following:
    - Development of environmental and water management plans based on impact and incident monitoring (facilitate in decision-making, serve as early warning to indicate remedial measures or that actions are required in certain areas) for the mine and region.
    - Generation of baseline/background data before project implementation.
    - Identification of sources of pollution and extent of pollution (legal implications or liabilities associated with the risks of contamination moving off site).
    - Monitoring of water usage by different users (control of cost and maximizing of water reuse).
    - Calibration and verification of various prediction and assessment models (planning for decommissioning and closure with regards to financial provision and required actions).
    - Identification and design of appropriate water treatment technology.
    - Control of unit processes such as water treatment plants or process plants (through process control loops).
    - Evaluation and auditing of the success of implemented management actions (ISO 14000, compliance monitoring).
    - Assessment of compliance with set standards and legislation (EMPs, water use licenses); and
    - Assessment of impact on receiving water environment.

2.4 WATER QUALITY STANDARDS

The following water quality standards are used to guide the water quality assessment:

- South African National Standard (SANS). Drinking Water Standard SANS 241: 2015.
- Targeted Water Quality Range (TWQR) (DWA, 1996).

3. BASELINE HYDROLOGY

An understanding of the baseline hydrology is required in order to inform the flood studies, design of stormwater management measures and site wide water balance as well as the potential impact to the receiving environment. This section presents a summary of the baseline review of various information sources and defines the baseline climatic and hydrological conditions of the site and surroundings.

3.1 CLIMATE

3.1.1 Rainfall

This project site climate data was obtained from the Water Resources of South Africa Manual WR2012 (WRC, 2012) which comprises the climatic and catchment information of each quaternary catchment in South Africa. The average hydro-meteorological parameters were calculated for quaternary catchments on the site.

The site's Mean Annual Precipitation (MAP), and Mean Annual Evaporation (MAE), respectively, are to be 870 mm and 1 383 mm, respectively, as shown in Table 3-1. The evaporation in the area is relatively higher than the amount of rainfall this catchment receives. The monthly distribution of the rainfall and evaporation is presented in Figure 3-1.

Table 3-1: Quaternary Catchment Parameters (WR2012)

Quaternary Catchment	Catchment area		S-pan evaporation		Rainfall	
	Gross (km^2)	Net (km^2)	Evap zone	MAE WR2005 (mm)	Rainfall zone	MAP
W12B	656	656	22A	1400	W1B	932
W12C	570	570	22A	1400	W1C	848
W12D	569	569	22A	1350	W1C	848
Average	-	-	-	1383	-	870

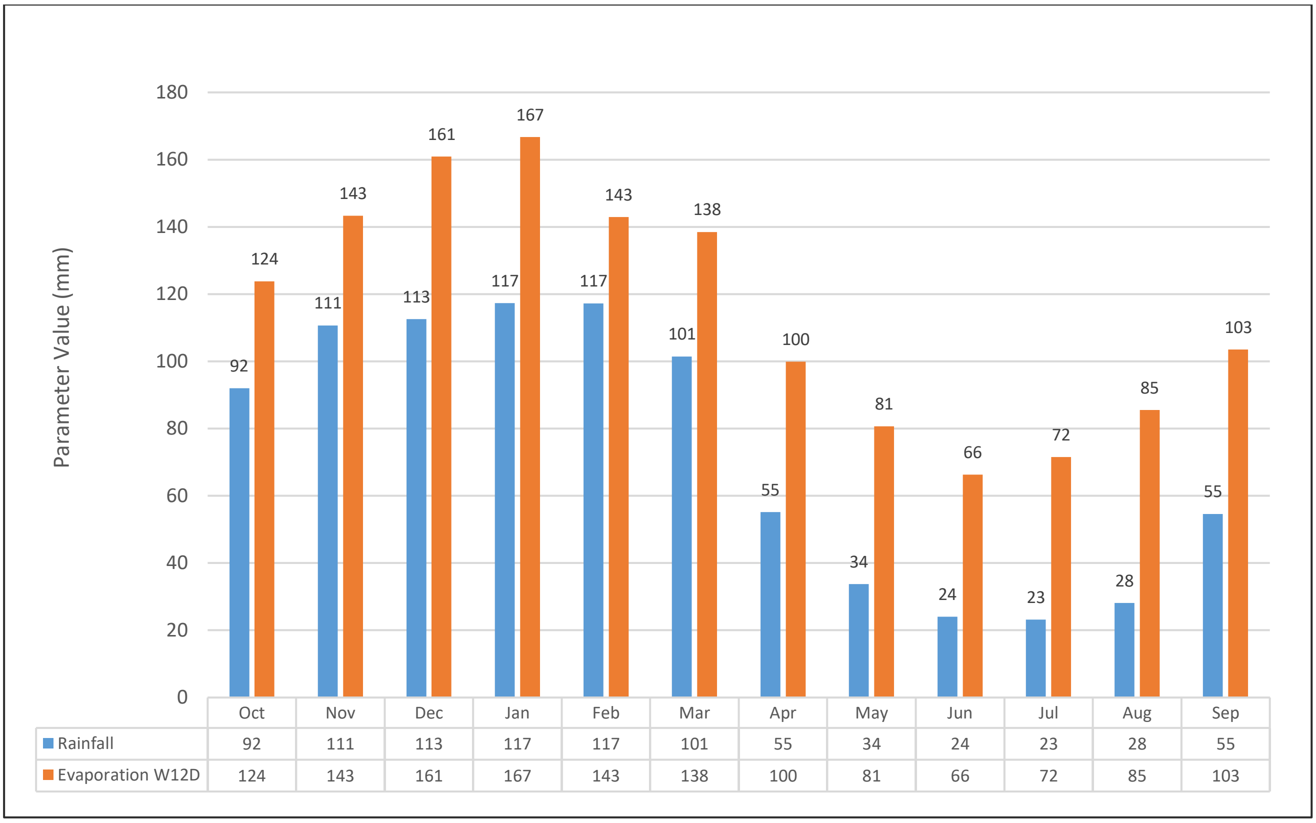


Figure 3-1: Rainfall and Evaporation Distribution Around the Project Site

The average monthly rainfall for the quaternary catchments (W12B, W12C and W12D) were obtained from the Water Resources Study (WR2012). Rainfall data for each quaternary catchment is natively presented as a percentage of MAP which is then converted into average monthly values. The monthly rainfall data for all three quaternary catchments influenced by the proposed mine were averaged and are presented in Table 3-2. The driest months observed from the quaternary catchment data are June, July and August, with July recording a lowest rainfall of 23mm. The month of December, January and February are the wettest months with January and February recording 117mm.

The daily rainfall data from station 0303833W (Eshowe) for the period extending from 1920-2000 was extracted from Daily Rainfall Data Extraction Utility Programme and was extended to year 2022 using data from South African Weather Service. The wettest months were December, January and February, with January recording 173mm. The month of June, July and August were the driest months, with the lowest rainfall of 25mm recorded in June. Table 3-2 present average monthly rainfall for both analyses.

Table 3-2: Monthly Average Rainfall (mm)

Month	Quaternary Catchment	Nearest Station – 0303833W
Jan	117	173
Feb	117	162
Mar	101	126
Apr	55	75

Month	Quaternary Catchment	Nearest Station – 0303833W
May	34	46
Jun	24	25
Jul	23	31
Aug	28	45
Sep	55	79
Oct	92	145
Nov	111	154
Dec	113	144
Total	**870**	**1205**
Wettest Month	116	163
Driest Month	25	34

3.1.2 Evaporation

Monthly evaporation data for the three QCs was obtained from the Water Resources of South Africa 2005 Study, (WR2005, 2012). The project area lies within evaporation zone 22A, which has an MAE of 1 383 mm. The evaporation obtained is based on Symons pan evaporation measurements and needs to be converted to lake evaporation using factors obtained from WR2005. Table 3-3 gives a summary of the monthly average evaporation for the project site.

Table 3-3: Summary of Monthly Average Evaporation (WR2012)

Month	Average Evaporation (mm)
January	167
February	143
March	138
April	100
May	81
June	66
July	72
August	85
September	103
October	124
November	143
December	161
Total	**1383**

Month	Average Evaporation (mm)
Wettest Month	149
Driest Month	73
Average	115
Annual	1383

3.1.3 Storm Depth-Duration-Frequency (DDF)

Design storm estimates for various return periods and storm durations were sourced from the Design Rainfall Estimation Software for South Africa, developed by the University of Natal in 2002 as part of a WRC project K5/1060 (Smithers and Schulze, 2002). The software extracts the storm depth-duration-frequency (DDF) data for the six closest rainfall stations, as presented in Table 3-4, and was used to interpolate DDF data for the project area, as presented in Table 3-5. These rainfall depths were adopted and used in the estimation of design flood peaks for different return periods, as detailed in Section 5, Flood Hydrology.

Table 3-4: Six Gridded Rainfall Stations around the Project Site

Station Name	SAWS Number	Reliabilities	Distance	Record	Coordinates		MAP	Altitude
		%	(km)	(Years)	E	S	(mm)	(m)
303667	0303667_P	34.5	4	45	28° 37´	31° 23´	909	866
Melmoth (Golden Reef)	0303666_S	24.4	5.1	32	28° 36´	31° 23´	887	854
Melmoth (Pol)	0303695_W	27.5	5.7	36	28° 35´	31° 24´	849	771
Springvale	0303633_W	21.2	11.5	30	28° 33´	31° 21´	882	834
Nkwalini	0304015_S	16.0	16.6	52	28° 45´	31° 31´	705	157
Mtonjaneni	0337628_W	36.9	20.1	50	28° 28´	31° 20´	801	1165

Table 3-5: Storm Depth-Duration-Frequency (DDF) Rainfall for the Project Site

Duration	Return Period in Years						
(m/h/d)	2	5	10	20	50	100	200
5 m	15.6	21.8	26.6	31.9	39.9	46.7	54.4
10 m	19.0	26.6	32.5	39.0	48.7	57.0	66.4
15 m	21.3	29.9	36.6	43.8	54.7	64.1	74.6
30 m	27.9	39.0	47.8	57.3	71.5	83.7	97.5
45 m	32.6	45.7	55.9	67.0	83.6	97.9	114.0
1 h	36.4	51.0	62.4	74.8	93.4	109.4	127.4
1.5 h	42.6	59.6	73.0	87.5	109.2	127.9	148.9
2 h	47.6	66.6	81.5	97.7	122.0	142.9	166.4

Duration	Return Period in Years						
4 h	57.0	79.8	97.6	117.0	146.0	171.0	199.2
6 h	63.3	88.6	108.4	129.9	162.1	189.9	221.2
8 h	68.2	95.4	116.8	140.0	174.7	204.7	238.4
10 h	72.2	111.1	123.7	148.3	185.1	216.8	252.5
12 h	75.7	116.0	129.7	155.5	194.1	227.3	264.8
16 h	81.6	114.2	139.8	167.6	209.1	244.9	285.3
20 h	86.4	121.0	148.1	177.5	221.5	259.5	302.2
24 h	90.6	126.9	155.2	186.1	232.2	272.1	316.9
1 d	76.9	127.6	131.7	157.9	197.0	230.8	268.8
2 d	97.1	135.9	166.2	199.3	248.7	291.4	339.4
3 d	111.2	155.7	190.5	228.4	285.1	333.9	388.9
4 d	122.0	170.9	209.1	250.7	312.8	366.4	426.7
5 d	131.1	183.6	224.7	269.4	336.1	393.7	458.6
6 d	139.1	194.8	238.3	285.7	356.5	417.6	486.3
7 d	146.2	204.7	250.4	300.2	374.6	438.9	511.1

3.2 HYDROLOGICAL SETTINGS

3.2.1 Regional Hydrology

The proposed project falls between QC W12B, W12C and W12D. QC B12A falls within the uSuthu-Mhlatuze WMA. QC W12B is drained by the perennial Mhlatuze, KwaMazula, Nyawushane and Mavungwini rivers. QC W12C is drained by the Mfule River, Nhlozane and Mfulazane River. QC W12D is drained by the Mfule and Mhlatuze River. The natural drainage systems flow in an eastern direction towards the outlet flowing into the Indian Ocean. The hydrology around the site is presented in Figure 3-2.

The WRSM2000/Pitman Software is a mathematical model that simulates the movement of water through an interlinked system of catchments, river reaches, reservoirs, irrigation areas and mines (WRC, 2012). WRSM2000 simulates naturalised runoff around the project site at a unit runoff of 112.5 mm per annum. The runoff, when expressed as a percentage of rainfall, equates to 13%. The monthly runoff is likely to be distributed as presented in Table 3-6.

Table 3-6: Mean Annual Runoff (MAR) for Catchments around the Project Site

QC	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	MAR
W12B	6.2	5.4	5.4	5.8	9.0	10.9	7.2	5.9	5.6	5.7	5.1	6.9	79.0
W12C	7.7	7.1	6.9	7.2	11.8	13.2	8.5	6.6	5.8	6.4	5.0	7.5	93.7
W12D	12.6	17.9	17.9	19.2	21.8	18.6	13.3	10.4	7.9	8.3	7.1	9.8	164.8
Average	8.8	10.1	10.1	10.7	14.2	14.2	9.7	7.6	6.4	6.8	5.7	8.1	112.5

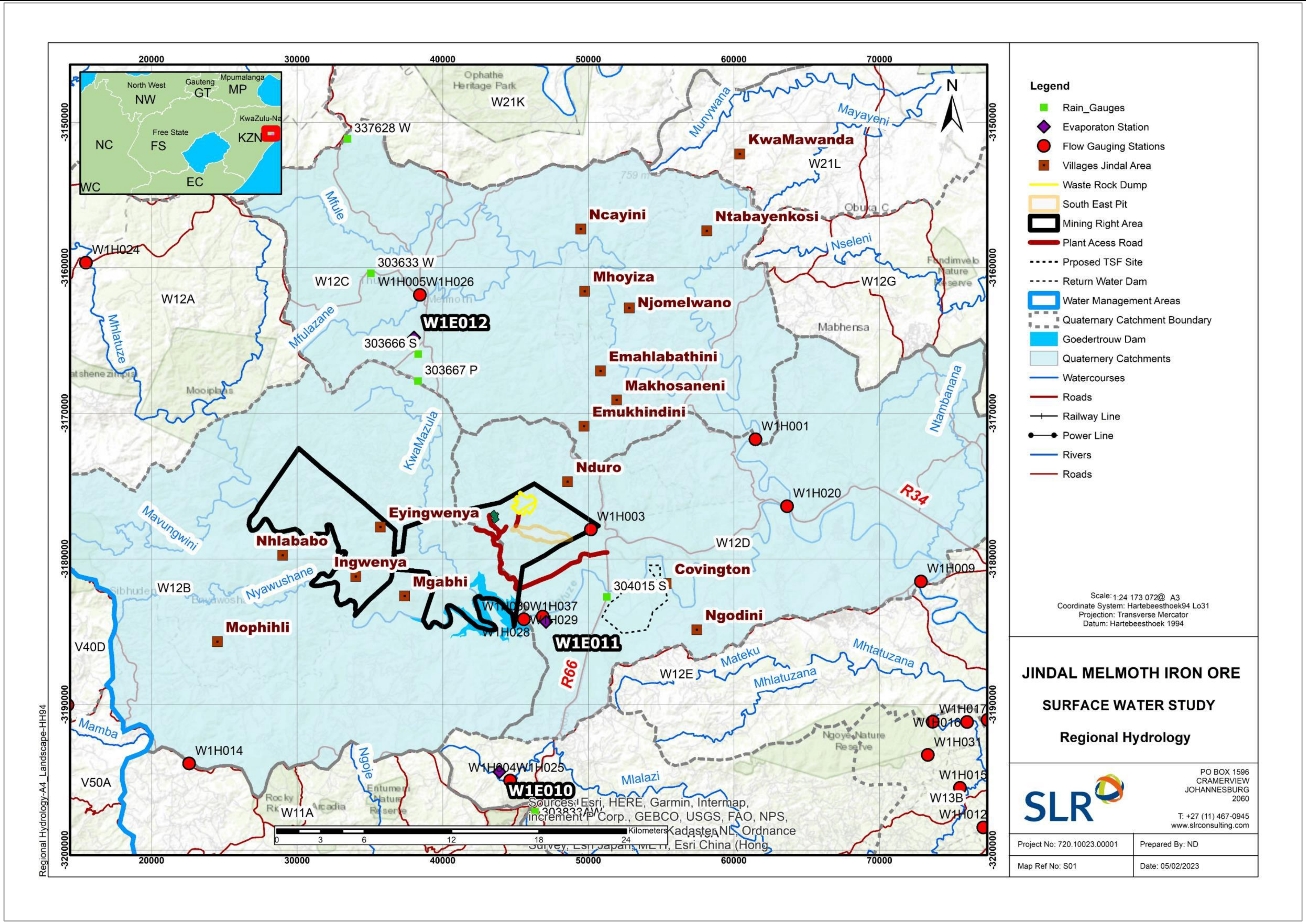


Figure 3-2: Regional Hydrology

3.2.2 Topography

The topography of the area is determined by the type of bedrock underlying the soils of the geology of the area. Melmoth is 800 m above sea level and is surrounded by low sandstone mountains and mudstone valleys. The regional geology of the area has given rise to a considerable diversity of relief, from gently rolling slopes to hilly and severely incised slopes found along drainage ways and stream valleys.

4. SURFACE WATER QUALITY

This section presents a discussion of the baseline water quality of the local watercourses. Surface water sampling was undertaken by a SLR hydrologist on 14 May 2021. Six surface water quality samples were collected and analysed. Eight water monitoring points were also obtained from the DWS water quality database. The location and description of the surface water monitoring points are presented in Table 4-1 and Table 4-2 as well as in Figure 4-1.

Table 4-1: SLR Water Quality Monitoring Stations

Point	Coordinates		Description
	Latitude	Longitude	
SW2	-28.717768°	31.274721°	Near Ntabandlovu Village, a small river crossing
SW3	-28.772743°	31.368183°	Upstream of Goedertroudam.
SW5	-28.653209°	31.407021°	West of R66 Road
SW7	-28.540284°	31.503128°	Near Ncayini Village on unnamed road
SW8	-28.631711°	31.567029°	Approximately 2 km southwest of Makhaseni Village
SW9	-28.715301°	31.509862°	Approximately 1.4 km East of the proposed Mine Pit

Table 4-2: DWS Water Quality Monitoring Stations

Station Number	Coordinates		Station Description
	Latitude	Longitude	
W12_103330	-28.7724	31.46878	Normanhurst 3023 - Goedertrou Dam on Mhlatuze River: at Dam Wall (NEMP nmmp) A01
W12_102826	-28.7725	31.46667	Goedertrou Dam on Mhlatuze River: Point in Dam Q02
W12_102825	-28.7725	31.46667	Normanhurst 3023 - Goedertrouw Dam (Lake Phobane) on Mhlatuze River: near Dam Wall (NCWQ) Q01
W12_102820	-28.7725	31.46667	Goedertrou Dam on Mhlatuze River: Down Stream Wei
W12_102819	-28.5522	31.15833	Mhlatuze River at Naauwkloof (Mtuza)
W12_102814	-28.7017	31.65139	Mfule River at Quneba/Rail (Mful)

Station Number	Coordinates		Station Description
	Latitude	Longitude	
W12_102808	-28.7725	31.46667	Mfulazane River at Golden Reef (NCWQ)
W12_102807	-28.5717	31.39278	Mhlatuze River at Normanhurst

4.1 WATER QUALITY STANDARDS

Various DWS water quality guidelines were assessed to determine the most important receptors and/or potential surface water users in the area. To achieve this, the following were determined to be of most relevance:

- Aquatic Ecosystems;
- Irrigation;
- Livestock Watering, and
- South African National Standard for drinking water (SANS241: 2015).

The DWS Water quality guidelines for irrigation, aquatic ecosystems, livestock watering and drinking water standards (SANS 241) were used to assess the water quality status. It should be noted that many of the values identified related to the DWS irrigation guidelines adopts a conservative approach by specifying the potentially most sensitive crops.

4.2 WATER QUALITY ANALYSIS

The water quality results were compared against the DWS guidelines for irrigation, livestock watering and aquatic ecosystems including the SANS241 guidelines for drinking water. The relevant water quality results are shown in Table 4-3. The water quality results were mostly within the water guidelines range except for a few exceedances.

Exceedances in Aluminium (Al), Copper (Cu), Mercury (Hg), pH and Total Cyanide (CN) were recorded in all sampling points when compared to the Aquatic Ecosystems Guidelines. Electrical Conductivity (EC) was also in exceedance in all the six water sampling points sampled by SLR.

From the DWS Database exceedances have been recorded in pH, EC and Total Cyanide in all monitoring points when compared to the Most Sensitive Users (MSU) Guidelines.

Exceedances are highlighted and are marked in bold in the water quality result tables below (Table 4-3 and Table 4-4.

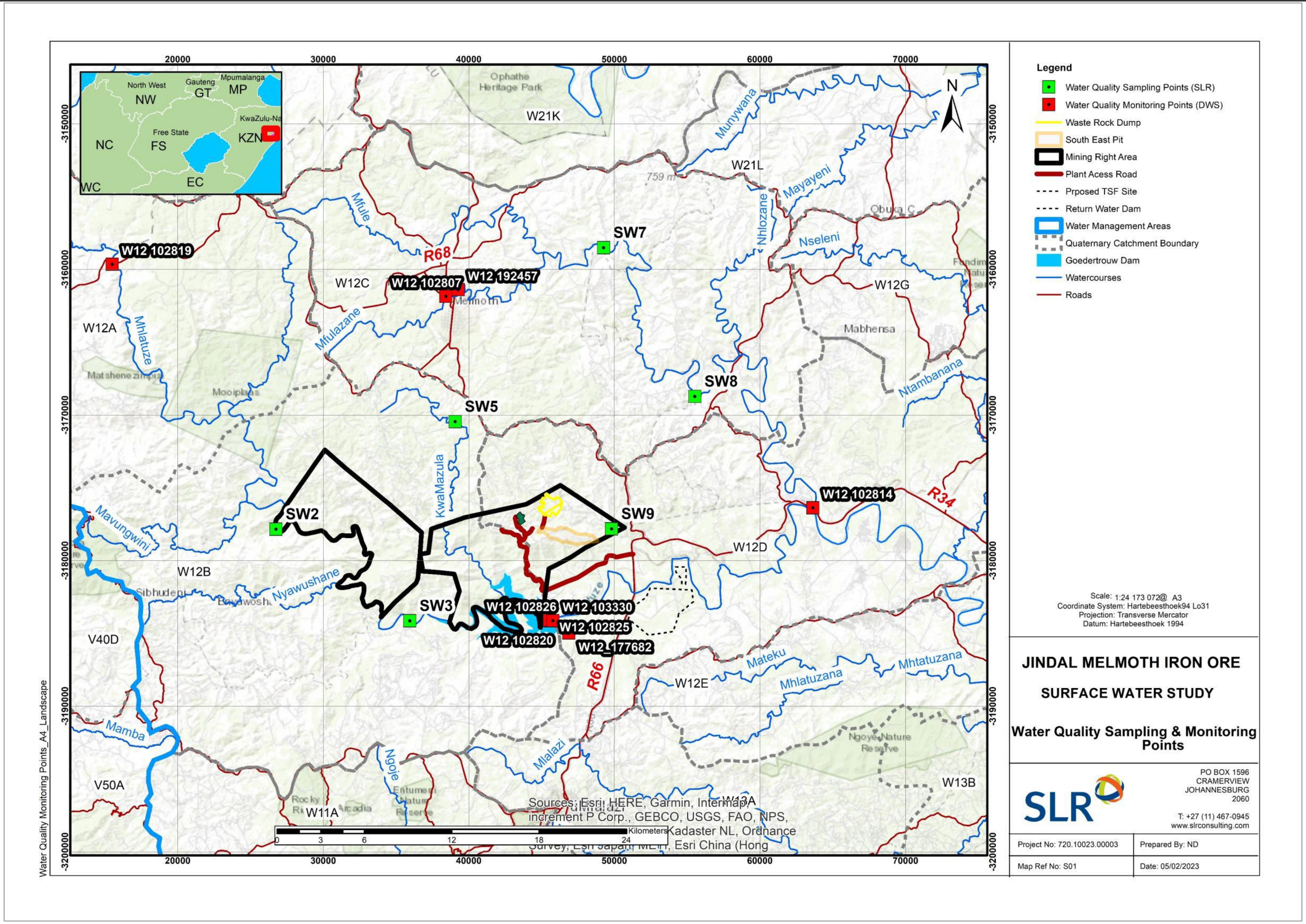


Figure 4-1: **Water Quality Sampling and Monitoring Points**

Table 4-3: Water Quality Guidelines compared to MSU Water Quality Guideline Requirements (SLR Sampling Results, 2021)

Determinant	Units	Water Quality Monitoring Points						Water Users/Guidelines				
		SW2	SW3	SW5	SW7	SW8	SW9	Irrigation	Livestock Watering	Aquatic Ecosystem	SANS241: 2015	Exceedances in all guidelines
Al	mg/l	**0.48**	**0.81**	**0.18**	**0.24**	**0.23**	**0.24**	5	5	0.005	0.3-0.5	All
As	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.1	1	0.01	0.01	All
B	mg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5-15	0.5	-	2.4	All
Cr	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.1	1	0.007	≤0.05	All
Ca	mg/l	8.41	10.59	3.12	9.56	8.99	12.82	-	1000	-	<150	All
CO	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05 - 5.0	1.0 - 2.0	-	≤500	All
Cu	mg/l	**0.08**	**0.05**	**0.1**	**0.07**	**0.07**	**0.08**	0.2	0.05	0.0003	≤2	All
Pb	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0	1	0.0002	≤0.01	All
Fe	mg/l	0.73	0.83	0.58	1.87	0.89	0.88	5	10	-	≤2	All
K	mg/l	1.39	1.34	2.98	2.43	2.62	1.67	-	-	-	-	All
Mn	mg/l	<0.05	<0.05	0.06	<0.05	<0.05	<0.05	0.02	10	0.18	≤0.4	All
Mg	mg/l	4.18	4.3	2.57	9.81	7.78	3.61	-	500	-	<200	All
Na	mg/l	9.98	9.92	11.81	32.55	29.23	16.42	70	2000	-	≤ 200	All
Ni	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.02	0.1	-	≤0.07	All
SI	mg/l	7.96	8.19	5.66	6.22	7.55	10.98	-	-	-	-	
Zn	mg/l	<0.05	<0.05	0.08	<0.05	<0.05	0.05	1	20	0.002	≤ 5	All
Hg	mg/l	**0.008**	**<0.005**	**0.006**	**<0.005**	**<0.005**	**<0.005**	-	0.001	0.00004	≤ 6	All
Cl	mg/l	14.54	16.8	23.69	45.08	43.43	24	-	1500	-	≤ 300	All
F	mg/l	0.41	0.53	0.07	0.15	0.31	0.26	2	2	≤0.75	≤1.5	All
NO2-N	mg/l	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	5	10	-	≤0.9	All
NO3-N	mg/l	<0.5	<0.5	1.03	0.78	<0.5	<0.5	5	10	-	≤11	All
SO4	mg/l	6.71	8.59	2.22	5.55	5.55	3.93	-	1000	-	≤500	All
PO4	mg/l	<0.2	<0.2	<0.2	0.98	<0.2	<0.2	-	-	-	-	All
pH	pH units	**8.02**	**7.87**	**7.03**	**7.93**	**8**	**7.88**	6.5-8.4	-	±5% of Background level	≥ 5 and ≤ 9.7	All
EC	µS/cm	98	100	101	291	245	141	0.4	1.54	-	≤0.17	All
TDS	mg/l	381	255	502	202	634	94	-	1000	-	≤ 1200	All
CN	mg/l	<0.002	<0.002	<0.002	<0.002	<0.002	0.003	-	-	0.001	≤0.2	All
NH3-N	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	5	7	-	≤1.5	All
P-Alk as CaCO3	mg/l	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	-	-	-	-	All
M-Alk as CaCO3	mg/l	30	38	13	75	60	45	-	-	-	-	All

Determinant	Units	Water Quality Monitoring Points						Water Users/Guidelines				
		SW2	SW3	SW5	SW7	SW8	SW9	Irrigation	Livestock Watering	Aquatic Ecosystem	SANS241: 2015	Exceedances in all guidelines
Total CN*	mg/l	**<0.07**	**<0.07**	**<0.07**	**<0.07**	**<0.07**	**<0.07**	-	-	0.001	≤0.2	All

Table 4-4: Water Quality Results compared to MSU Water Quality Guideline Requirements (DWS Database Water Quality Results)

Station Number		W12_103330	W12_102826	W12_102825	W12_102820	W12_102819	W12_102814	W12_102808	W12_102807	Water Users/Guidelines				
Parameter	Units	17/01/05	86/04/23	18/04/25	97/06/23	87/05/21	88/04/28	97/08/26	18/03/28	Irrigation	Livestock Watering	Aquatic Ecosystem	SANS241: 2015	Exceedance in all guidelines
Ca	mg/l	-	6.4	7.9	7.6	15.6	8.7	6.4	6.6	-	1000	-	<150	All
Cl	mg/l	13	19.6	16.5	12.5	132.8	40.5	20.2	31.8	-	1500	-	≤ 300	All
DMS	mg/l	-	103	107.80	104	506	154	115	115.57	-	-	-	-	
EC	µS/cm	-	17.4	17.5	15.7	76	25.9	17.4	20.4	0.4	1.54	-	≤0.17	All
F	mg/l	0.27	0.21	0.154	0.19	0.26	0.05	0.17	0.025	2	2	≤0.75	≤1.5	All
K	mg/l	-	1.91	1.5	1.95	4.49	1.72	1.2	3.1	-	-	-		All
N	mg/l	-	0.223	-	-	0.719	0.403	-	-	0.02	0.1	-	≤0.07	All
Mg	mg/l	-	4.9	5.9	4.7	16.8	7.4	4.5	4.7	-	500	-	<200	All
Na	mg/l	-	15.8	13.3	13.2	123.6	27.9	19.1	20.2	70	2000	-	≤ 200	All
NH4_N	mg/l	-	0.04	0.03	0.042	0.07	0.07	0.02	0.03	5	7	-	≤1.5	All
NO3_NO2	mg/l	0.901	0.05	0.666	0.308	0.02	0.31	0.271	0.05	5	10	-	≤11	All
P	mg/l	0.46	0.012	-	-	0.071	0.035	-	-	-	-	-	-	-
pH	pH units	-	7.19	8.1	7.93	7.45	7.02	7.83	7.9	6.5-8.4	-	±5% of Background level	≥ 5 and ≤ 9.7	All
PO4	mg/l	0.41	0.003	0.013	0.016	0.043	0.003	0.01	0.005	-	-	-		All
Si	mg/l	5.49	7.67	7.3	6.38	12.79	8.63	7.67	7.9	-	-	-	-	All
SO4	mg/l	9.58	6.4	8.8	10.3	9.7	14	8.5	4	-	1000	-	≤500	All
TAL	mg/l	54	39.1	41.6	43.1	166.2	42.7	44	36.8	5	5	0.005	0.3-0.5	All

5. FLOOD HYDROLOGY

5.1 METHODOLOGY AND INPUT PARAMETERS

5.1.1 Design Flood Peak Estimation

Design flood peaks for catchments draining the proposed mine site were estimated using six methods. Design flood peaks were estimated for both the 1:50- and 1:100-year recurrence interval storm events. The underlying assumption is that the largest possible peak flow will be observed when the storm rainfall event has a duration equal to the time of concentration of the catchment, i.e., the time required for the entire catchment to contribute runoff at the outlet (SANRAL, 2013).

The six methods used to estimate the suitable design flood peaks for the site are as follows:

- Rational Method (RM2).
- Rational Method Alternative 3 (RM3).
- Empirical Method (Midgley and Pitman) (also referred to as MIPI).
- Standard Design Flood (SDF).
- The Unit Hydrograph method (UH).
- Soil Conservation Services (SCS) Method.

The comparison of the different flood peaks for the 1:100-year recurrence interval can be seen in Table 5-1 while the flood peaks for the 1:50-year are presented in Appendix A.

Table 5-1: 1-100-Year Flood Peaks (m^3/s)

Catchments	1:100-year Flood Peaks						Adopted Flood Peaks
	RM	RM3	UH	SDF	MIPI	SCS	
S1	951.8	**1,614.9**	840.3	2,955.6	1,059.3	**2,055.0**	2,055.0
S2	946.5	**1,605.3**	834.2	2,946.7	1,054.6	**2,026.8**	2,026.8
S3	9.6	**16.4**	6.9	39.9	19.1	**6.2**	16.4
S4	1.8	**3.9**	0.3	9.6	4.9	**1.1**	3.9
S5	9.2	**17.8**	2.6	43.4	19.7	**9.5**	17.8
S6	141.6	**205.1**	110.5	502.9	156.2	**168.9**	205.1
S7	135.0	**192.9**	111.2	473.0	154.5	**165.6**	192.9
S8	3.5	**5.8**	2.3	14.3	10.3	**3.0**	5.8
S9	15.3	**26.2**	9.3	62.3	28.7	**11.4**	26.2
S10	122.8	**187.3**	101.3	445.7	131.7	**135.6**	187.3
S11	29.9	**54.2**	17.7	129.0	41.5	**23.8**	54.2
S12	133.9	**214.2**	95.4	509.7	123.4	**131.2**	214.2
S13	104.8	**163.6**	72.0	389.4	120.6	**104.3**	163.6
S14	8.5	**16.5**	2.3	39.3	17.3	**6.5**	16.5

Catchments	1:100-year Flood Peaks						Adopted Flood Peaks
	RM	RM3	UH	SDF	MIPI	SCS	
S16	24.7	**31.9**	12.6	76.9	1.3	**14.6**	31.9
S18	0.4	**0.6**	0.0	1.4	2.4	**6.2**	0.6
S19	4.6	**9.6**	0.1	23.2	13.2	**3.6**	9.6
S20	6.2	**11.6**	2.5	28.4	12.7	**4.9**	11.6
S21	5.6	**11.7**	0.5	28.6	13.9	**1.8**	11.7
S24	9.0	**18.1**	1.9	28.5	15.6	**6.1**	18.1
S25	3.6	**8.0**	0.2	16.9	9.1	**2.6**	8.0
S26	201.8	**340.9**	170.0	737.5	173.5	**166.4**	340.9
S27	0.4	**0.9**	0.0	2.0	2.1	**0.4**	0.9
S29	20.1	**41.7**	3.6	87.6	28.8	**14.6**	41.7
S30	17.1	**31.0**	7.8	65.1	24.9	**11.9**	31.0
S31	203.5	**359.3**	204.2	754.6	179.6	**164.5**	359.3
S32	52.9	**74.6**	68.3	165.8	88.2	**70.6**	74.6
S33	56.1	**80.7**	63.8	179.3	87.9	**66.2**	80.7
S34	74.6	**113.8**	64.4	253.0	85.3	**69.7**	113.8
S35	19.3	**40.1**	2.7	86.9	31.6	**8.6**	40.1
S36	0.4	**0.9**	0.0	1.8	2.3	**0.4**	0.9
S37	0.4	**0.9**	0.0	1.8	2.3	**0.4**	0.9
S38	12.7	**17.6**	10.9	39.1	22.9	**168.9**	17.6
S01	28.9	**33.6**	10.9	79.8	28.4	**9.3**	33.6
S02	14.4	**16.8**	4.5	40.0	16.7	**6.1**	16.8
Kwasengeni 1	224.3	**246.3**	225.7	586.0	159.4	**155.2**	246.3
Kwasengeni 2	219.6	**239.5**	192.2	569.9	157.2	**145.1**	239.5
Kwasengeni 3	211.9	**232.1**	145.1	557.1	150.5	**154.6**	232.1

5.1.2 Input Parameters

These are input parameters to peak flow estimation described above. Each sub-catchment was characterised by its hydraulic parameters including the time of concentration (TC), longest flow path, slope, distance from catchment outlet to centroid (LC) etc. The parameters are presented in Table 5-2.

Table 5-2: Delineated Catchment Characteristics

Subcatch (s)	Actual Area (ha)	River (km)	LC (km)	Height Difference (m)	Slope	TC (Hour)	TC (Minutes)
S1	148,291	143.64	85.0	901	0.0090	12.04	722.7
S2	145,729	141.40	83.0	898	0.0091	11.92	715.3
S3	91	1.62	0.8	23	0.0203	1.23	73.5
S4	10	0.40	0.2	20	0.0714	0.48	28.5
S5	64	0.94	0.5	29	0.0441	0.79	47.6
S6	3741	14.64	8.3	268	0.0262	3.23	193.7
S7	3,866	16.51	8.5	279	0.0241	3.48	208.7
S8	37	0.98	0.4	3	0.0044	1.39	83.4
S9	140	1.60	0.6	23	0.0205	1.21	72.9
S10	2,374	10.37	5.5	293	0.0404	2.48	149.0
S11	237	2.49	1.2	199	0.1142	1.00	60.0
S12	2,049	7.02	3.4	248	0.0505	1.96	117.8
S13	1,737	7.98	3.3	240	0.0430	2.17	129.9
S14	55	1.32	0.5	104	0.1126	0.75	44.8
S15	32	0.92	0.39	105	0.1630	0.58	34.7
S16	167	1.98	0.8	40	0.0289	1.24	74.4
S17	74	0.91	0.6	55	0.0863	0.67	40.1
S18	21	0.89	0.5	48	0.0770	0.68	40.7
S19	26	0.60	0.2	36	0.0853	0.55	33.1
S20	45	1.27	0.8	51	0.0574	0.86	51.5
S21	13	0.70	0.4	74	0.1510	0.52	31.1
S23	17	0.48	0.3	64	0.1905	0.41	24.7
S24	183	2.78	1.0	55	0.0282	1.46	87.7
S25	48	1.04	0.7	95	0.1305	0.65	38.7
S01	114	1.45	0.74	165	0.073	0.24	14.23
S02	52	1.23	0.62	124	0.049	0.25	14.5
Kwasengeni1	2,717	9.63	4.82	361	0.078	0.98	58.9
Kwasengeni2	2,540	8.13	4.06	306	0.089	0.82	49.08
Kwasengeni3	2,415	8.1	4.05	289	0.089	0.82	49.1

5.2 RESULTS

The RM, UH and MIPI resulted in flood peaks of the same magnitude falling in the lower range. These peaks were not adopted because they are less conservative.

The SDF resulted in significant peaks, falling to an upper range. The SDF method was developed specifically to fit the South African catchments; however, it tends to overestimate flood peaks for smaller catchments (less than 100 ha in this study), thus it was not considered for use. RM3 and SCS methods resulted in flood peaks falling within the medium range and are in the same magnitude and were deemed suitable to develop floodlines. Flood peaks estimated using SCS were adopted for larger catchments within the TSF area because they are considered more conservative. Adopted flood peaks for floodline modelling are presented in Table 5-1.

6. HYDRAULIC FLOOD MODELLING

6.1 INTRODUCTION

In order to inform the infrastructure layout of the mining operation, understand and manage the risks of flooding to the operation and assess compliance with Condition 4 of GN704, modelling of the 1:100-year floodlines is required.

The following section details the approach and the methods used in the development of a hydraulic model for the purpose of determining the floodlines.

6.2 METHODOLOGY

6.2.1 Choice of Software

Suitable software was selected, and the following was used:

- HEC-RAS 6.2 (US Army Corps of Engineers, 1995) was used to model the flood elevation profile for the 1:100-year flood event. HEC-RAS is a hydraulic programme designed to perform one-dimensional hydraulic calculations for a range of applications, from a single watercourse to a full network of natural or constructed channels.
- ArcGIS - The software is used worldwide and has been thoroughly tested through numerous case studies. The flood inundation from HEC-RAS is mapped in a Geographic Information Systems (GIS) as well as relevant maps.
- Google Earth – The software was used to identify the land use and land cover in the surrounds of the site in addition to information gathered during the site visit.

6.2.2 Qualification and Exclusions

A comprehensive review of rivers, streams and drainage was undertaken, and a selection of Area of Influence (AoI) was made. The following qualifications and exclusions apply:

- The floodlines determination study was limited to the confirmed mine infrastructure.
- AoI selection around the WRD was limited to perennial rivers only, mainly to emphasize the importance of flooding impact and maximum flood levels. It is assumed that all the rivers and streams located within the WRD area will be diverted during construction.
- Floodlines were not determined for the rivers traversing the mine pit because mining pits are established through extensive prospecting and geological modelling and mining is undertaken in areas where economically mineable resources occur. It is assumed that the mining pit cannot be relocated, therefore it insignificant to undertake floodlines and flood extent mapping.

6.2.3 Topographic Data

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

The Client provided site topographical information obtained from the side-wide Light Detection and Ranging (LiDAR) Survey. LiDAR Survey provided contour data of 1m interval which were used to develop a Digital Elevation Model (DEM) that assigns elevation to cross-sections.

6.2.4 Roughness Coefficients

The Manning's roughness factor "n" is used to describe a specific surface's flow resistant characteristics. Based on the Aerial Imagery obtained from the LiDAR survey. The watercourse network is characterised by regular channels that are densely vegetated with significant trees and shrubs. The manning values ("n") ranging between 0.025 and 0.04 were assigned to the channel and a range between 0.33 to 0.5 were assigned for left and right banks.

6.2.5 Time of Concentration

The time of concentration was calculated using the empirical formula for the longest water path for natural channels as developed by the United States (US) Soil Conservation Services (SCS) Method and as presented in the SANRAL drainage manual (SANRAL, 2006). The input parameters to the empirical formula include the length the watercourse and average watercourse slope.

The average slope for the longest watercourse was calculated using the 10-85 method (m/m) as developed by the US Geological Survey (USGS, 2009), which accounts for the length of the longest watercourse and the height difference between height at 10% and 85% length of the longest watercourse.

The time of concentration and associated input parameters such as the height difference and length of the longest watercourse are presented in Table 5-2.

6.3 MODEL DEVELOPMENT

Development of the hydraulic model includes the following steps:

- Creation of a DEM from the topographical survey data;
- Generating cross-sections through the watercourses;
- Importing cross-sections and hydraulic modelling within HEC-RAS to generate flood levels at modelled cross-sections; and
- Importing flood levels and projecting levels onto the DEM to determine the flood inundation areas.

6.4 KEY ASSUMPTIONS

In-line with the development of the floodlines, the following assumptions were made: The topographic data (1m resolution) provided by the Client is deemed sufficient for hydraulic modelling and able to generate cross sections that are suitable to contain flow.

- Suitable Manning's ‘n’ values were used to represent the boundary conditions of both the channel and floodplain.
- Levees (hydraulic feature in model) have been added to confine flow to the main channels and better represent channel topography.
- Steady-state hydraulic modelling was undertaken, which assumes the flow is continuous at the peak rate. The steady state hydraulic modelling was selected because it is more conservative and will ensure that development is located further away from the probable flood.

- A mixed flow regime, which is tailored to both subcritical and supercritical flows, was selected for running of the steady state model.
- The most recent layout of the proposed infrastructure was used.

6.5 FLOODLINE RESULTS

Floodlines on river sections are analysed to evaluate risks associated with potential flooding of infrastructure and protection of natural water resources. Legislation provides guidelines with regards to minimum requirements of placement of infrastructure in relation to a natural watercourse.

South Block Floodlines

Floodline assessments on the proposed mine infrastructure were conducted in accordance with Condition 4 of the GN704. The main purpose of floodlines determination is to identify areas around natural watercourses that need to be protected.

The infrastructure such as the processing plant, WRD, primary crusher, east mining pit and the incoming power yard are located within the 1:100-year floodlines.

The overland pipelines traverse two significant streams and the maximum flood depths around the pipeline river crossing are 0.6 metres and 2.65 metres for Crossing 1 and Crossing 2, respectively. The maximum flood depth represents the maximum vertical height from the lowest ground level point in the middle of the river to the surface water level.

Maximum flood depths around the processing plant ranges between 0.86 m and 1.96 meters; this flood level may be buffered through flood protection berms where feasible. Floodlines for the rivers passing through the infrastructure located within the South Block are presented in Figure 6-1.

Maximum flood depths for the Mhlathuze River reach exceed 7 metres; this flood level is very high as expected for this significant river.

South-East Pit Floodlines

Main rivers draining the South-East Pit, were identified as S01, S02, Kwasengeni1, Kwasengeni2 and Kwasengeni3. Floodlines for these rivers were determined and are shown in Figure 6-1.

6.6 CONCLUSION AND RECOMMENDATIONS

Condition 4 of the GN704 indicates that no mining activity or associated infrastructure may be located or placed within the 1:100-year flood line or within a horizontal distance of 100 metres from any watercourse, whichever is greatest. A conservative approach would be to accept a wider flood plain for protection of the resource and to allow water to flow freely over a protected zone. It is therefore recommended that the mine infrastructure be relocated outside the floodlines and where necessary rivers be diverted outside of the infrastructure footprint.

In the event that the mine infrastructure cannot be relocated, it is recommended that suitable flood protection measures be designed to ensure the safety of the infrastructure and surrounding environment during flood events. This may include diversion of rivers, specifically around the WRD.

Suitable remedial measures should also be investigated for the rivers passing through the South East Pit area. Maximum flood depths specified throughout the various streams must be considered during the development of flood protection berms including relevant engineering freeboard. The flood protection berms need to be relatively high along their full alignment in order to withstand the flood level and flood velocities. Information on flood depths, velocities and elevations are provided in a table in Appendix F.

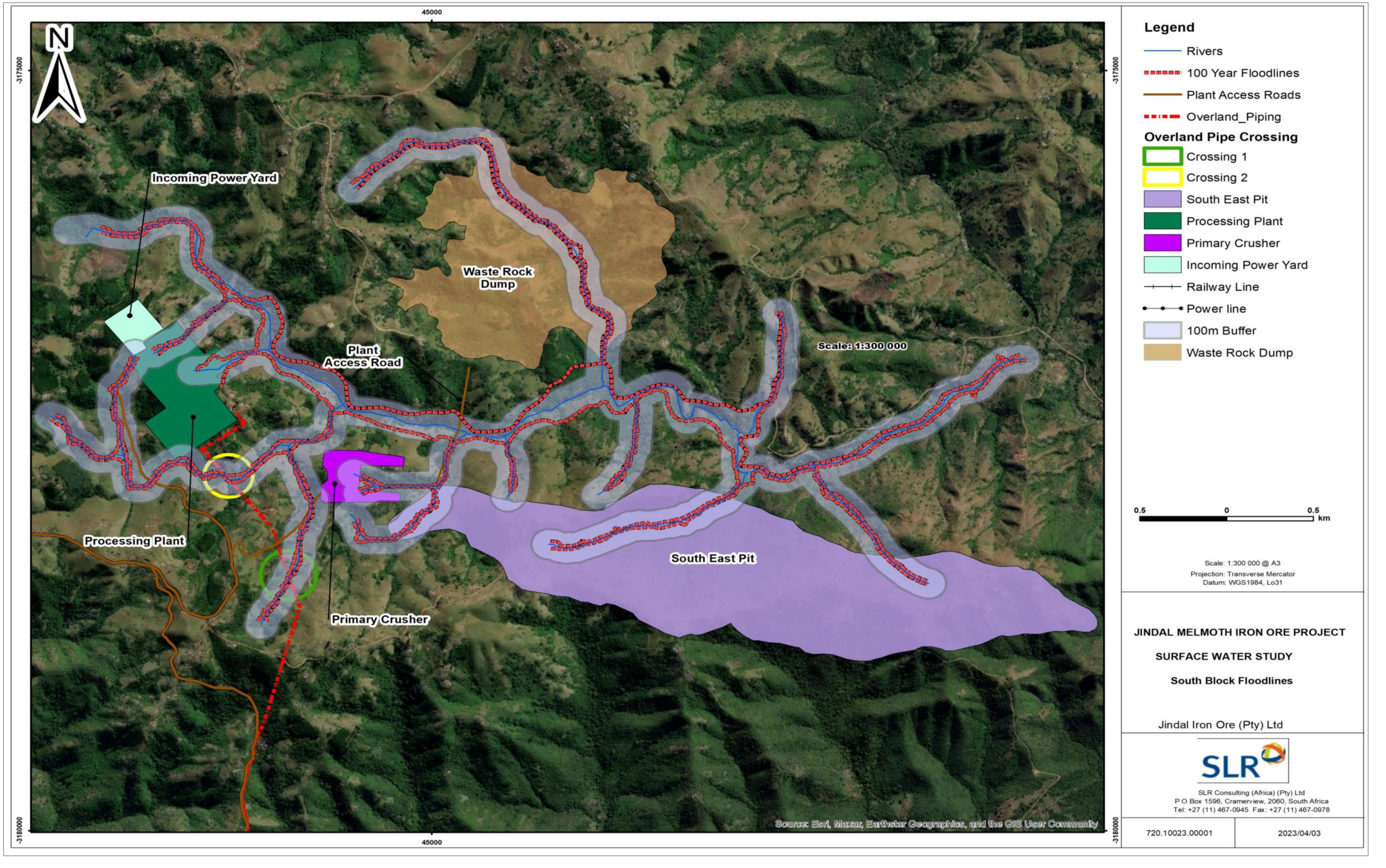


Figure 6-1: Floodlines around the Mine Infrastructure in South Block

7. STORMWATER MANAGEMENT PLAN

7.1 INTRODUCTION

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

- Bulk earthworks which will strip vegetation and expose topsoil and subsoils to erosion by stormwater thereby increasing levels of suspended solids within local watercourses and water features;
- Earthworks and minerals processing operations may expose elements naturally occurring within soils and geology to stormwater, mobilising elements into local watercourses and water features;
- Storage and usage of process specific chemicals and vehicular related pollutants which, if not properly managed, may be washed by stormwater into local watercourses and water features; and
- Discharge of polluted or improperly treated stormwater, process water and sewage water into local watercourses or water features

An impact upon the baseline water quality caused by mining operations may impact upon the local aquatic ecosystems, and/or local human populations who use the water for drinking, washing, irrigating or livestock watering. In addition to the above, if not managed correctly, stormwater may pose a risk of flooding to a proposed development.

In support of the EIA and hydrological impact assessment, a site-wide conceptual stormwater management plan (CSWMP) is required to comply with national regulations. The CSWMP must ensure compliance with the National Water Act (Act No. 36 of 1998) and Government Notice 704 (Government Gazette 20119 of June 1999) (hereafter referred to as GN704).

The CSWMP is developed through:

- A review of the applicable regulations;
- A review of the baseline hydrology, site operations and surroundings;
- Delineation of clean water and dirty water catchments based on proposed site operations;
- Modelling and conceptual design of stormwater infrastructure in a suitable software package; and
- Recommend infrastructure and practices that will further aid with compliance.

Costing for the conceptual stormwater management design is not covered under this scope of work. The high-level concepts proposed in this report will require refinement under the detailed design phase. Detailed designs of the infrastructure proposed here should be designed by qualified engineers and such designs will then comprise further detail for construction including costing.

7.2 APPLICABLE REGULATIONS AND GUIDELINES

GN704 outlines the regulations for the use of water for mining and related activities and is aimed at protecting water resources. Regulations 5, 6, and 7 of GN704 are applicable to this study and are summarised below:

- **Regulation 5:** restricts the use of residues or substances which cause or are likely to cause pollution of a water resource from use in the construction of any dams, impoundments or embankments or any other infrastructure;
- **Regulation 6:** 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 for a 1:50 year recurrence event (i.e. clean and dirty water systems should not spill into each other more frequently than once in every 50 years). Any dirty water dams should have a minimum freeboard of 0.8m above full supply level; and
- **Regulation 7:** indicates that all dirty water or substances that may cause pollution should be prevented from entering a water resource (e.g. by spillage, seepage, erosion, etc.) and ensure that water used in any mining, industrial, etc. process is recycled as far as practicable.

Further requirements are outlined in the Department of Human Settlements, Water and Sanitation (DHSWS) 'Best Practice Guidelines (BPGs) for Water Resource protection in the South African Mining Industry' are highlighted below:

- **BPG A4 Pollution Control Dams, Section 6.4.3**. BPG4 defines the allowable RWD or PCD spillage frequency as being one spill every 50 years on average. To achieve this requirement, a RWD or PCD should be designed with an annual spillage probability of 1:50 (2%) or less. Further, BPG A4 recommends that the final design criteria should be determined through the use of a long-term continuous simulation water balance model, run at an appropriate time step (preferably daily).

- **BPG G1 Stormwater Management, Section 4.2** defines a methodology of planning, designing and implementing stormwater management measures to ensure separation of clean and dirty water and provides guidelines to ensure sustainability over the mine's life cycle. It also offers guidelines for the following:
    - Classification of clean and dirty areas;
    - Conceptual designs and review taking into account that at this stage, "The designer has to balance the need to obtain preliminary sizes so that water conveyance systems and retention structures can be provisionally sized, without undertaking a detailed design that may have to be discarded due to inadequacies in the stormwater management plan, or changes in the conceptual design.";
    - Assess the suitability of the existing infrastructure and define the changes to the stormwater infrastructure that may be required; and
    - Design of the required infrastructure informed by all prior steps.

As discussed above, the CSWMP will require the following at a minimum:

- Capacity: dirty water systems are to be designed, constructed, maintained and operated so that they are not likely to spill into any clean water system or the environment more frequently than once in 50 years.
- Conveyance: all water systems are to be designed, constructed, maintained and operated so that they convey a 1:50 year flood event.
- Freeboard: as a minimum, any dirty water dams are to be designed, constructed, maintained and operated to have a minimum of a 0.8m freeboard above full supply level.
- Collect and Re-Use: it is required that dirty water be collected and re-used as far as is practicable.

- Diversion: the flow of any surface water or floodwater into operational areas must be minimised.

7.3 PROPOSED INFRASTRUCTURE LAYOUT

The stormwater management plan is informed primarily by the existing terrain and proposed infrastructure. The proposed infrastructure layout has been shown in preceding sections. The terrain and layout for South Block has the following features which may affect the stormwater management plan:

- According to the topographical survey, the site is situated on hilly terrain with hill tops, valleys and several rivers running through the site;
- The location of South Block is subject to potentially high runoff from the north-western side of the project area which drains down into the mining area;
- The plant and processing areas are self-contained and hence dirty water produced in these areas will be contained as determined by external design teams/engineers;
- The South East pit will collect potentially dirty water runoff within the pit which will need to be collected, stored or re-used; and
- Planned built-up areas and access routes are likely to cause damming in low-lying areas.

7.4 STORMWATER MANAGEMENT CONCEPT

The concept of the proposed stormwater management plan for Jindal South Block is to divert and allow clean water within the mine area to flow across the site as free surface flow. Dirty water runoff will be directed and discharged into lined conveyance and storage facilities. It is recommended that the results of the waste classification, groundwater study and geotechnical investigation be used in order to inform the lining details during detailed design phases.

Based on the proposed infrastructure design, the plant and processing areas (dirty water producing areas) are self-contained and have stormwater infrastructure (channels, berms and pollution control dams) built-in to these areas. Cut-off channels and culverts are proposed to divert clean water around proposed infrastructure and access routes.

Further, earthen cut off/diversion channels and berms are proposed for construction around the project site and waste dumps. The cut-off channels will intercept and divert clean runoff from upstream catchments and contain dirty runoff within certain areas.

7.5 STORMWATER MODELLING

In order to inform the conceptual design model, an understanding of site-specific climatic conditions, topography, geotechnical and ground conditions is required. Previous sections of this report detail specific site and hydrological conditions, however; the following design considerations are used here to inform the conceptual stormwater infrastructure:

Table 7-1: Stormwater design criteria

Design consideration	Design value	Reference
Design recurrence interval	1:50	Based on Regulation GN704
Design storm duration	24 hours	Based on Regulation GN704

Design consideration	Design value	Reference
Design storm depth	232 mm	Hydrological analysis
Curve numbers	Waste Rock Dump: 71 Pit Areas: 74	SCS (Soil Conservation Service)
SCS Design storm	Type II	SCS (Soil Conservation Service)

The model was built using the latest PCSWMM software (version SWMM5.1.015) which utilises a combination of hydraulic and hydrological computational analyses. The following was assumed for the analyses:

- Manning's n values of 0.015 were used for concrete channels and culverts and a value of 0.08 were used for unlined/earthen channels;
- All slope and length values were assumed from the site survey which was supplied by the Client;
- Catchments were delineated from the site survey supplied by the Client ;
- The catchments were characterised by applying SCS Curve Numbers to describe the terrain; and
- Trenches and channels were assumed to be trapezoidal in cross section.

A snapshot of the model is shown Figure 7-1 showing the delineated clean and dirty catchments.

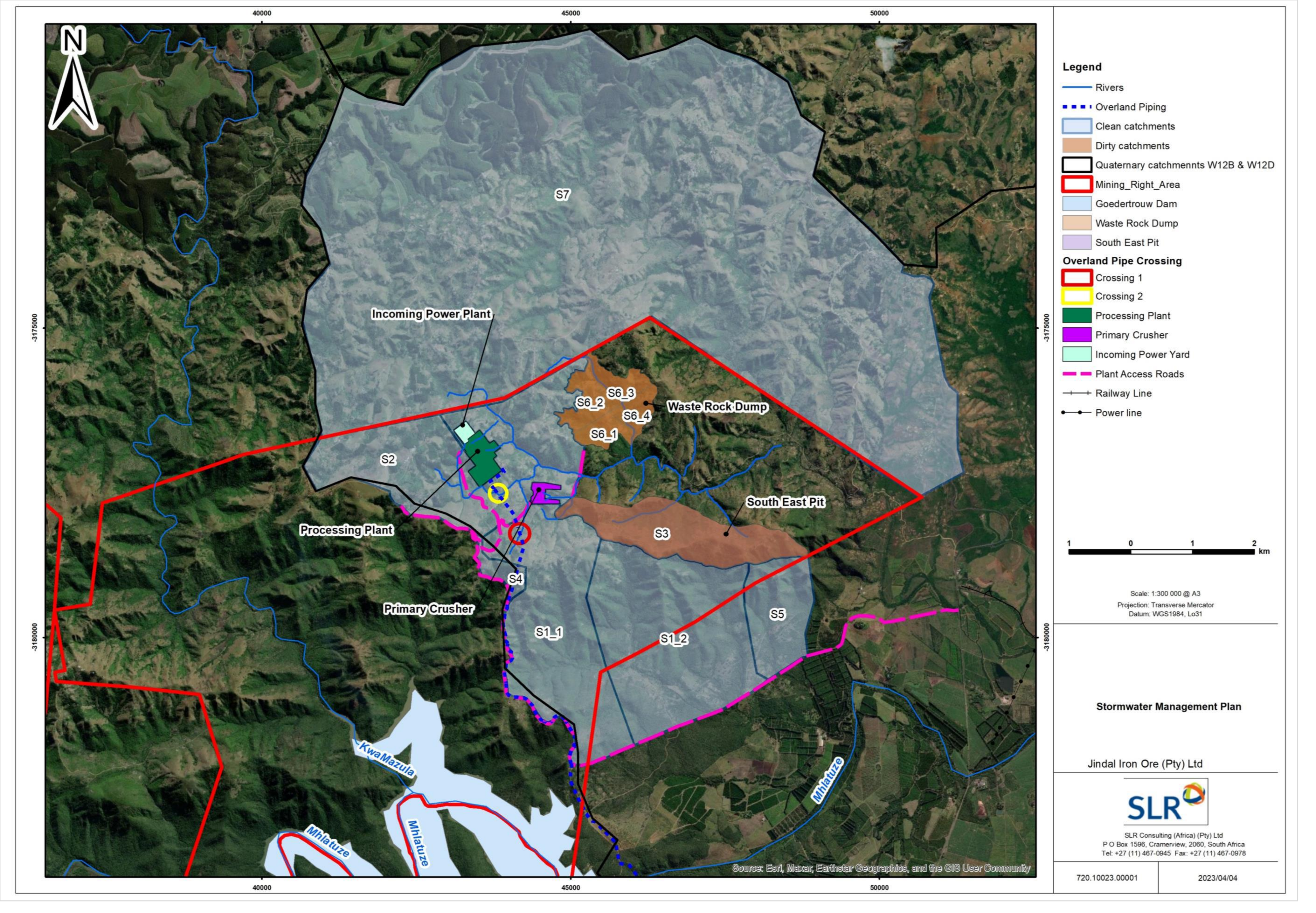


Figure 7-1: PCSWMM Model and Delineated Catchments

7.6 CONCEPT DESIGN

7.6.1 Conveyance Infrastructure

From the model, the following stormwater conveyance infrastructure was proposed:

Boundary diversion berm

A large catchment (5 033 Ha) north of the South Block drains into the project area. A diversion berm surrounding the site is required to ensure clean water from this catchment does not enter. A height of 1.5m was determined as being adequate for the berm.

Waste rock dump containment berms/ paddocks

The waste rock dump (WRD) requires containment berms to prohibit dirty water produced in this area from mixing with clean water. The berms were modelled as earthen channels having a bottom width of 50 m and a height of 1 m. This can be achieved by placing a 1 m high berm at least 50 m away from the WRD extents. The berms should be located around the WRD crest and toe as seen in Figure 7-2 (The design of the WRD was provided by the external design team (Geotheta Consulting Engineers and Scientists) – Drawing No: 2201682-103 Rev A). The containment berms will need to be reinstated after every raise and extension of the WRD.

Due to the shape of the WRD, a containment facility is required at the toe of the waste rock dump to contain the dirty water that will flow towards this natural valley. The sizing of this pollution control dam is detailed in Section 1.5.2.

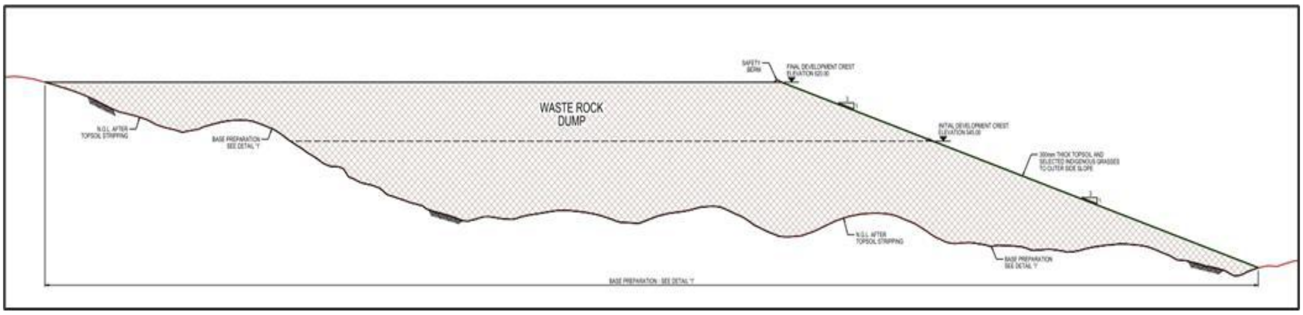


Figure 7-2: Typical waste rock dump section

Clean water culverts

Several culverts are required around the mine site where the proposed built-up access roads cut-off existing clean water catchments and rivers. The culverts will divert clean water and prevent damming behind the proposed processing areas which are designed to be built up on terraces. Culvert lengths need to be confirmed when the access road design has been finalised. The culverts have been modelled as multiples of 2.5 m wide by 1.5 m high rectangular concrete culverts.

Site diversion berms

The open pit will require a diversion berm at the edge of the pit to divert clean water from entering the pit. The diversion berms have been modelled as 1m high earthen berms.

Pit pipeline and pump

A pumped pipeline system is proposed to pump pit water to the processing plant. It is anticipated that the pipeline route will change as the pit extends, however, the pump and pipeline system has been modelled for the 10-year pit extent. The 10-year pit extent and volume is used here as this was the available information provided by the external design team (Wood PLC) involved in the pit design.

Dimensions of the proposed conveyance infrastructure are summarised below, however; full details from the stormwater model are provided in Appendix E.

Table 7-2: Proposed conveyance infrastructure

Structure		Dimensions		
		No.	Depth/Height/Diameter (m)	Length (m)
Clean Water	Mine diversion berm	-	1.5	9 100
	Waste rock dump diversion berms	-	1	8 735
	Pit diversion berms	-	1	9 226
	Culvert C2	2	1.5	Dependent on design of access roads
	Culvert C6	1	1.5	
	Culvert C7	10	1.5	
	Culvert C8	2	1.5	
	Culvert C9	5	1.5	
Dirty Water	Pipeline to Plant	-	TBC	±2 420

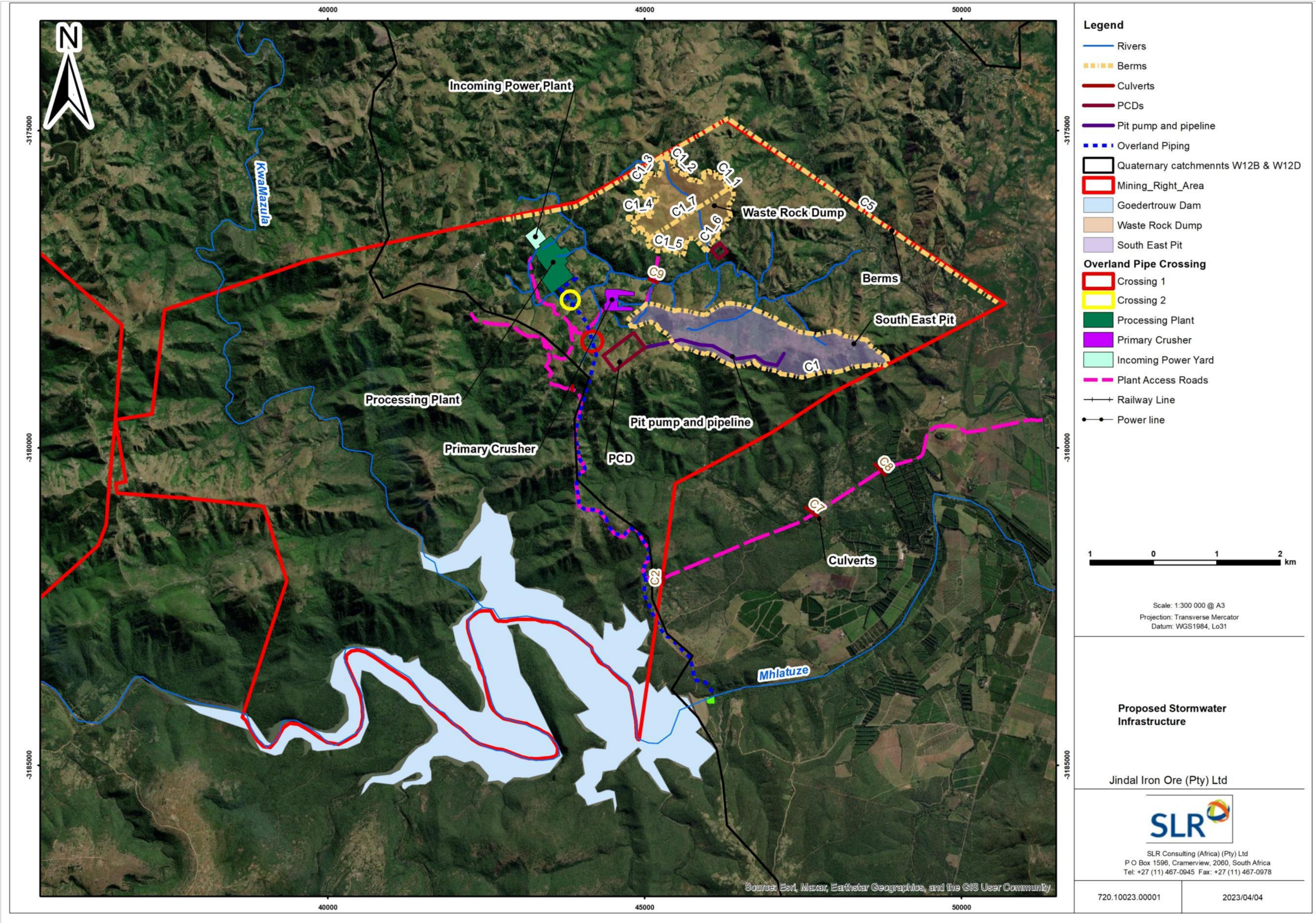


Figure 7-3: Proposed Stormwater Infrastructure Layout

7.6.2 Containment Infrastructure

As determined from the model, two pollution control dams (PCDs) are recommended. PCD1 is intended to store dirty water pumped from the open pit. This PCD is proposed to be located at the plant for re-use during processing, however, it may be located anywhere within the mine site where the water may be re-used.

PCD2 is intended to store dirty water runoff from the WRD. This PCD is located at the toe of the proposed WRD extent. Proposed locations and estimated area of both PCDs are shown Figure **7**-**3**.

To determine adequate storage volumes for the PCDs; a daily time step rainfall-runoff model for the dirty water was coupled with a daily time step water balance model. The rainfall-runoff model is based on the Soil Conservation Service (SCS) method and is used to estimate the portion of the rainfall which infiltrates or runs off from each catchment, for each day of the simulation. The PCD water balance model considers stormwater inflows, the direct rainfall reaching the dam, the evaporation losses and the return water pumping policy and calculates the volume of water in the PCD for each day of the simulation.
The key variables and assumptions used in the modelling are as follows:

- The model is run on a daily time step using the 80 years of daily rainfall data from 1920 to 2000;
- Fixed monthly evaporation values were used as defined in Section 3.1.2;
- Stormwater runoff from two catchment types were considered:
  - Impermeable surfaces; and
  - Permeable (soil) surfaces.
- The pit has been modelled for the 10-year pit extents and volume;
- The return water pumping system will be set up to pump water out of the PCD whenever water is available. There are many opportunities available for use of dirty water around the mine, such as:
  - Dust suppression;
  - Use within the Plant;
  - Dirty water treatment and reuse.
- The PCDs have been modelled assuming vertical sides for simplicity; and
- The volume of water in the dams, the evaporation, and the amount abstracted through pumping and the spill volumes were calculated for each day over the full simulation record available. The simulation calculates the required capacity of the dam and the number of spills during the 80-year simulation period which is directly related to the abstraction rate.

The daily volume, the spill volume as well as the maximum dam volume for the chosen PCD size are shown below in Figure 7-4 and Figure 7-5.

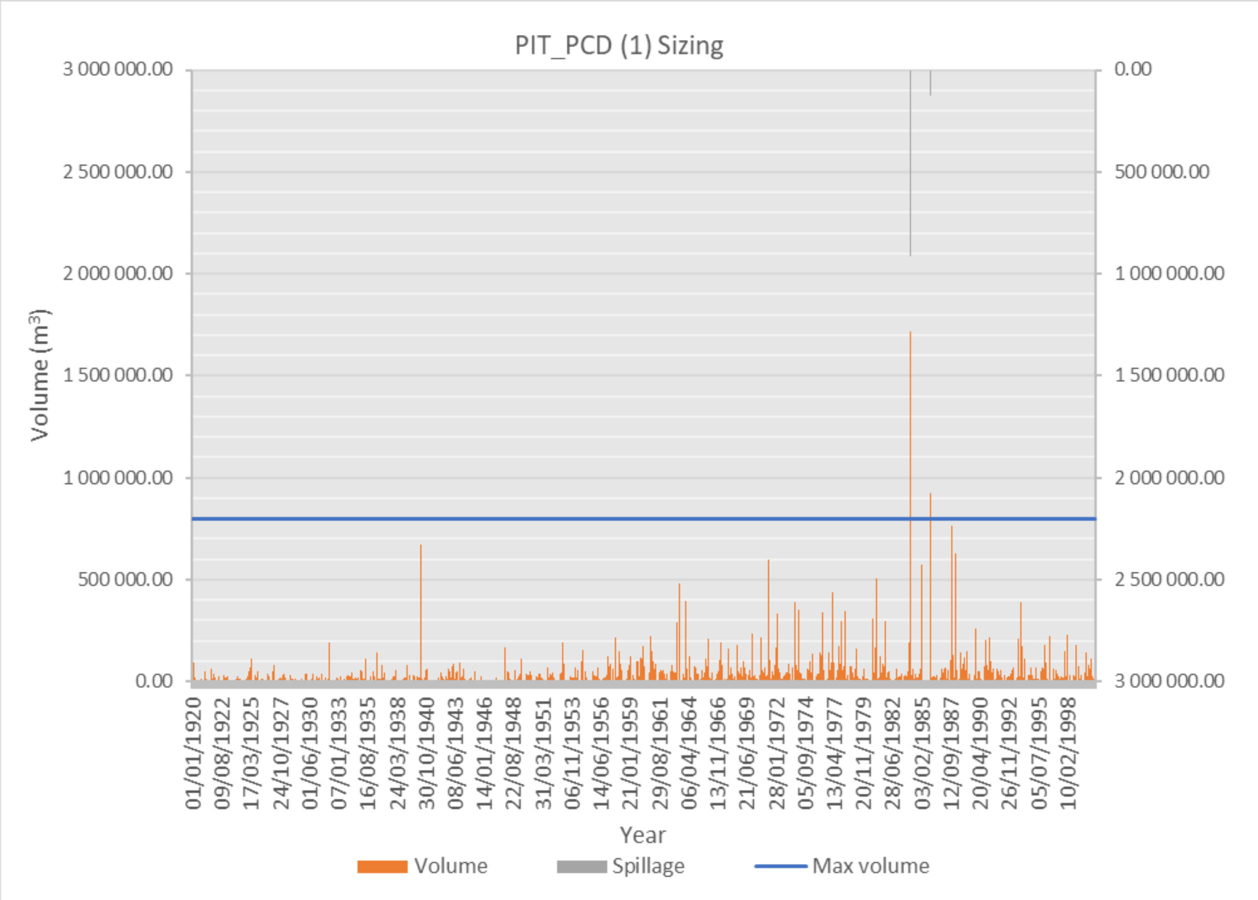


Figure 7-4: PCD 1 Sizing Results

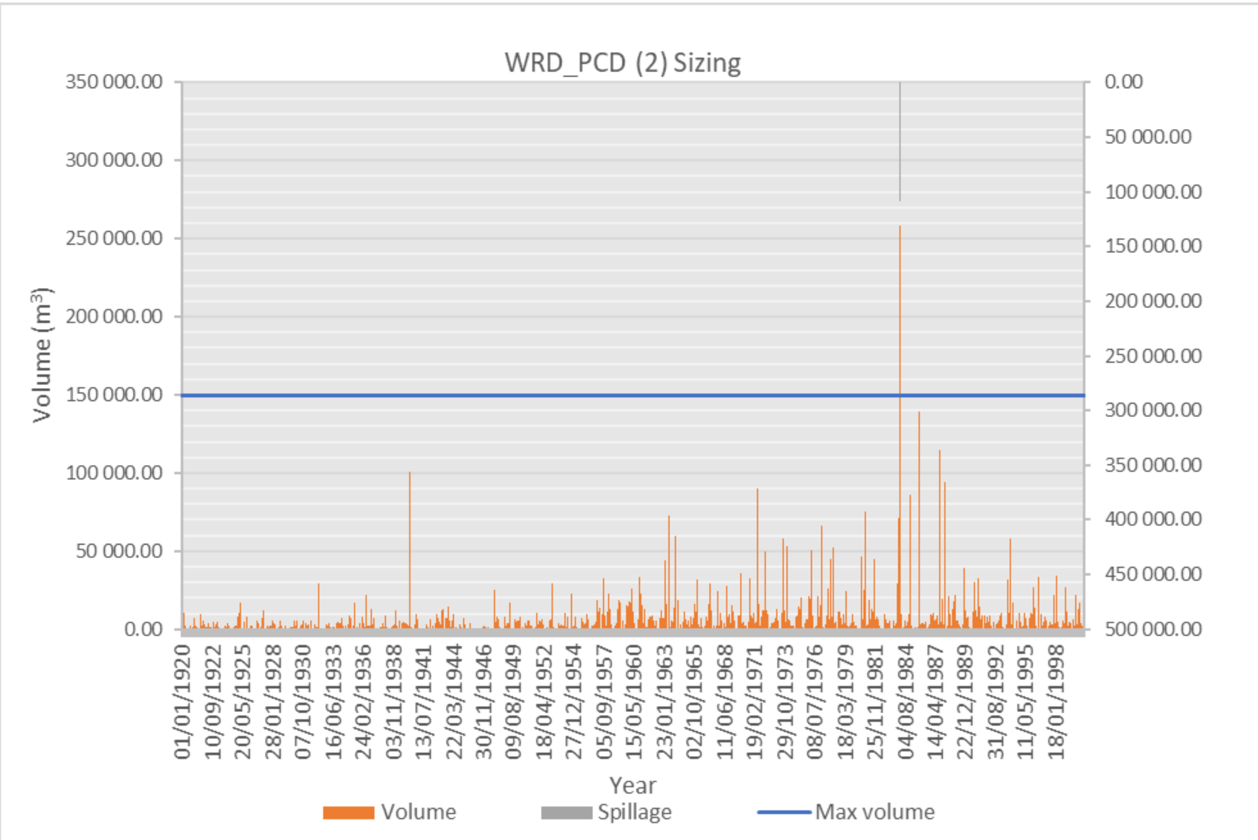


Figure 7-5: PCD 2 Sizing Results

The analysis indicates a preliminary volume for PCD1 of 800 000 cubic metres to adhere to the GN704 requirement of spilling into the environment not more frequently than once in 50 years. Figure 7-4 shows the PCD spilling two (2) times over the 80-year record which can be assumed as one spill over a 50-year record. This is assuming that rainfall from 2000 to current follows a similar pattern observed in the available data. The volume also takes into account a pumping rate of 960 m^3/day which has been assumed based on available pump sizes for this application.

The analysis also indicated a preliminary volume for PCD2 of 150 000 cubic metres. Figure 7-5 indicates this size of PCD has a spill frequency of once in the 80-year rainfall record which adheres to the GN704 requirement of spilling into the environment not more frequently than once in 50 years. This PCD is intended to store and evaporate dirty water.

The sizing analysis is high level at this stage and further refinement is required during subsequent phases. Preliminary dimensions of the PCDs are shown in Table 7-3. It is recommended that a waste classification, groundwater study and geotechnical investigation be undertaken in order to inform lining details for the proposed PCDs.

Table 7-3: Proposed preliminary PCD dimensions

Facility	Assumed Depth (m)	Plan area (m^2)	Volume (m^3)	Assumed pumping volume (m^3/day)
PIT PCD (1)	5	160 000	800 000	960
WRD PCD (2)	5	30 000	150 000	-

7.6.3 Pumping Infrastructure

A pump and pipeline system is proposed to pump pit stormwater to the proposed PCD 1. The pump abstraction rate was assumed to be 960 m^3/day based on two pumps operating to an estimated head of approximately 200 m from the pit bottom to the PCD inlet. This is based on the 10-year pit extent. The pumps are likely to require variable speed motors to cater for the pit extensions each year. The pipeline diameter can only be determined once a suitable pump operation philosophy is established during design phases. Pumping operations must be considered in great detail during design phases as the high head requirement will require specialist designs.

7.7 CONCLUSION AND RECOMMENDATIONS

A stormwater management plan has been conceptualized for the proposed plan layout of the South Block of Jindal Melmoth Iron Ore Mine to meet the applicable legislation. It is proposed that the recommendations made for the proposed stormwater infrastructure be taken to preliminary and detailed design for implementation. The following considerations should be noted:

- The proposed stormwater infrastructure detailed here is at a conceptual level and will require refinement which may require alterations to the dimensions and details presented here;
- Additional studies such as geochemical waste assessments, geotechnical investigations and structural detailing may be required to further the designs presented here at a later stage; and
- Terraces, platforms and road designs which alter the existing terrain have been considered here with information provided by external design teams (Wood PLC and Geotheta Consulting Engineers and Scientists). Alterations to these designs may require revision of the designs presented here.

8. SITE WATER BALANCE MODELLING

8.1 METHODOLOGY

A daily timestep probabilistic Water Balance Model (WBM) has been developed, in accordance with the guidelines specified in the DWAF Best Practice Guideline G2: Water and Salt Balances (2006c), to assess the surface water management system over the entire Life of Mine (LOM). The aim of the WBM is to represent the surface water system of the Melmoth site as it is developed. The WBM is used to characterise the potential for water excess or deficit. The WBM incorporates all projected inflows and outflows and tracks the water volumes in each storage element. It is a live model and should be continuously updated as new data becomes available. The WBM was developed in the GoldSim modelling package (version 114.0).

The GoldSim model evaluates the impact of the site development and its proposed water management system. The system response was tested under varying climatic conditions:

- 500 different sequences of rainfall over the entire simulated period, developed following the methodology of the Stochastic Climate Library tool, this is described in further detail in Section 8.2.1

The average water make (i.e., the average excess water volumes) have been determined, the probable additional raw water volumes which will be sourced, the probable pit inundation volumes, as well as the probability of spillages or decants from the various facilities over the LOM.

8.2 WBM SYSTEM DESCRIPTION

8.2.1 Probabilistic Rainfall Analysis

Probabilistic climate data for the water balance model (WBM) was generated using the daily rainfall record from SAWS rain gauge 0303833AW and applying the Stochastic Climate Library tool's (eWater CRC) approach to generate synthetic rainfall sequences which are statistically equivalent to the historical record.

The purpose of the probabilistic rainfall generation is to develop multiple climate sequences based on the recorded rainfall data of the area. These sequences have the same statistical characteristics of the historical data set for a range of parameters, including mean, variance, skew, and number of wet days or dry days. Each sequence has an order in which the rainfall has occurred. For example, one sequence may have wetter years at the start of the sequence, where another sequence may have the wetter years towards the end of the sequence. Some sequences may be wetter or dryer than others in order to account for the variability of the climate which may occur after the mine is rehabilitated. The probabilistic rainfall data replicates the seasonality of the rainfall data.

Probabilistic rainfall data was produced for 500 replicates of the 32-year LOM. The outputs of the stochastically generated rainfall were compared to the historically recorded rainfall data as shown in Figure 8-1 for the full rainfall record, indicating an acceptable fit when considering the range of annual rainfall totals assessed.

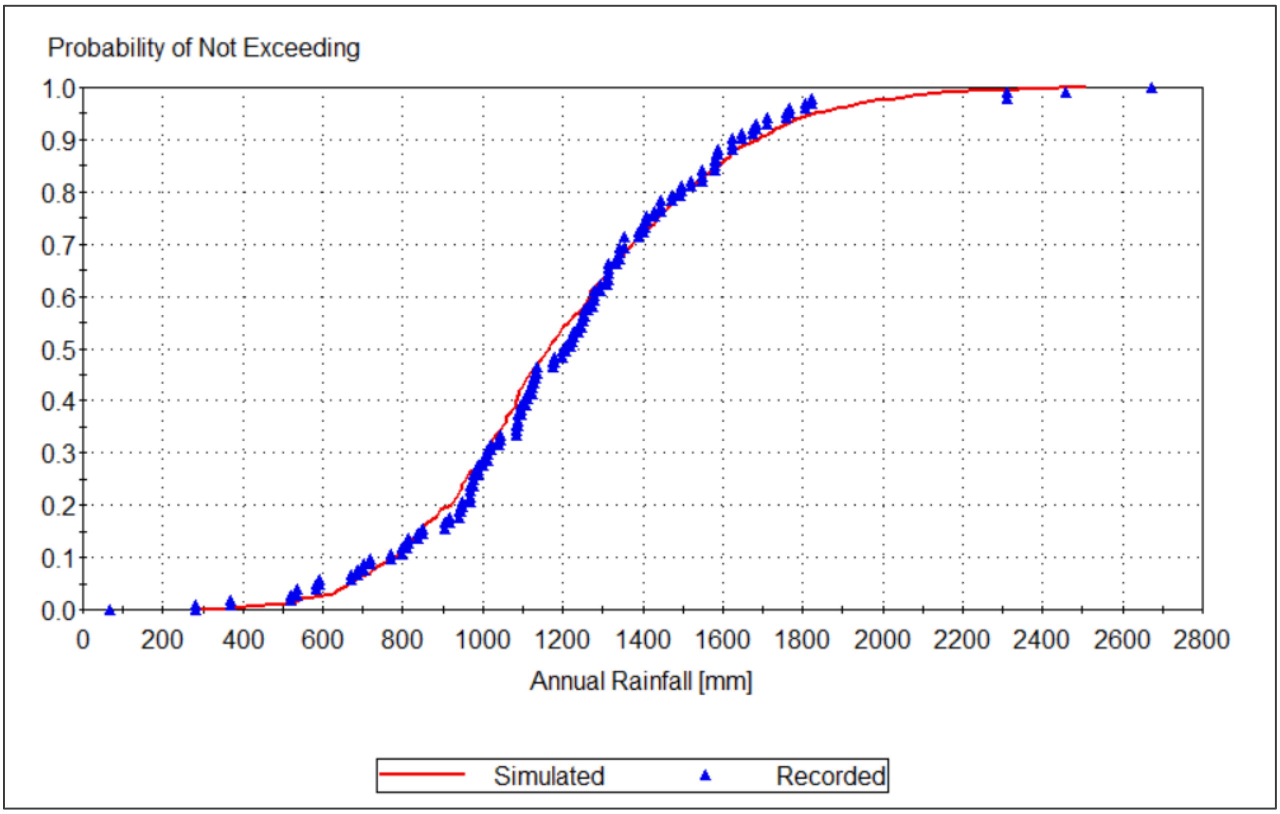


Figure 8-1: Stochastic and Historical Data Comparison – Annual Rainfall

8.2.2 Water Sources

Raw water

Raw water is sourced from the Goedertrouw Dam and pumped to the Raw Water Tank from where it is pumped to the Raw Water Dam located in the Processing Plant area. A maximum transfer capacity of 1,500 m^3/hr (36,000 m^3/d) has been assumed for this source.

Surface Runoff

The WBM utilises the SCS method to determine runoff volumes from the various catchments. The curve numbers (SCS CN) assumed for these catchments are indicated, along with the catchment areas (as supplied by Wood), in Table 8-1.

Table 8-1: Catchments included in the WBM

Name	Footprint (ha)	SCS CN	Runoff discharges to / pumped to
Tailings Storage Facility	1,100	n/a*	Return Water Dam
Pit	257 (Final Footprint)	80	Site PCD1
Waste Rock Dump	200	n/a*	Site PCD 2
Raw Water Pond	0.60	85	Raw Water Pond
Process Water Pond 1	5.25	85	Process Water Pond 1
Process Water Pond 2	0.23	85	Process Water Pond 2
Process Plant	36.7	85	Plant PCD

Name	Footprint (ha)	SCS CN	Runoff discharges to / pumped to
Mining Offices	10.2	85	Offices PCD
Mining Yard	12.2	85	Yard PCD
Filter Plant / Rail Siding	5.9	85	Rail Siding PCD

*To calculate the runoff volumes predicted from the TSF and Waste Rock Dump, hydrological modules following the ACRU multi-layer soil moisture accounting approach where calibrated for the local area to generate average runoff rates of 45% and 10% respectively. These modules more readily replicate multi-day responses and runoff depths following major events.

The pit footprint will progressively increase over the LOM, an arbitrary start date of 1 Jan 2024 has been used in the model from when mining starts. The increasing footprint over time is indicated in Figure 8-2.

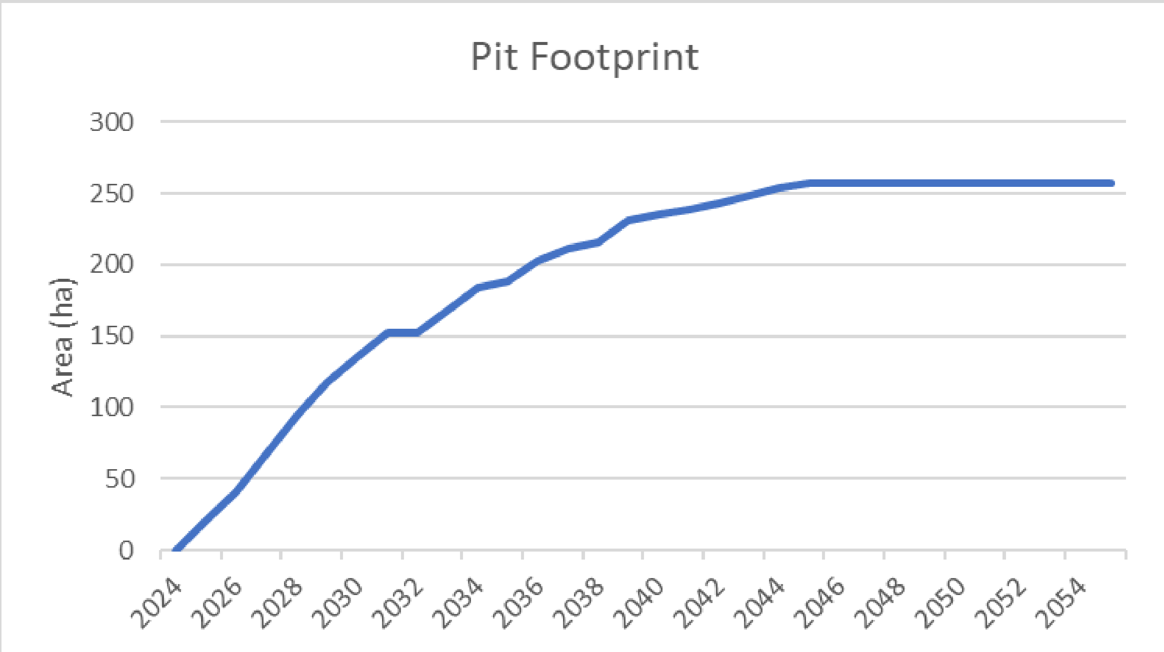


Figure 8-2: Pit Footprint

Groundwater

Groundwater ingress to the pit has been assumed negligible in comparison to surface water volumes and has been excluded from the WBM.

8.2.3 Water Demands

The following water demands/users have been included in the model, based on the static process water balance supplied by Wood (June 2023):

Processing Plant

The plant make-up water demand has been calculated as follows:

- Inflows
  - ROM Moisture = 218 m^3/hr
  - Raw floc make-up = 17 m^3/hr
  - GSW = 150 m^3/hr
  - Filtered water for dust suppression = 10 m^3/hr

- Outflows
    - Concentrate Thickener Feed = 547 m^3/hr
    - Tailings Thickener Overflow = 31,491 m^3/hr
    - Tailings Thickener Underflow = 2,751 m^3/hr
- **Nett demand (potable) = 177 m^3/hr from the WTP**
- **Nett demand (process) = 34,571 m^3/hr from Process Water Pond 1**

Concentrator Thickener

The plant make-up water demand has been calculated as follows:

- Inflows
    - Concentrate Thickener Feed = 547 m^3/hr
    - Concentrated floc = 4 m^3/hr
    - GSW (from Process Water Pond 2) = 12 m^3/hr
- Outflows
    - Product Moisture = 104 m^3/hr
    - Concentrate Thickener Overflow = 495 m^3/hr
- **Nett demand (process) = 48 m^3/hr from the Process Water Pond 2 (includes the 12 m^3/hr for GSW)**
- **Nett demand (potable) = 4 m^3/hr from WTP**

Miscellaneous Users

Several water demand locations have been included in the modelling:

- Potable Water supplied from the Water Treatment Plant (WTP)
    - Raw Floc make-up: constant at 17 m^3/hr
    - Concentrated floc: constant at 4 m^3/hr
    - GSW: constant at 150 m^3/hr
    - Filtered water for dust suppression: constant at 10 m^3/hr
    - Potable use for personnel: 2 m^3/hr
    - **Total potable demand: 183 m^3/hr (4,392 m^3/d)**
- Dust Suppression 400,000 m^3/yr (45 m^3/hr)

8.2.4 Mine Water Storage

Several storage facilities will be constructed around site to assist with erosion and sedimentation control as well as general water distribution and balancing. A summary of the dam surface areas and storage capacities of all the proposed surface storage facilities is provided in Table 8-2.

Table 8-2: Storage Facilities

Name	Capacity (m^3)	Footprint (m^2)
Return Water Dam	3,830,800	350,000
Site PCD 1	800,000	160,000
Site PCD 2	150,000	30,000
Raw Water Pond	5,988	1,996
Process Water Pond 1	67,074	13,415
Process Water Pond 2	1,022	341

Name	Capacity (m^3)	Footprint (m^2)
Plant PCD	14,550	6,273
Offices PCD	4,450	2,600
Yard PCD	4,450	2,600
Rail Siding PCD	4,450	1,750

8.2.5 Water Management System

A diagram of the proposed water management system is provided in Figure 8-3.

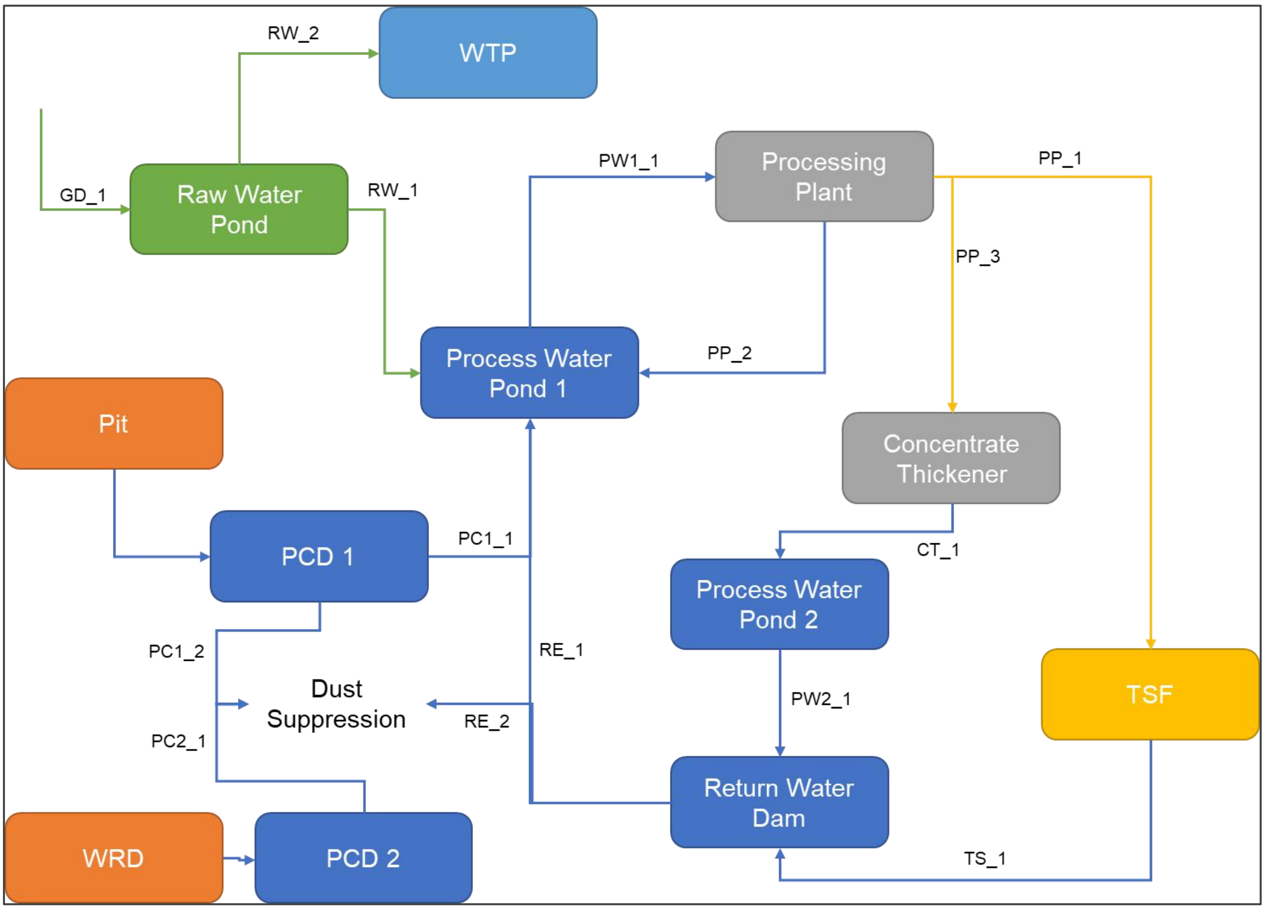


Figure 8-3: Mine Water Management System

8.3 WBM RESULTS

8.3.1 Water Balance

The average annual predicted inflow, outflow and system storage rates are provided in Table 8-3.

Table 8-3: Average Annual Water Balance

	Annual Average (ML/year)
Inflows	
Direct Rainfall	507
Raw Water Supply (Goedertrouw)	7,636

	Annual Average (ML/year)
Runoff	6,842
ROM Moisture	1,911
Total	**16,896**
Outflows	
Evaporation	1,231
Seepage	15
Dust Suppression	366
Product Moisture	912
Tailings (entrained)	14,228
Potable use	18
Overflow	77
Total	**16,847**
Change in volumes in storage	**22**

The principal source when considering the generation of MAW is runoff from the TSF with the majority of the predicted water uses and/or losses associated with entrainment within the TSF. The average water balance across the system in m^3/hr is shown in Figure 8-4.

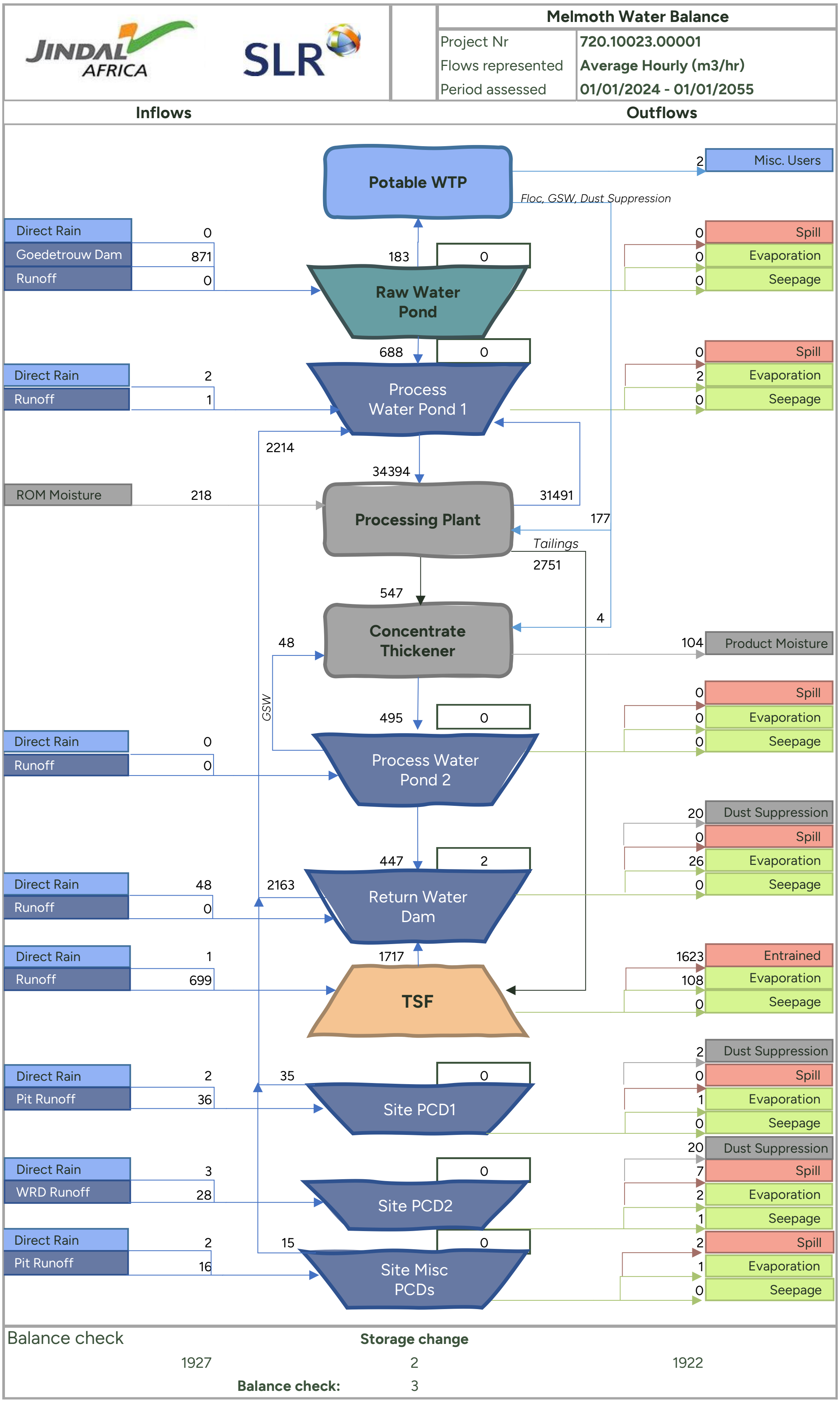


Figure 8-4: Average Annual Water Balance (m^3/hr)

8.3.2 Water Supply

The Goedertrouw Dam supply source has an assumed transfer capacity of 1,500 m^3/hr. The predicted average demand over the Life of Mine is estimated at 871 m^3/hr, or approximately 7,500 ML/year as indicated in Figure 8-3. The results however indicate that annual average demand volumes may occasionally (2% of the time) exceed 1,300 m^3/hr (or almost 12,000 ML in a year). In very wet years (i.e., 98th percentile rainfall), the annual demand rates may drop below 3,000 ML.

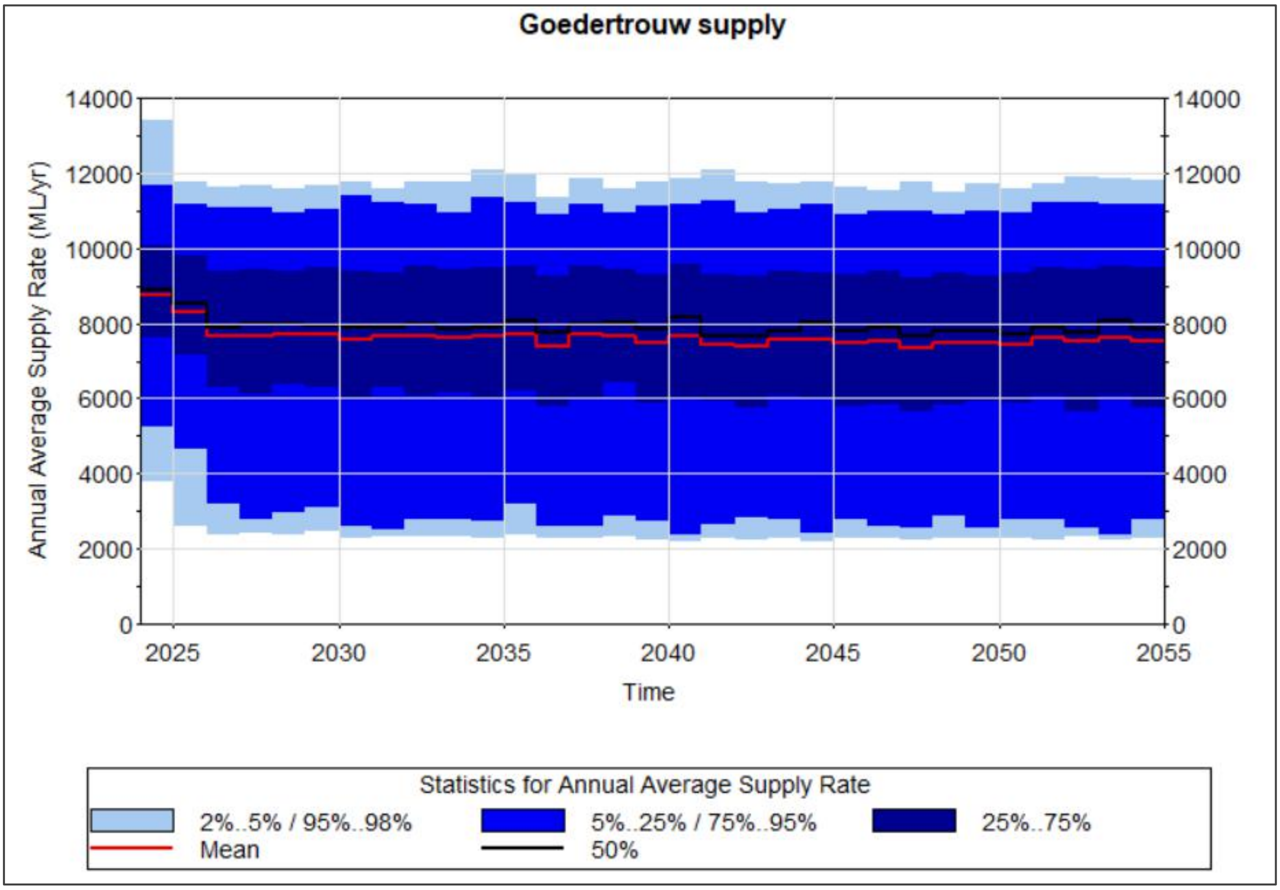


Figure 8-5: Predicated Raw Water Demand – Probable Range

8.3.3 Mine Affected Water Inventory

The predicted range of water stored within the Return Water Dam over the LOM is shown in Figure 8-6. The results indicate that the majority of the time (median) the volumes should be below 500,000 m^3, however during the wet season the volumes in storage will often (more than 25% of years) exceed 1,500,000 m^3. The current assumed operating principals and system assumptions at this dam, result in a predicted spill frequency of less than 1 in 500 years.

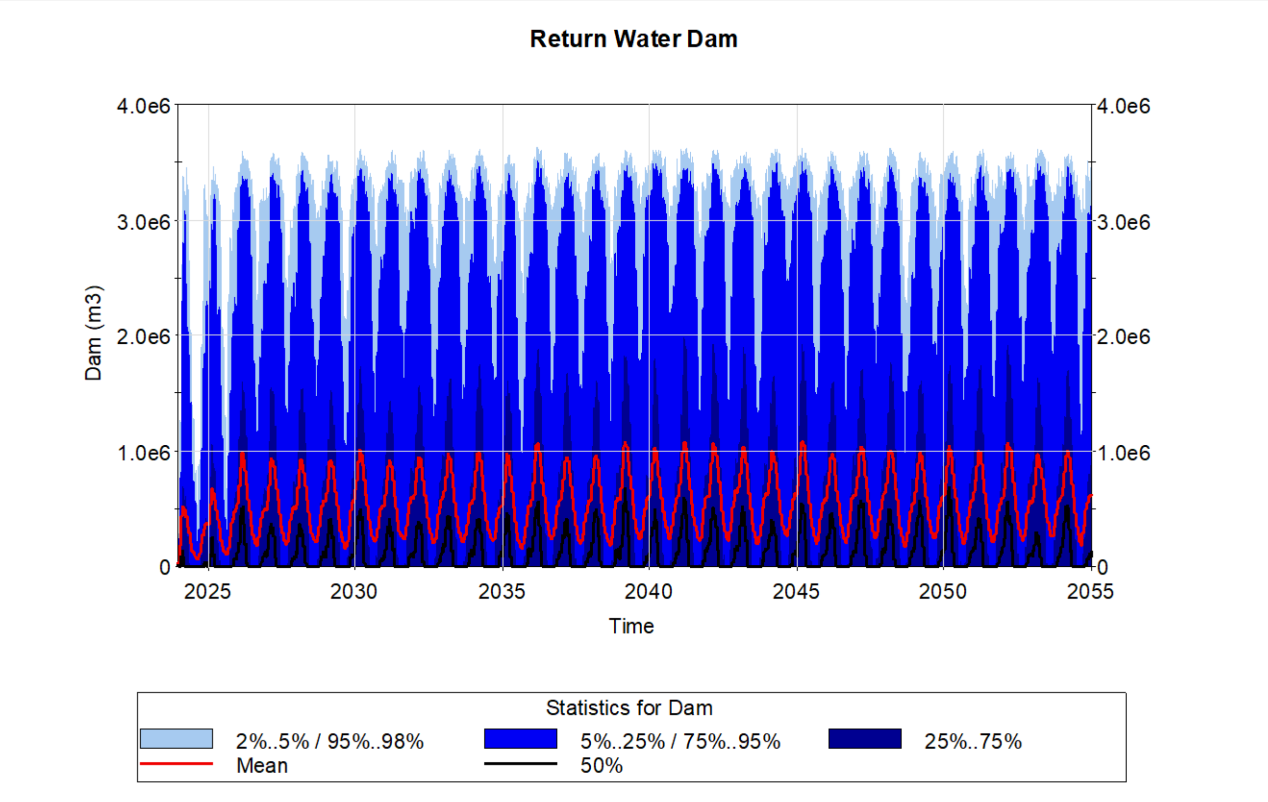


Figure 8-6: Average Predicted Range of Water Volume in Return Water Dam

Runoff will accumulate within the pit from where it will be transferred to the Site PCD1 (assumed transfer capacity of 1,600 m^3/hr). The average predicted volumes accumulating in the pit over the LOM are shown in Figure 8-7, and the 98th percentile values in Figure 8-8. The results indicate that generally volumes in excess of 20,000 m^3 need to be safely accommodated, however following significant events or wet periods there is a 2% probability that these volumes could exceed 400,000 m^3, especially in the latter years of the mine's life.

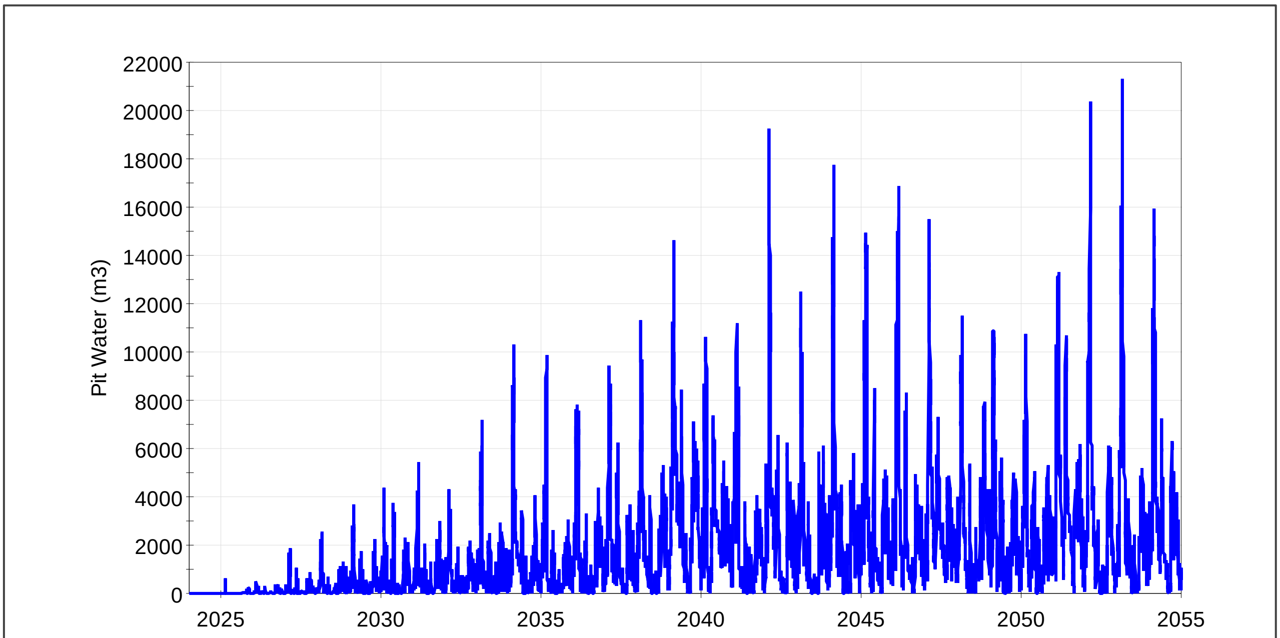


Figure 8-7: Predicted Average Water Volumes Accumulated in Pit

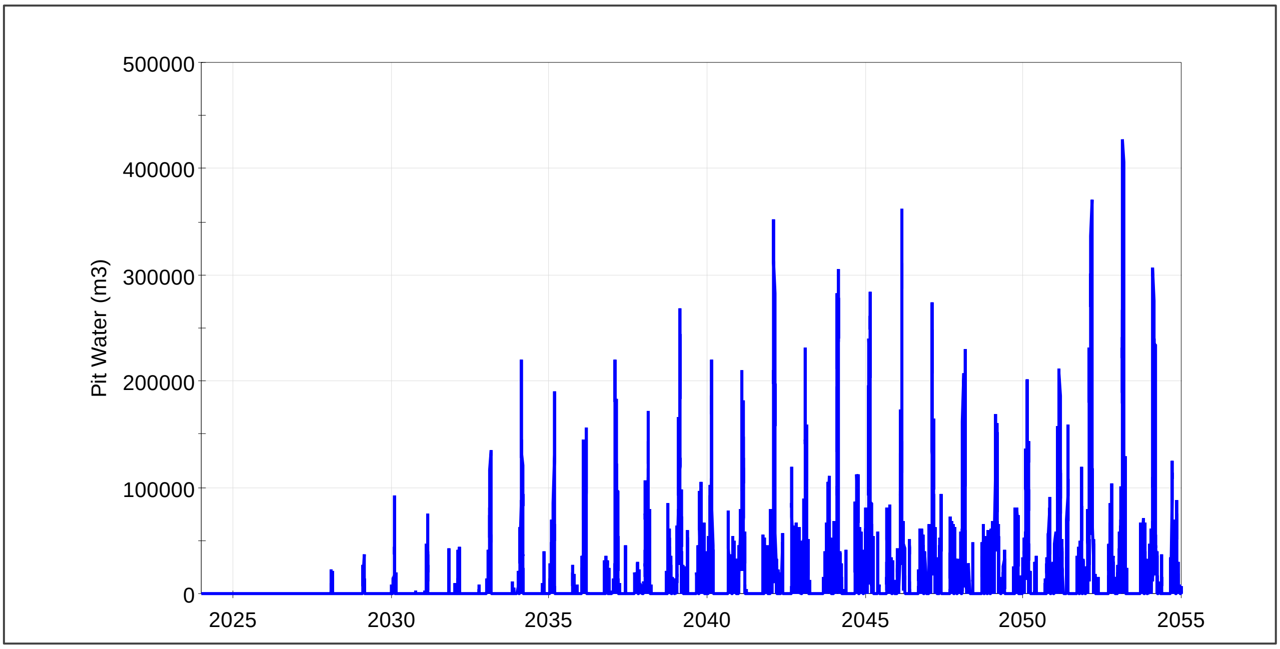


Figure 8-8: Predicted Water Volumes Accumulated in Pit – 98th Percentile

8.4 LIMITATIONS OF ASSESSMENT

The accuracy of the assessment is reliant on the accuracy of the utilised data. SLR has assumed all source data to be fit for purpose and sufficiently accurate for the purpose of this assessment. Except where noted, no verification of accuracy of the information has been carried out. In the event that some of the information which was relied upon for this assessment is found to be inaccurate, then some or all of the findings may change.

Several assumptions have been made to inform the development of the WBM, modelling and sensitivity assessment provides guidance onto the likely importance of these assumptions and parameters on the model results. However, the passage of time and additional studies may refine these assumptions leading to improvements in model accuracy, and changes to the conclusions drawn in this report.

Although the analyses undertaken as detailed in this report were done so with the appropriate care and professionalism, this report shall only be used for the purposes intended. The analyses detailed in this report were undertaken solely for the purpose of addressing the requirements to assess the impact on the site water balance which may be brought about by the proposed extension. The results of the assessment should be considered in terms of relative change to the approved base case and not necessarily on their own merit.

This report should be read in full, and no excerpts are to be taken as representative of the findings. This report has been prepared on behalf of Jindal and SLR accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

9. POTENTIAL WATER SUPPLY TO THE PROPOSED MINE DEVELOPMENT

9.1 BACKGROUND

The proposed development includes processes that will require raw water. The supply of water has therefore been explored, including the potential abstraction of water from Goedertrouw Dam, and the detailed report on the assessment (Ward, 2022) is appended as Appendix G.

The Goedertrouw Dam, with a capacity of 304 million m^3 (1987 survey), is situated in the middle reaches of the Mhlathuze catchment. The MAR into the dam is estimated at 163 million m^3/annum. In terms of the MAR, the Goedertrouw Dam is considered to be a large dam (1,87 times the MAR), the implication of which is that there would be little to be gained out of raising the dam. The dam was completed in the early 1970's and was constructed primarily to meet the rapid growth in industrial, mining and urban requirements of the Richards Bay area, but also for irrigation purposes. Water is distributed to irrigators via a canal as well as releases into the Mhlathuze River, which are abstracted by pumps along its length while water for other users is abstracted at the Mhlathuze Weir. The natural inflow into the Goedertrouw Dam is supplemented by transfers from the Thukela River (DWAF, 2004).

In 1996, an emergency scheme was implemented to transfer water from the Thukela River to the Mhlathuze system, via the Goedertrouw Dam. Water is transferred at a rate of about 1,2 m^3/s whenever the water level in the Goedertrouw Dam drops below 90%, although this is an operating rule that is frequently reviewed. The infrastructure related to the transfer scheme consists of a pump station situated at a small weir at Middeldrift on the Thukela River and a pipeline which crosses the catchment divide and discharges into the upper reaches of the Mhlathuze River. The capacity of the transfer can be increased relatively easily to 3,0 m^3/s by increasing the pumping capacity of the pump station (DWAF, 2004).

The water resources of the Mhlathuze catchment are complex since it consists of numerous inter-related components, namely, a large dam (Goedertrouw), transfers in from the Thukela and Mfolozi Rivers, natural lakes and run-of-river abstractions. The yield of the Mhlathuze system was determined during a recent detailed water resources study taking into account the complexity of the operating rules of the catchment. The total yield of the Mhlathuze system (excluding groundwater) is given as 247 million m^3/annum which relates approximately to the 1:50 year yield of the Mhlathuze system (DWAF, 2004).

Compulsory Licensing has been carried out in the Mhlathuze Catchment and the current water deficit is 9 million m^3/annum (Ward, 2022). Water requirements in the Mhlathuze catchment are driven largely by industries and mining, the development of which is in turn dictated by the global economy. Sudden and dramatic increases in the water demand are therefore a real possibility (DWAF, 2004).

With the water allocations as they stand there is at present no room for industrial, urban or other expansion, unless there is major new infrastructure development.

9.2 POTENTIAL INTERVENTIONS TO SUPPORT THE PROPOSED MINING DEVELOPMENT

It is possible that the water required for the proposed mining development could be provide through one or more of the following interventions, as provided by Ward, 2022 (Appendix G). Details of the options to be used will need to be agreed with the DWS through a WULA.

The Tugela Transfer Phase 2 was initiated because of the 2014 drought. The latest information is that completion of the scheme is scheduled for 2023, however this is likely to be reviewed due to the slow progress on site. After allowing for the current deficit, the requirement for the proposed mining development would take up over one third of this new supply.

The Mhlathuze weir ultimately provides water to Lake Nsezi. Spills from the Mhlathuze weir, during local rainstorms, have been in excess of what is required by Lake/Estuary. These spills may therefore be captured for use by Jindal.

Mhlathuze Water has already looked at duplicating the pipeline from the weir to the water treatment plant, which could provide an additional 24 Mm^3 per annum. This project was subsequently put on hold but could be revived through an agreement between Jindal and Mhlathuze Water.

In addition, Jindal could appoint a professional service provider with relevant experience and with agreement with the Infrastructure Branch of DWS to provide release instructions directly to the operator of Goedertrouw Dam. The intention would be for the appointed professional service provider to develop operating rules to maximize the yield of the dam and minimize losses/spills during the wet seasons, and to convey these directly to the Dam operator. This could provide an additional 18 Mm^3 per annum.

Jindal is also exploring other options to secure a water allocation within the Mhlathuze catchment, which would need to follow the process of redistribution of water in the catchment. Details of these options are not currently available.

10.GOEDERTROUW DAM AND DOWNSTREAM CATCHMENTS

The proximity of the proposed development to the Goedertouw Dam and neighbouring agricultural land has raised concerns from water users in the area.

It is understood that there are two areas of concerns:

- Impacts on the quantity of water available from Goedertrouw Dam and the downstream catchments; and
- Impacts on the quality of water in catchments downstream of the proposed development.

Figure 10-1 indicates the catchment area of the Goedertrouw Dam, which encompasses W12A and W12B. The infrastructure proposed within the Mining Right Area (the WRD, South East Pit and Power Yard) all fall within quaternary catchment W12D, which is to the east and falls outside of the catchment area of the Goedertrouw Dam. The proposed development will therefore not impact on the runoff entering Goedertrouw Dam.

In order to show the impact of the proposed development on downstream catchments, a point immediately downstream of the development was chosen and is referred to in this Section as "Point A".

The catchment area of Point A is 175 km^2 as shown in Figure 10-2. The total area of the dirty water catchments resulting from the proposed development is 5.72 km^2. This translates to a loss in catchment area, due to the proposed development and only within the catchment area of Point A shown in Figure 10-2, of 3.3%. The impact of the proposed development decreases for points in downstream catchments i.e., the ratio of the dirty water catchments (from the proposed development) to total catchment area would be less than 3.3%, further downstream from the development. The proposed development is therefore expected to have minimal impact (if any) on the runoff to the catchments downstream of the proposed development.

As discussed in the preceding section, all dirty water catchments within the area of the proposed development will be suitably cut-off from the clean water systems to ensure that dirty water is contained as per the regulations.

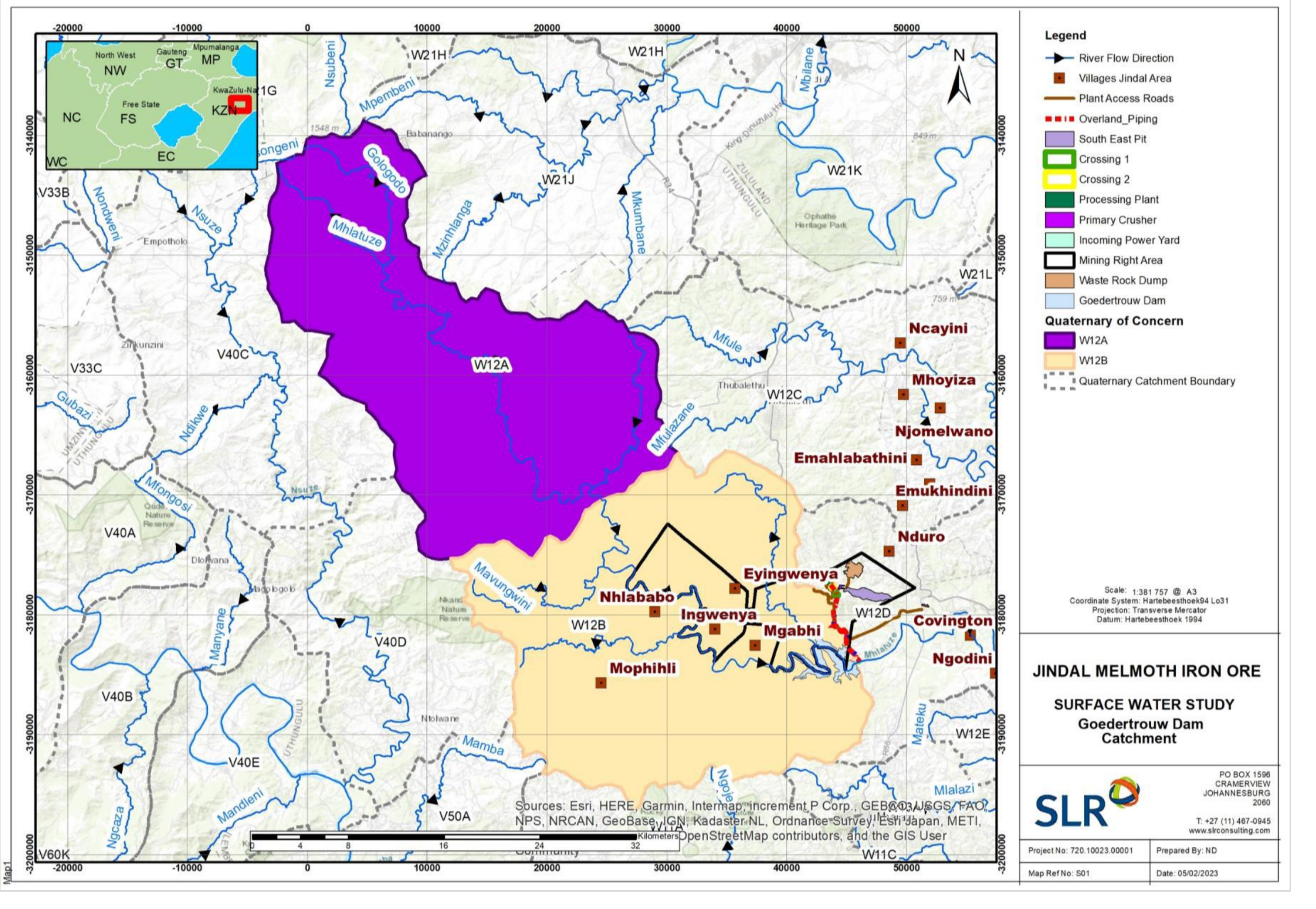


Figure 10-1: Catchment area of Goedertrouw Dam

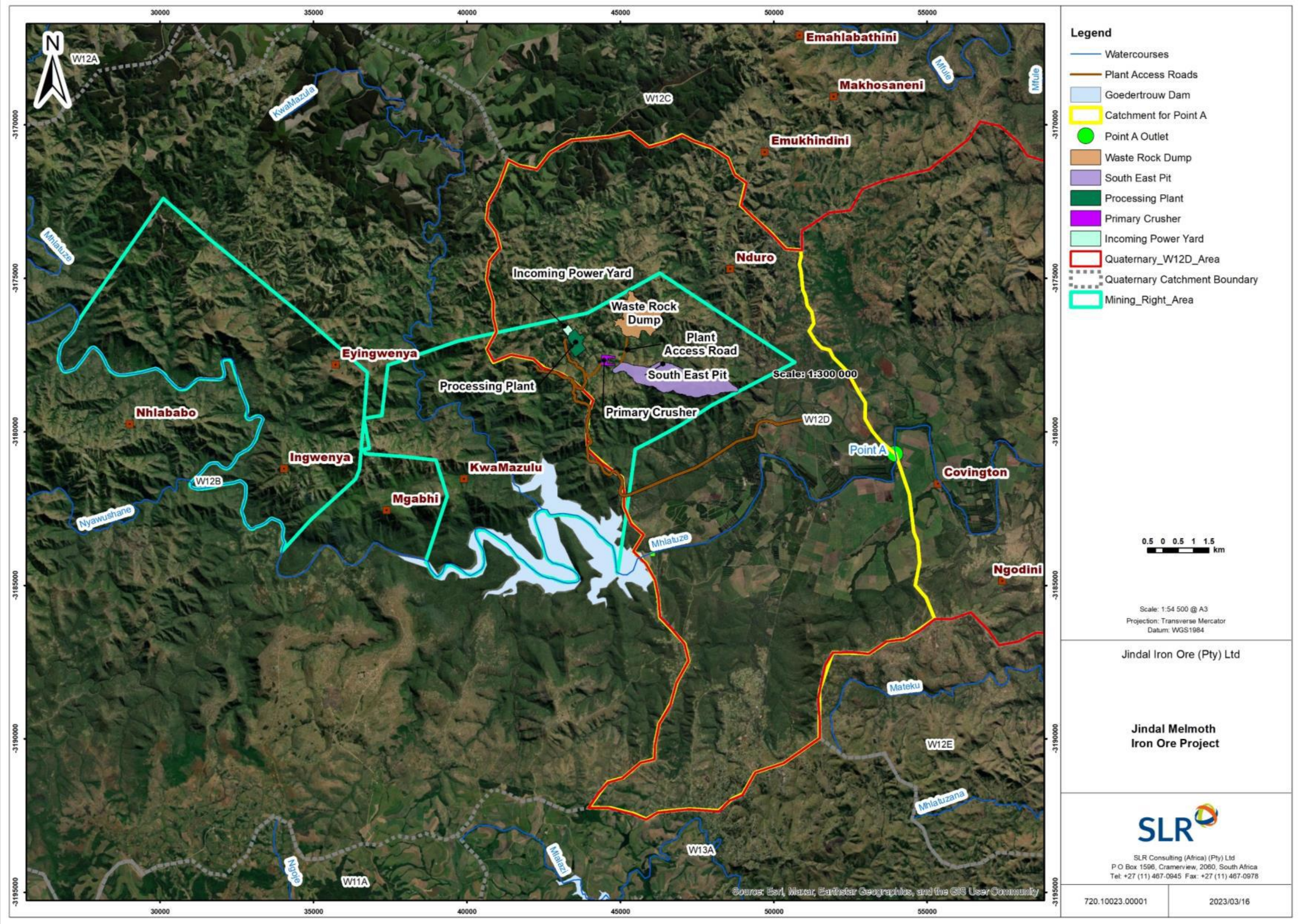


Figure 10-2: Catchments Downstream of Proposed Development

11.IMPACT ASSESSMENT, MITIGATION AND MONITORING

Informed by the mine plan layout, baseline hydrology, design specifications for the storm water management measures, and the water balance results, the potential impacts of the proposed activities on surface water receptors as well as the sensitivity of the surface water resources are discussed in this section and presented along with a summary of mitigation measures and monitoring requirements.

Impacts are assessed cumulatively where possible, in that the assessment takes into account the currently impacted environment. The impact assessment undertaken here is for the proposed Jindal Project and its associated infrastructure. The impacts of the proposed Wate Rock Dump, South East Pit and infrastructure (Plant and access roads) are identified and assessed based on the impact's magnitude as well as the receptor's sensitivity.

The surface water impacts associated with the proposed Jindal MIOP are assessed according to the three main stages of the project namely the construction phase, the operation phase and the closure phase, as well as the major activities within those phases.

The proposed mining project includes various mitigation measures recommended in the SWMP, flood lines and the water balance model assessments. Theoretically without these measures the impacts on the environment would be much higher, although the mine would almost certainly not be allowed to proceed without achieving compliance with current best practice and relevant industry guidelines presented in this and other reports. The potential unmitigated impacts (worst-case scenario), and residual impacts of the project after considering the design mitigation measures proposed within this report are qualitatively assessed in this section.

An impact assessment methodology will be followed to identify and mitigate the potential impacts that the project activities will have on the hydrological environment.

11.1 CONTAMINATION OF SURFACE WATER RESOURCES

11.1.1 Description of impact

There are several sources in all project phases that have the potential to pollute surface water, particularly in the unmitigated scenario. In the construction, decommissioning and closure phases these potential pollution sources are temporary and diffuse in nature. Although these sources may be temporary, the potential pollution may be long-term. The operational phase would present the longer-term potential pollution sources.

11.1.2 Impact assessment

CONSTRUCTION PHASE

Water Quality Impacts

- Construction activities that include the use of vehicles and machinery, storage of chemicals, fuels and materials as well as the storage of domestic and industrial waste have the potential to result in contamination of watercourses.

- Soluble construction materials also have the potential to dissolve in runoff from the area. This can result in the increase of dissolved solids in downstream waterbodies during periods of rainfall and subsequent flow resulting in a water quality impact.
- Deterioration of water quality during the construction phase can be attributed to the following:
  - Clearing of the surface area and site preparation for the new infrastructure would result in exposure of soil surfaces to potential erosion. When a large area of vegetation is cleared and topsoil disturbed, it exposes loose material which is susceptible to erosion.
  - Water contamination could result from poor management of waste during the construction phase if not adequately managed. Typically, the following pollution sources exist: fuel and lubricants, sewage etc.
  - Water quality deterioration as a result of discharge of dirty water into the catchment around the Project when unplanned events do occur, some of the structures may overtop and overflow, causing dirty material to wash into nearby streams.

The impact on surface water quality during the construction phase is assessed to have a very high intensity and would occur over the short-term (1-5 years). It could impact immediate neighbours, however the significance prior to mitigation is assessed to be medium. With the implementation of mitigation measures the impact can be reduced to low (Tablke 11-1).

Table 11-1: Impact Summary – Contamination Potential (Construction Phase)

Description of Impact		
Type of Impact	Direct	
Nature of Impact	Negative	
Phases	Construction	
Criteria	**Without Mitigation**	**With Mitigation**
Intensity	Severe change (Very high)	Minor change (Low)
Duration	Short-term (1 and 5 years)	Short-term (1 and 5 years)
Extent	Beyond site	Beyond site
Consequence	Medium	Low
Probability	Probable	Probable
Significance	**Medium**	**Low**
Degree to which impact can be reversed	*Provided mitigation measures are implemented the impact should be able to be reversed.*	
Degree to which impact may cause irreplaceable loss of resources	*Low as most all associated activities e.g. land clearing will be carried out in demarcated areas and will be confined within a short period. Also, the nature of the construction phase in short term.*	
Degree to which impact can be avoided	*High if the mitigation set can be implemented.*	
Degree to which impact can be mitigated	*High as the set mitigation measures are achievable.*	
Cumulative impact		

Nature of cumulative impacts	*The Mhlatuze catchment is under irrigated crops, predominantly sugarcane and citrus, which is found along the Mhlathuze River downstream of the Goedertrouw Dam. Other key activities in the catchment are cattle and subsistence farming. Irrigation return flows from the substantial irrigation activities in the middle reaches of the catchment do certainly reduce the water quality. Construction phase activities of the proposed mine might add to existing water quality challenges if not mitigated.*	
Rating of cumulative impacts	**Without Mitigation**	**With Mitigation**
	Medium	Low
Residual impact		
Residual impact discussion	The residual impact is considered to be LOW with only limited impacts on the environment.	

OPERATIONAL PHASE

Water Quality Impacts

- Contaminated stormwater runoff from operational areas containing potential pollutants such as oils, solvents, paints, fuels and waste materials.
- Some of the structures may have the potential for seepage such as the WRD, PCD dams and plant infrastructure areas.
- The project could cause pollution of water resources through sediment transport.
- Contamination of the water courses during heavy downpours or in the case of unplanned events e.g. spills or leaks
- Discharge of excess water from the PCDs after excessive rainfall would also present risks to water quality, although this is expected to occur during the extreme events.

The impact on surface water during the operational phase is assessed to have a prominent intensity and would occur over the long-term. It could impact immediate neighbours and as such the significance prior to mitigation is assessed to be HIGH. With the implementation of mitigation measures the impact can be reduced to Medium (Table 11-2).

Table 11-2: Impact Summary – Contamination Potential (Operational Phase)

Description of Impact		
Type of Impact	Direct	
Nature of Impact	Negative	
Phases	Operational	
Criteria	**Without Mitigation**	**With Mitigation**
Intensity	Severe change (Very high)	Moderate change (Medium)
Duration	Long-term (10 and 20 years	Long-term (10 and 20 years
Extent	Beyond site	Beyond site
Consequence	High	Medium
Probability	Probable	Probable
Significance	**High**	**Medium**
Degree to which impact can be reversed	*Provided mitigation measures are implemented the impact should be able to be fully reversed*	
Degree to which impact may cause irreplaceable loss of resources	*Medium as the area receives considerable amount of rainfall. Stormwater management infrastructure might spill.*	
Degree to which impact can be avoided	*It could be high provided spill- clean-up plans are available and used and pollution prevention measures are implemented.*	
Degree to which impact can be mitigated	*Medium as the stormwater management measures are designed to mitigate the impact.*	
Cumulative impact		
Nature of cumulative impacts	*There are no major heavy/ mining industries immediate to the proposed project site except for agriculture and livestock production activities. Mining activities are further downstream in Richards Bay area close to the coast.*	
Rating of cumulative impacts	**Without Mitigation**	**With Mitigation**
	Low	**Low**
Residual impact		
Residual impact discussion	*The residual impact can be low after the implementation of mitigations*	

DECOMMISSIONING AND CLOSURE PHASES

Water Quality Impacts

Compacted surfaces from moving vehicles and machinery during the decommissioning and closure phase could potentially lead to an increase in runoff into the nearby streams. Surface water resources are receptors of fine materials and contaminants arising from the demolition of infrastructure and earthworks and transported by rainwater and surface runoff. This may be deposited in watercourses resulting in siltation and contamination of surface water with chemical pollutants. The contaminants might include oil, fuel, from moving vehicles and storage areas, domestic and other industrial chemicals.

At elevated concentrations contaminants can exceed the relevant surface water quality limits imposed by local guidelines. In the unmitigated scenario, the moderate intensity contamination of surface water resources could occur for periods longer than the life of the proposed Project thus having a MEDIUM significance. With mitigation, pollution can be prevented and/or managed and as such the impacts can be reduced within the life of the proposed project to a LOW significance.

Table 11-3: Impact Summary – Contamination Potential (Decommissioning & Closure)

Description of Impact		
Type of Impact	Direct	
Nature of Impact	Negative	
Phases	Decommissioning and Closure Phases	
Criteria	**Without Mitigation**	**With Mitigation**
Intensity	Prominent change (High)	Moderate change (Medium)
Duration	Medium-term (5 to 10 years)	Medium-term (5 to 10 years)
Extent	Beyond site	Beyond site
Consequence	Medium	Medium
Probability	Probable	Possible / frequent
Significance	**Medium**	**Low**
Degree to which impact can be reversed	***Partially reversable*** *as there is the potential for impact to the surface water quality post closure, even if this is considered to be a LOW significance.*	
Degree to which impact may cause irreplaceable loss of resources	***Low,*** *Some infrastructure such as waste rock dumps may contain low levels of polluting substances, which may find their way to natural rivers or drainage channels but are not expected to cause irreplaceable losses. In addition, the implementation of the mitigation measures will promote the containment of potential polluting substances..*	
Degree to which impact can be avoided	***High,*** *The SWMP and other recommended mitigation measures are expected to significantly reduce the risk of potential impacts. The stormwater management designs aim to contain all dirty water as per the regulations.*	
Degree to which impact can be mitigated	***High,*** *mitigation measures are expected to reduce the impact from Very High/Medium to Low during construction and post decommissioning as the source of contaminants would be lower than during operations.*	
Cumulative impact		
Nature of cumulative impacts	*There are no major industries or other mining projects in the immediate vicinity of the proposed Jindal MIOP, except for the agriculture and livestock production activities in surrounding areas. The Mhlatuze catchment is currently predominantly used for irrigated commercial crops, largely sugarcane and citrus, which are found along the Mhlathuze River downstream of the Goedertrouw Dam. Other key activities in the catchment are cattle and subsistence farming. Return flows from the substantial irrigation activities in the middle reaches of the catchment are likely to contribute to the reduced water quality in this area. Construction phase activities of the proposed mine could have an additional impact on existing water quality challenges if not mitigated. The contribution is, however, likely to be LOW with the implementation of mitigation measures.*	
Rating of cumulative impacts	**Without Mitigation**	**With Mitigation**
	Low	**Low**
Residual impact		
Residual impact discussion	*Post closure of the Jindal MIOP there is the potential for long term impact on the surface water quality, however, provided that sufficient rehabilitation of the site is undertaken and post closure monitoring in place, the residual impact is considered to be LOW.*	

11.1.3 Mitigation

The following mitigation measures per phase are recommended:

Construction Phase

- Minimise the disturbance of vegetation and soils as much as possible by restricting construction activities within demarcated areas.
- Clear areas as and when needed for construction related purposes.
- Phasing / scheduling of earthworks should be implemented in order to minimise the footprint that is at risk of erosion at any given time, or schedule works according to the season
- Progressive rehabilitation of disturbed land should be carried out to minimize the amount of time that bare soils are exposed to the erosive effects of rain and subsequent runoff.
- Traffic and movement over stabilised areas should be controlled (minimised and kept to certain paths), and damage to stabilised areas should be repaired timeously and maintained.
- In case of an occurrence of a discharge incident that could result in the pollution of surface water resources, the emergency response procedure should be implemented.
- Water quality monitoring will be undertaken as per the monitoring programme outlined in Section 11.1.4.
- Maintenance of vehicles to be done in a bunded lined area or off-site.
- The spill kit must be kept on-site and be easily accessible.

Operation Phase

- The stormwater management has been designed in accordance with the regulations of GN704 and the following has been recommended:
  - Dirty water will be separated from clean water.
  - Dirty water and clean water drainage system has been specified around the plant, the WRD and the Pit.
  - Containment of dirty water from dirty water catchments (WRD, South East Pit and Process Plant area) will be undertaken via PCDs.

- All hazardous chemicals (new and used), mineralized waste and non-mineralised waste must be handled in such a manner that they do not pollute surface water. This will be implemented by means of the following:
  - Pollution prevention through basic infrastructure design such as waste storage containment, hardstanding and containment bunds.
  - Maintenance of vehicles to be done in a bunded lined area or off-site.
  - Pollution prevention through maintenance of equipment.
  - Pollution prevention through education and training of workers (permanent and temporary).
  - A spill clean-up plan must be in place and all employees trained in the use thereof to enable containment and remediation of pollution incidents.
  - The spill kit must be kept on-site and be easily accessible.

- Water quality monitoring will be undertaken as per the monitoring programme outlined in Section 11.1.4.
- In case of an occurrence of a discharge incident that could result in the pollution of surface water resources, the emergency response procedure should be implemented.
- Good housekeeping practices should be implemented and maintained by timeous cleaning-up of accidental spillages. Waste should be disposed to a licensed waste site. In addition, spill cleaning kits and material safety data sheets for chemical and hazardous substances should be accessible and available where these are used for immediate clean-up of accidental spillages of pollutants.

Closure and Decommissioning Phase

- In case of an occurrence of a discharge incident that could result in the pollution of surface water resources, the emergency response procedure should be implemented.
- Spill kit must be kept on-sit
- Maintenance of vehicles to be done in a bunded lined area or off-site.
- Phasing / scheduling of earthworks should be implemented in order to minimise the footprint that is at risk of erosion at any given time, or schedule works according to the season.
- Water quality monitoring will be undertaken as per the monitoring programme outlined below.
- A post rehabilitation audit should be undertaken to ascertain whether the remediation has been successful and if not, further measures should be recommended and implemented.

11.1.4 Monitoring

The following monitoring is recommended:

- Analytical suites as outlined in Table 11-4 for recommended water quality analysis should be undertaken until a longer-term baseline has been established. Additional monitoring should be done after storm events.
- The monitoring plan should be reviewed regularly, no more than every three years to ensure appropriateness of sites and sampling frequency during operations.

Table 11-4 : Surface Water Quality Parameters of Concern

Parameters of Concern	
pH	Nitrate as N
Electrical conductivity	Ammonia
Total dissolved solids	Potassium
Total suspended solids	Nickel
Aluminium	Manganese
Calcium	Magnesium
Fluoride as F	Iron
Total alkalinity as $CaCO_3$	Copper
Chloride as Cl	Lead
Sulphate as SO_4	Sodium
Uranium	*E.coli*

Reporting

Reporting on the above monitoring should be as follows:

- Internal Reporting – Monthly for:
  - Water Levels in holding dams; and
  - Drainage Inspections.
- External Reporting to DWS– Annual for:
  - Water Quality; and
  - Spillages / Emissions.
- Accidental spillages and overflows should be reported as and when they occur to occur to the Department of Water and Sanitation.

11.2 FLOODING

11.2.1 Description of impact

Pre-development natural drainage across the project area is via natural drainage flow paths. Development can alter the hydrologic response of an area and, ultimately, an entire watershed. The removal of vegetation as well as the compaction of surfaces during construction of the mine and associated infrastructure will very likely result in increased runoff.

11.2.2 Impact assessment

CONSTRUCTION, OPERATIONAL & DECOMMISSIONING PHASE

Flooding impact

Floodlines have been determined for the entire South Block area. It has been deducted that the Plant, Southeast Pit and the WRD traverse the 1:100-year floodlines in some areas.

These infrastructures are therefore susceptible to flooding. This potential impact will continue throughout all phases: construction, operational and closure. Also, in the event of heavy rainfall or rainfall of longer duration the watercourses traversing the buildings, other mine as supporting infrastructure may overflow inundating the exposed infrastructure.

The significance is medium in all phases without mitigation. Flooding is normally accompanied with high losses because of damage and losses it causes. Flood damages can be direct and tangible (in contact with flood water and can be expressed in monetary value) or indirect and intangible (not in contact with flood water and cannot be expressed in monetary value). With mitigation this reduces the severity to low thereafter. The probability of the flooding is definite, but the magnitude of the risk of flooding is low throughout all the phases of the life of the mine infrastructure.

The rating provided in Table 11-5 is reliant on the flood protection berm, river diversions and stormwater management measures as a mitigation measures.

Table 11-5 : Impact summary – Flooding

Description of Impact	
Type of Impact	Direct
Nature of Impact	Negative
Phases	All

Criteria	Without Mitigation	With Mitigation
Intensity	Prominent change (High)	Minor change (Low)
Duration	Long-term (10 and 20 years	Long-term (10 and 20 years
Extent	Site	Site
Consequence	Medium	Low
Probability	Probable	Probable
Significance	**Medium**	**Low**
Degree to which impact can be reversed	***Partially reversible*** *Mitigation measures are designed to accommodate flood events as per the regulations. Without mitigation measures, increased dirty and clean runoff may be expected and result in possible contamination of water resources and failure of mining infrastructure.*	
Degree to which impact may cause irreplaceable loss of resources	***Low,*** *The development will not increase the degree to which flooding would normally occur as the development occupies a relatively small area and increased runoff will be contained as per the SWMP..*	
Degree to which impact can be avoided	***Low*** *as the infrastructure that impedes the watercourses is unlikely to be relocated, the infrastructure will impact the 1:100yr floodline. However, impacts are expected to be relatively low as the SWMP incorporates storage or diversion of design floods as per the regulations. Mining infrastructure is also expected to be designed to mitigate against flood damage.*	
Degree to which impact can be mitigated	***Low*** *provided the flood protection measures are implemented (berms, diversion and stormwater management measures) to protect infrastructure as recommended.*	
Cumulative impact		
Nature of cumulative impacts	*The cumulative impact with the installation of the berms, river diversion and implementation of stormwater management measures is considered to be very low as there are currently no other impacts in the catchment that would be impacted by flooding.*	
Rating of cumulative impacts	**Without Mitigation**	**With Mitigation**
	Low	**Very low**
Residual impact		
Residual impact discussion	*The impact is low with the implementation of flood protection measures.*	

11.2.3 Mitigation

Flood protection measures including berms, river diversion and stormwater management measures that aims at protecting infrastructure against flooding are recommended. The design specification of the flood/ stormwater management measures is presented in Section 7.4.

11.2.4 Monitoring

Monitoring and inspection of channels, containment berms, silt traps, culverts, pipelines, PCDs for signs of erosion, cracking, silting and blockages of inflows, to ensure the performance of the storm water infrastructure is recommended. Monitoring should be undertaken monthly during wet season and after storm events or as per the site management schedule.

11.3 ALTERATION OF NATURAL DRAINAGE PATTERNS AND FLOW

11.3.1 Description of impact

Natural drainage across the project area is via preferential flow paths (natural drainage line). Development of the mine infrastructure and associated SWMP measures, diversion of rivers can alter the hydrologic response of an area and, potentially, an entire watershed within which the project is proposed.

The development can remove beneficial vegetation and replace it with turf grass lawns and impervious roofs, driveways, parking lots, and roads, thereby reducing the site's pre-developed evapotranspiration and infiltration rates. Construction of the mine and its supporting infrastructure would reduce the runoff reporting downstream due to stormwater management measures and alter instream flow regimes. During the low flow season, flows in rivers downstream may receive little water than during the pre-development period as water that would have infiltrated, or runoff downstream might be intercepted and contained onsite. In wet season, rivers may experience high volumes of surface runoff because of the increased in impervious areas introducing un-natural/ foreign flows into receiving rivers. Intense rainfall storms may induce soil erosion causing sedimentation in downstream reaches of nearby rivers.

11.3.2 Impact assessment

CONSTRUCTION, OPERATION AND DECOMMISSIONING PHASE

Surface water run-off will be managed utilising engineered infrastructure, which is to be designed and constructed as required by legislation and specified in Section 7. When the stormwater management measures that attenuate surface runoff are constructed on site, clean stormwater will be diverted around the infrastructure, and it will alter the drainage flow. The runoff amount reporting downstream consequently would also be altered. A portion of rainfall during wet seasons will be in the waste rock dump and the pit, this is expected to occur beyond the life of the mine.

The alteration to drainage patterns will continue for the construction, operational and decommissioning phases. A summary of the impact is provided in Table 11-6.

Table 11-6: Impact Summary: Alteration of Natural Drainage Patterns and Flow (Construction and Operation)

Description of Impact		
Type of Impact	Direct	
Nature of Impact	Negative	
Phases	All	
Criteria	**Without Mitigation**	**With Mitigation**
Intensity	Severe change (Very high)	Moderate change (Medium)
Duration	Long-term (10 and 20 years	Long-term (10 and 20 years
Extent	Site	Site
Consequence	Medium	Low
Probability	Probable	Probable
Significance	**Medium**	**Low**
Degree to which impact can be reversed	*Irreversible as some of the rivers and catchments will be permanently altered. The WRD and pit would be present beyond the life of the mine.*	

Degree to which impact may cause irreplaceable loss of resources	*High as watercourses downstream maybe susceptible to erosion and sedimentation. Newly introduced flow regimes might favour and unfavour different aquatic life.*	
Degree to which impact can be avoided	*Low as mine infrastructure cannot be relocated.*	
Degree to which impact can be mitigated	*Medium as there are conceptually designed stormwater management structures. Some SWM infrastructure is designed to spill at specified frequency, this will help reduce drastic change in flow regimes that are too frequent.*	
Cumulative impact		
Nature of cumulative impacts	*Very unlikely as there are no other activities taking place close to the project site.*	
Rating of cumulative impacts	**Without Mitigation**	**With Mitigation**
	Low	**Very low**
Residual impact		
Residual impact discussion	*The residual impact is considered moderate after implementation of mitigations*	

11.3.3 Mitigation

- In order to minimise the alteration of flow, clean water around the mine infrastructure must be diverted and be allowed to get back natural flowpaths into the environment.
- There are no other mitigation measures to minimize the flow and alteration of drainage paths.

11.4 CUMULATIVE IMPACTS

11.4.1 Description of impact

The environmental aspects that have been assessed cumulatively in this section includes

- Water quality
- Water quantity

11.4.1.1Water Quality

A significantly large area of the Mhlatuze catchment is under irrigated crops, predominantly sugarcane and citrus, which is found along the Mhlathuze River downstream of the Goedertrouw Dam (DWAF,2004). The other key activities in the catchment are cattle and subsistence farming. These are major users of water in the catchment. Mining is limited to the coastal dunes primarily in the vicinity of Richards Bay where Titanium and other heavy metals are extracted from the dune sands.

The water quality problems which do arise are from irrigation in the middle reaches of the catchment (Mhlathuze Water, 2004). Irrigation return flows from the substantial irrigation activities in the middle reaches of the catchment (where the proposed mine located) do certainly reduce the water quality.

Water quality results from sampling done by SLR in May 2014, indicated exceedances in Aluminium (Al), Copper (Cu), Mercury (Hg), pH, Electrical Conductivity (EC) Total Cyanide (CN) in all six sampling points when compared to the Aquatic Ecosystems Guidelines and DWS Database. These exceedances are likely associated with agricultural activities, where there is diffuse of pesticides from irrigated crops.

It is of importance to develop a monitoring program and continue to monitor the cumulative impact of the proposed mine on surface water resources. Cumulative impact on water quality due to the proposed mine project is assessed to be low as clean and dirty water catchments will be separated as outlined in section 7 minimizing contamination of surface water.

The cumulative impact due to the proposed TSF will be investigated and reported separately.

11.4.1.2Water Quantity

As mentioned in the preceding sections, the Mhlatuze catchment is under irrigated crops predominantly sugarcane and citrus. These water usersmostly receive water from Goedertouw Dam. The cumulative impact on the quantity of water available from Goedertrouw Dam and the downstream catchments due to the proposed mine is of importance to be assessed.

The infrastructure proposed within the Mining Right Area (the WRD, South East Pit and Power Yard) all fall within quaternary catchment W12D, is lying to the east outside of the catchment area of the Goedertrouw Dam. The proposed development will therefore not impact on the inflow into Goedertrouw Dam.

The mentioned infrastructure falls in the W12D QC. The gross catchment area of the W12D catchment is 569 km^2. The total area occupied by the infrastructure where dirty water will emanate from (dirty catchment) is 5.72km^2. This translates to a 1% loss in the gross catchment area due to the proposed development. The cumulative impact on runoff reduction from the catchment is assessed to be low because of the small percentage of area lost relative the overall size of the W12D QC.

11.4.2 Water management

The project's water circuit and the water management strategy need to be defined. The reuse of process water will be prioritised, thereby ideally reducing the impacts from the project on the surface water resources. The site wide water balance should be conducted and refined on an on-going basis with the input of actual flow volumes and then used as a decision-making tool for water management.

Water Conservation and Water Demand Management (WC/WDM) measures are essential and necessary for this project to ensure that water is collected and reused within the mine to reduce the need for make-up water. A mine water balance needs to be updated as per Best Practice Guideline 2 (BPG 2). This will aid in defining and driving the mine's water management strategies.

11.5 MONITORING MEASURES AND PLAN

A monitoring programme is an essential tool to identify any risks of potential impacts as they arise and to assist in impact management plans. A surface water quality monitoring plan is proposed for the proposed mine. The water quality must be compared against DWS water quality guidelines for irrigation, aquatic ecosystems, livestock watering and drinking water standards (SANS 241) to assess the water quality status. The minimum suite for water quality monitoring is provided in Table 11-7.

The location and description of the surface water monitoring points are presented in Table 4-1 as well as in Figure 4 1. Surface water levels may also be monitored in the same location as water quality. The monitoring plan should be reviewed periodically to ensure the appropriateness of sites and sampling frequency.

Table 11-7: Surface Water Quality Analytical Suite

Parameters	
pH	Nitrate as N
Electrical conductivity	Ammonia
Total dissolved solids	Potassium
Total suspended solids	*E.coli*

Parameters	
Aluminium	Manganese
Calcium	Magnesium
Fluoride as F	Iron
Total alkalinity as $CaCO_3$	Copper
Chloride as Cl	Lead
Sulphate as SO_4	Sodium

Table 11-8: Proposed Monitoring Plan for Surface Water Resources

Description	Monitoring Location	Frequency of sampling	Frequency of Reporting	Applicable phase of Project	Responsible Party for Implementation / Monitoring/Audit
Flooding Impact					
Inspection of flooding of for infrastructure and land areas prone to flooding must be undertaken. Especially with the increased impervious areas, during an intense event flood water is likely to pond affecting areas that were not found to be inside the 1:100-year flood line.	-Road Crossings -Flood protection/stormwater infrastructure -Workshop/office areas -Areas around the WRD, pit and plant.	After heavy storms and during all rainfall storms during the wet season.	After every heavy storm.	All Phases of project	Environmental Compliance Officer (ECO) and or Resident Engineer (RE)
Surface Water Quality					
Monitoring of water quality upstream and downstream of the proposed mine.	Location of monitoring point are provided in Table 4-1. Additional monitoring points and location can be established during the first monitoring.	Motoring should be undertaken quarterly.	Reporting should be undertaken after each sampling event.	All Phases of project	ECO/RE
Soil Erosion and Sedimentation					
Soil erosion and sedimentation monitoring in all soil erosion potential sources	Cleared and compacted areas where the infrastructure will be built. The downstream areas of road crossings.	Monitoring of erosion should occur during construction after every rainstorm or flood event, and during the operational phase monthly during first the wet season or during routine maintenance inspections, as applicable.	After every major rainstorm / flood. Monthly monitoring report compiled by the appointed ECO during the construction phase.	All phases of project	ECO/RE

Description	Monitoring Location	Frequency of sampling	Frequency of Reporting	Applicable phase of Project	Responsible Party for Implementation / Monitoring/Audit
Leakage/ spill events					
A leak and spill management plan must be formulated to monitor and detect as soon as possible. Site walkovers to determine the condition of facilities and identify any leaks or overflows, blockages, overflows, and system malfunctions for immediate remedial actions.	Roads and areas where vehicles commute and areas where chemical storage containers are located and workshop areas.	Identification of any leakage events should occur monthly during the operation and construction phase, or directly after a leakage has been detected and for the operational phase, during maintenance activities .	Monthly monitoring report compiled by the appointed ECO during the construction, operational and closure phases; and Report should be compiled for three phases of the project.	All phases of project	ECO/RE
	Areas where leakage is visible/detected.			All phases of project	ECO/RE
Infrastructure Monitoring					
Inspection of the SWM measures, channels/ diversions, and road crossing for signs of erosion, cracking and silting to ensure the performance of these are as still as intended.	All proposed infrastructure	Daily during maintenance	Daily. Should erosion occur, measures should be reinstated.	All phases of project	ECO/RE

12.CONCLUSION AND RECOMMENDATIONS

This surface water study was undertaken by a suitably qualified and independent Hydrologist to comply with the NEMA regulations requirements. A summary of the NEMA regulations requirements for technical specialist studies and cross references to the relevant supporting information is presented in Appendix B.

A SWMP has been developed to ensure compliance with the requirements of GN 704 where dirty water runoff will be diverted and discharged into lined conveyance and storage facilities. As part of the detailed design process, it is recommended that a waste classification, groundwater study and geotechnical investigation be undertaken in order to inform the lining details of conveyance and storage facilities during detailed design phases.

Baseline water quality assessment has been undertaken by SLR. Six surface water quality samples were collected. Eight water monitoring points were also obtained from the DWS water quality database. The DWA Water quality guidelines for irrigation, aquatic ecosystems, livestock watering and drinking water standards (SANS 241) were used to assess the water quality status. The water quality results were mostly within the water guidelines range except for a few exceedances. It is further recommended that monitoring be undertaken frequently. The minimum suite for water quality monitoring is presented in Table 11-7.

The proximity of the proposed development to the Goedertrouw Dam and neighbouring agricultural land has raised concerns from water users in the area. The proposed development will not impact on the runoff into Goedertrouw Dam due to difference in spatial location of the dam and the proposed mine infrastructure. The infrastructure proposed within the Mining Right Area (the WRD, South East Pit and Power Yard) all fall within quaternary catchment W12D. The dam receives runoff from both W12A and W12B quaternary catchments and located in W12B. The overall runoff reduction from W12D quaternary catchments due to the catchment loss to mine and SWM dirty catchments is assessed to be LOW. Dirty catchments take 1% of the gross catchment area of W12D (569km^2). Should there be a need to request additional water for mine operational processes from Goedertrouw and Tugela River, necessary applications and abstraction assessment are recommended, at this stage the need, quantities and how the abstractions will work are not yet fully established. It is further recommended that such abstraction activities, should they be realised, form part of the mine's surface water monitoring program.

In addition to this, the localised runoff impact due to the proposed development on catchments just immediately downstream of the development, referred to as 'Point A" in Section 10, is expected to be very low. This is due to small ratio (<3.3%) of the dirty water catchments (from the proposed development) to total catchment area at "Point A".

A site wide water balance based on the defined water circuit is recommended. A water management strategy is also recommended where the reuse of process water will be prioritised, thereby ideally reducing the impacts from the project on the surface water resources as well as estimating the mine's water demand.

Flood lines for the 1:100-year recurrence intervals were determined for the project site. Mine infrastructure was found to be within the floodlines as detailed in Section 6.5. However, with the implementation of mitigation measures which includes diversion of rivers around the proposed infrastructure is recommended to allow for the mine development to take place with minimal impact to the receiving environment. Cumulative impacts on water quality and quality were also assessed to be LOW. Cumulative impact due to the proposed TSF will have not been considered in the study, it will be assessed in the potential upcoming TSF stud(ies).

Informed by the mine plan layout, baseline hydrology, design specifications for the storm water management measures and the flood lines the potential impacts of the proposed activities on surface water receptors, as well as the sensitivity of the surface water resources, along with a summary of mitigation measures were conducted. They are presented in detail from Section 11.1 to 11.3.

A monitoring programme is an essential tool to identify any risks of potential impacts as they arise and to assist in impact management plans by assessing if mitigation measures are operating effectively. Monitoring should be implemented throughout the life of the mine. A proposed monitoring plan is shown in Table 11-8.

The outcomes of the baseline assessments, flood lines modelling, and storm water management should be implemented in the design of the mine and associated infrastructure. Subject to the implementation of the flood protection measures, aiming at reducing the spatial extent of a 1:100-year flood footprint the recommendations proposed herein, it is concluded that the activities should be authorised.

All measures implemented for the mitigation of impacts, should be regularly reviewed against best practice guidelines and to achieve compliance with the various licences issued on site by the authorities (DWS). The project can continue if all mitigation and monitoring measures are implemented as recommended.

13.REFERENCES

DWAF. (2004). Internal Strategic Perspective: Usuthu to Mhlathuze Water Management Area Version 1: March 2004, South Africa: Department of Water Affairs and Forestry.

DWAF. (2006c). Best Practice Guideline G2: Water and Salt Balances. Pretoria, South Africa: Department of Water Affairs and Forestry.

South Africa. (1998). General Notice 704 of the National Water Act (36 of 1998). Pretoria: Department of Water and Forestry.

Ward. (2022). Report on water requirements for Jindal mine for use by Jindal and stakeholders, April 2022, Norman Ward.

WRC. (1990). Water Resources of South Africa 1990 - Volume 1 Appendices. WRC Report 298/1.1/9

WRC. (2021). Water Resources of South Africa, 2012 Study (WR2012). http://waterresourceswr2012.co.za/.

Government Notice No.704 (GN704). GG20119. 4 June 1999. National Water Act, 1998 (Act No. 36 of 1998). Regulations on Use of Water for Mining and Related Activities.

SANRAL. (2006). Drainage Manual. Pretoria.

SANRAL. (2013). Drainage Manual. 6th Edition Application Guide. Pretoria.

The South African Atlas of Climatology and Agro hydrology (WRC, 2008) General land cover

APPENDIX A: 1:50 YEAR FLOOD PEAKS

Catchments	1:50-year Flood Peaks					
	RM	RM3	UH	SDF	MIPI	SCS
S1	734.7	1282.1	602.1	2372.4	836.9	1431.3
S2	730.6	1275.4	597.8	2365.3	833.1	1410.4
S3	7.4	13.5	5.0	32.1	15.1	4.2
S4	1.4	3.2	0.2	7.7	3.9	0.8
S5	7.1	14.7	1.9	34.8	15.6	6.7
S6	110.7	169.1	81.0	403.7	123.4	120.2
S7	105.5	159.0	81.6	379.6	122.1	117.8
S8	2.7	4.8	1.7	11.4	8.1	2.1
S9	11.8	21.6	6.7	50.0	22.7	8.0
S10	96.0	154.4	75.7	357.7	104.0	93.4
S11	23.1	44.7	12.7	103.6	32.8	16.9
S12	104.9	176.6	71.0	409.1	97.5	93.0
S13	81.8	134.9	52.6	312.6	95.3	73.9
S14	6.5	13.6	1.6	31.6	13.6	4.3
S16	14.2	26.3	9.0	61.7	61.8	10.4
S18	0.3	0.5	0.0	1.1	1.9	4.4
S19	3.6	7.9	0.1	18.6	10.4	2.5
S20	4.8	9.6	1.8	22.8	10.0	3.5
S21	4.3	9.6	0.3	23.0	11.0	1.3
S24	6.9	14.9	1.4	30.9	12.6	4.4
S25	2.8	6.6	0.1	13.6	7.2	1.9
S26	159.1	281.0	126.9	592.0	137.0	118.0
S27	0.3	0.8	0.0	1.6	1.6	0.3
S29	15.5	34.4	2.6	70.3	23.5	9.7
S30	13.2	25.6	5.6	52.3	19.6	8.5
S31	160.5	296.3	151.6	605.7	141.9	116.5
S32	41.0	61.5	50.0	133.1	69.7	51.6
S33	43.5	66.5	46.6	144.0	69.4	48.4
S34	58.0	93.8	47.0	203.1	67.4	49.5
S35	14.9	33.1	2.0	69.8	25.0	6.3

Catchments	1:50-year Flood Peaks					
	RM	RM3	UH	SDF	MIPI	SCS
S36	0.3	0.7	0.0	1.5	1.8	0.3
S37	0.3	0.7	0.0	1.5	1.8	0.3
S38	9.8	14.5	7.8	31.4	18.1	120.2
S01	22.4	27.7	7.8	64.1	22.5	6.5
S02	11.1	13.9	3.2	32.1	13.2	4.1
Kwasengeni 1	177.7	203.0	175.1	470.4	125.1	106.9
Kwasengeni 2	173.7	197.4	145.1	457.4	124.4	99.9
Kwasengeni 3	167.6	191.3	144.0	443.1	118.9	109.6

APPENDIX B: SUMMARY OF EIA REGULATIONS (2014), AS AMMENDED IN 2017, APPENDIX 6

A specialist report prepared in terms of the Environmental Impact Regulations of 2014 (as amended in 2017) must contain:	Relevant section in report
Details of the specialist who prepared the report	Appendix C: TECHNICAL SPECIALIST CV
The expertise of that person to compile a specialist report including a curriculum vitae	Appendix C: TECHNICAL SPECIALIST CV
A declaration that the person is independent in a form as may be specified by the competent authority	Appendix D: DECLARATION OF INDEPENDENCE
An indication of the scope of, and the purpose for which, the report was prepared	Section 1.2
An indication of the quality and age of base data used for the specialist report;	Section 3.1 and Section 4
A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change	Section 4 and Section 8
The duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment	Section 3
A description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used;	Numerous methodologies discussed throughout the report
Details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternative;	Baseline hydrological conditions are discussed in Section 3
An identification of any areas to be avoided, including buffers	Floodline results and buffers are discussed in Section 0
A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Figure 6-1 and Figure 7-3
A description of any assumptions made and any uncertainties or gaps in knowledge;	As described in Section 6.4, Section 8.4
A description of the findings and potential implications of such findings on the impact of the proposed activity or activities	Alternatives are discussed within EIA study
Any mitigation measures for inclusion in the EMPr	Section 0, Section 7 and Section 8
Any conditions for inclusion in the environmental authorisation	-
Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Section 8
A reasoned opinion as to whether the proposed activity or portions thereof should be authorised	Section 8
Regarding the acceptability of the proposed activity or activities; and	Section 8

A specialist report prepared in terms of the Environmental Impact Regulations of 2014 (as amended in 2017) must contain:	Relevant section in report
If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan	Various recommendations are made throughout the report, most notably Sections 0, 7 and 8
A description of any consultation process that was undertaken during the course of carrying out the study	N/A
A summary and copies if any comments that were received during any consultation process	N/A
Any other information requested by the competent authority.	N/A

APPENDIX C: TECHNICAL SPECIALIST CV

MEERESSA PILLAY, PR ENG

Technical Discipline Manager | Water and Wastewater Engineering | Johannesburg, South Africa

Meeressa is a Principal Engineer with over 18 years of experience in various civil engineering projects, primarily related to water resource engineering, dam engineering, water law and civils infrastructure.

Meeressa has experience in the various engineering project stages, such as conceptualisation, design, tender document preparation, construction monitoring and contract and construction management.

Since joining SLR in 2019, Meeressa has gained experience in mine waste engineering and in particular the monitoring of tailings storage facilities and the design of pollution control dams.

Meeressa worked for the Department of Water Affairs and Forestry between 2004 and 2008 and continued working on projects related to water use authorisations thereafter. Her experience allows her to provide specialized insight into water management planning and design with the knowledge of permitting requirements.

Education

- Approved Professional Person, Department of Water and Sanitation (DWS) (2018)
- Professional Engineer, Engineering Council of South Africa (ECSA) (2016)
- BSc Eng (Civil), University of KwaZulu-Natal (UKZN) (2003)

Project Experience

Construction management of tailings storage facility expansion for a gold mine in the Southern Region, Ghana, (2021-Ongoing)**
Project manager, management of on-site construction quality assurance staff.

Detailed design of a tailings storage facility for a gold mine in the Southern Region, Ghana, (2021-2022)
Project manager, Deputy Engineer of Record, Design of 115Mt TSF expansion. Construction management of TSF expansion.

Detailed design of stormwater management infrastructure within mining areas in South Africa, (2020-Ongoing)
In the role as project manager, reviewer, and design engineer. Scope included conceptual design feasibility and options analysis, detailed design and tender document preparation for conveyance infrastructure and storage infrastructure i.e., Pollution Control Dams. Development of stormwater management plans, impact assessment and advisory input on permit applications.

Monitoring of a tailings storage facility and water storage facilities for a gold mine in the Southern Region, Ghana, (2020-Ongoing)
Project manager, monthly monitoring of TSF, dam safety reviews of water storage dams.

Feasibility Study for the expansion of a tailings storage facility for a gold mine in the Southern Region, Ghana, (2020-2021)
Project manager, Deputy Engineer of Record. Feasibility study for 131Mt TSF expansion.

Options analysis for the expansion of a tailings storage facility for a gold mine in the Southern Region, Ghana, (2019-2020)
Project manager, site selection, options analysis, conceptual design.

Several dam safety evaluations in KwaZulu-Natal, South Africa, (2017-2019)
Project leader, visual assessment, survey, flood determinations and overall evaluation.

Design of civils infrastructure in Northern Region of KwaZulu-Natal, South Africa, (2014-2019)
Project leader, project management, design, contract documentation, construction supervision and management, site staff management.

Design of Category 2 earthfill embankment in KwaZulu-Natal, South Africa, (2013-2014)
Project leader, design, and document preparation.

Several feasibility studies for regional bulk water supply dams, South Africa, (2013-2014)
Site selection, options analysis, conceptual design.

Category 3 rockfill dam in Eastern Cape, South Africa, (2013-2014)
Contract management, construction monitoring and preparation of operation and maintenance manual.

Category 3 rockfill dam in Eastern Cape, South Africa, (2011-2013)
Construction monitoring as Assistant Resident Engineer.

Design of civils infrastructure in KwaZulu-Natal, South Africa, (2008-2011)
Design of water reticulation systems, inlet and outlet works of dams, roads, storm water infrastructure and bulk earthworks.

Water availability and feasibility studies for agricultural schemes in KwaZulu-Natal, South Africa, (2008-2011)
Design of water reticulation systems, inlet and outlet works of dams, roads, storm water infrastructure and bulk earthworks.

Numerous water use licence applications, South Africa, (2004-2011)
Assessment against requirements of the South African National Water Act (Act No. 36 of 1998), hydrological analysis and water balance modelling.

Memberships and Associations

- South African Institution of Civil Engineering (SAICE)

MERCY NYIRENDA

Senior Water Engineer | Water and Wastewater Engineering | Johannesburg, South Africa

Mercy currently specializes as a civil engineer in the water and wastewater infrastructure sector. This includes design, analysis and administration of bulk, residential and sanitation works projects throughout Africa for municipalities and private clients. Mercy has six years of experience in this role and her key technical experience has included conducting potable, stormwater and wastewater hydraulic designs, models, planning, administration, construction monitoring and reporting.

Education

- BSc (Eng.) Civil Engineering , University of the Witwatersrand (2015)
- MSc (Eng.) Civil Engineering, Optimization of Water Distribution Networks, University of the Witwatersrand (Current)

Project Experience

South 32 Mamatwan Conceptual Stormwater Management Plan, SLR (2022)
Mamatwan Mine situated in the northern Cape required a stormwater management plan to align with the requirements of the National Water Act (36 of 1998). The scope of work required dynamic modelling of the mining site which was conducted Mercy. Subsequent reporting, design and management of the project was completed by Mercy as well.

Osino Resources – Namibia, SLR (2022)
The client required a conceptual design of a sand storage dam to abstract 1 million metres cubed per annum for the semi-arid region in the Twin Hills area of Namibia for prospective mining rights. The conceptual design was completed by Mercy with reference to national regulations.

Northam Platinum Mine Ltd. – Eland Mine - Limpopo, South Africa, SLR (2021)
The client required an audit with reference to Government Regulation GN704 as part of the National Water Act (36 of 1998). The audit and reporting were conducted by Mercy. This included project management as well.

Northam Platinum Mine Ltd. – Zondereinde Operations - Mpumalanga, South Africa, SLR (2021)
This project dealt with the detailed design of stormwater management infrastructure as detailed by the previously completed conceptual stormwater management plan. The multi-disciplinary project included a static site wide water balance, design of stormwater channels, assessment of the two dam structures, geotechnical and geochemical assessments. Mercy was involved as project manager and design engineer.

AngloGold Iduapriem Mine Feasibility Study – Tarkwa, Ghana, Jones and Wagener (2020)**
As part of the large-scale project which included the design of a tailings storage facility and return water dam for the remaining life of mine, Mercy participated in the design of the pumping infrastructure. This included among others the tailings storage facility decant pump station and multi-phase delivery pipelines.

Sedibeng Regional Sanitation scheme - Gauteng, South Africa, GIBB Engineering and Architecture (2018-2020)**

The Sedibeng Regional Scheme consisted of various projects for the Sedibeng municipality, however, this portion of the work involved upgrading two of the biggest wastewater treatment works in the South of Johannesburg, Gauteng. Mercy was involved in designing the various pumping stations and process structures such as the digestors, conveyance channels etc.

CDC Schools - Eastern Cape, South Africa, GIBB Engineering and Architecture (2016)**

The CDC Schools project consisted of upgrading several informal schools in the rural Eastern Cape area. Mercy designed the water, sewer and fire networks as required by the scope of works.

Memberships and Associations

- Candidate Engineer, Engineering Council of South Africa (ECSA) (2016 – present)
- Associate member, South African Institute of Civil Engineering (SAICE) (2015 – present)

Publications

- Nyirenda, M. S., & Tanyimboh, T. T. (2020). Appraisal of water quality indices for service reservoirs. Water Science and Technology, 81(8), 1606-1614.

Amelia Basson, MIEAust CPEng NER
Principal Engineer | Water Resources | Johannesburg, South Africa

Amelia has over 16 years' experience in the field of environmental and water resources engineering. She has worked on projects ranging from water management planning and flow monitoring investigations, surface water assessments and modelling to more general water infrastructure design projects such as water supply and bulk water distribution.

Amelia has spent several years developing and applying stochastic water reticulation and hydrological simulation models for industrial and mining site. These were applied to identify and quantify risks related to water management practices, as well as optimise water infrastructure planning and sizing.

Recently Amelia spent time working on projects supporting Sydney Water's expansion and planning for the Western Sydney growth areas, through which she has gained extensive experience in urban water management and planning. She leads projects within the peri-urban landscape looking at impacts of development on the local receiving environment.

Amelia can apply her broader water resources skills alongside her industrial and urban water management knowledge to assist in developing integrated catchment wide water planning solutions.

Education

- MEng (Environmental and Water Resource Systems Engineering), Cornell University, Ithaca, New York, USA (2011)
- BEng (Hons) (Environmental), University of Pretoria, Pretoria, South Africa (2008)
- BEng (Mechanical), University of Pretoria, Pretoria, South Africa (2006)

Project Experience

Industrial/Mining Water Planning and Management

Hail Creek Major EA Amendment SW Impact Assessment, Glencore, Qld, Australia (2022-ongoing)
Water Engineer and Modeller – Reviewed and documented the existing Capcoal Water Management infrastructure and systems based on the latest OPSIM model. Modelled the Lakes Lindsay pit, water management infrastructure and local catchment in GoldSim to assess and inform the current operating procedures and quantify the associated risks. The results of the modelling were also used to assess the expected changes that will be brought about by the extension project. All results were documented and incorporated in the overarching surface water impact assessment.

Surface Water Engineer and Water Balance Modeller – Currently leading the team responsible for delivering the surface water studies and impact assessment required to support an application for a major EA Amendment at the Hail Creek Mine site. The works are considering a proposed expansion of the mine footprint and extension of the mine life.

Commodore Mine Extension EA Amendment, Intergen, Queensland, Australia (2022)
Surface Water Lead & Modeller - Lead and guided the team developing the Surface Water technical study report for the EA Amendment application associated with the proposed mine life extension. This included defining the existing surface water environment, the potential impacts to this environment due to the proposed extension as well as defining and quantifying appropriate mitigation measures. To support this a site-wide water balance model was developed to compare the existing approved footprint's impacts to the proposed

extension as well as predict the water volumes and qualities that may accumulate and require management on site for the remining LOM.

Oaky Creek Mine PRCP – Final Void Study, Glencore, Queensland, Australia (2022-2023)
Completed the Final Void water modelling and interpretation required to support the preparation of the Oaky Creek Coal Mine (OCC) Progressive Rehabilitation and Closure Plan (PRCP). This included consideration of long-term surface water groundwater interactions, potential climate change and predicted water quality trends.

Lake Lindsay Extension Project, Anglo American MC, QLD, Australia (2020-2021) **
Water Engineer and Modeller – Reviewed and documented the existing Capcoal Water Management infrastructure and systems based on the latest OPSIM model. Modelled the Lakes Lindsay pit, water management infrastructure and local catchment in GoldSim to assess and inform the current operating procedures and quantify the associated risks. The results of the modelling were also used to assess the expected changes that will be brought about by the extension project. All results were documented and incorporated in the overarching surface water impact assessment.

PFAS Mass Flux Study, Confidential site, Department of Defence, NSW, Australia (2021-2022) **
Surface Water Engineer – Developed a surface water monitoring program which included continuous and event-based auto-sampling to characterise the PFAS concentrations and flow relationships for surface water discharged from the site. Incorporated a hydrological model (using eWater MUSIC) to estimate long-term average, wet and dry runoff volumes and subsequently PFAS mass discharging from the site. The findings of the study are being used to inform remediation and treatment planning.

Batu Hijau Phase 8 Water management, PT Amman Mineral Nusa Tenggara, Sumbawa, Indonesia (2019-2020) **
Water Engineer – Reviewed and updated the existing GoldSim water reticulation simulation model to assess the current risks associated with the site wide water management infrastructure, controls and protocols. The model was then used to assess the impact of proposed system changes, such as raising the dam wall, to define the feasible options resulting in the highest risk reduction as the mine expands.

SACE Coal Fields Water Management Plans, AngloAmerican PLC, Mpumalanga, South Africa (2017-2019) **
Assessed the current water risks for six mine sites located within the SACE Coal Fields – specifically related to potential excess and shortfalls, quantified these risks and develop solutions to minimise them. The results of the analyses were then used to develop water managements for the individual collieries. In addition to this the potential volume of excess water available over the life of the mines and post closure was determined, identifying the full potential range based on the local historic climate records. The models, developed in GoldSim, were then applied to test future scenarios (related to changes in mine plans, infrastructure, operations management) and to feed into the planning for ongoing operations as well as closure.

Morwell Water Balance and PFAS Load Flux Study, Morwell, Energy Brix Australia (2019) **
Water Modeller – Estimated the relative contribution of site derived stormwater runoff/discharge and PFAS load to the local Creek and compared this against ambient concentrations from offsite lateral and upgradient sources. This involved site specific monitoring, including surface and groundwater levels, flowrates, grab water sample collection and passive water sample collection to determine average site contributions over the monitoring period. She then analysed the collected data and developed flow and load

contribution diagrams, followed by a long-term hydrological simulation model using eWater Source which she calibrated to the short-term flow records. The study assisted with improving the understanding of the local hydrogeological regime and quantified the contributions form the potential PFAS load sources.

Olympic Dam – Liquor Balance Model Review, BHP, SA, Australia (2019) **
Water Engineer – Independent internal review of the GoldSim liquor balance model used to simulate liquid transfers between the TSFs and the Evaporation Ponds.

North Goonyella Coal Mine, Water Balance Expansion, Peabody, SA, Australia (2019) **
Water Modeller - Expanded the existing GoldSim model to detail the underground dewater strategy and allow for the simulation of the resulting surface water reticulation changes.

Arnot Closed Colliery Water Management Plan, Seriti Resources, Mpumalanga, South Africa (2017-2018) **
Surface Water Engineer – Two opencast pits were previously mined, with closure works commencing in 1992. The pits were than backfilled and rehabilitated. Several voids and dams still exist within the old backfilled spoils. A stochastic water and salt balance model was developed of the system and recharge and salt generation rates calibrated using the available monitoring data. The model was then applied to inform and assess future management options including planning and sizing for treatment in the long run.

McCain SA Stormwater Management, McCain, Delmas, South Africa (2014-2016) **
Water Engineer – Assessed the storm water practices and infrastructure on site to ensure the separation of dirty and clean water and reduce the volume of impacted water discharged off site. Developed a PCSWMM model to determine the adequacy of the storm water conveyance structures.

KOSH Mining Complex Post Closure Flooding Model and Animation, Anglo Gold Ashanti, North-West, South Africa (2015-2016) **
Mine Water Modeller – In order to provide a coherent and credible conceptual understanding of mine water generation, migration and decant in the interconnected KOSH mining area, AGA and Village Main requested the development of a conceptual, post mining model to reflect the probable mine water recharge, migration and potential decant to surface. Venmyn Deloitte acted in an oversight and peer review capacity. A simulation model was developed using the available mine plan geometry (digitised from mine plans almost 100 years old) along with available geological information providing indicative recharge rates which could then be calibrated based on the available dewatering pumping records. The results of the simulation model were transferred to a digital animation platform to enable the visualisation of the flooding of the underground workings post closure.

South Deep In-Rush Modelling, North-West, South Africa (2017) **
Simulated the proposed re-watering of an adjacent mine and the resultant stresses on the underground plugs. Assessed the in-rush potential given various failure mechanisms of the plugs and determined the evacuation times available for such events.

Water Balance Modelling, Multiple Sites (2013-2019) **
Development of water balance simulation models to determine water make and assess risks related to water management. Developed these as interactive reporting and analysis tools to be used by client personnel. Clients included: AngloCoal, AngloPlat, AngloGold, Debswana, De Beers, Boss Mining, Exxaro, Foskor, Glencore, First Quantum Minerals, South32. Sites included: Kansanshi Copper Mine, New Vaal Colliery, Khutala Colliery, Greenside Mining Complex, Bokgoni, Mafube Mining, Amandelbult Platinum Mine, Vaal Ops Gold Mining Operations, Jwaneng Diamond Mine, OLDM Diamond Mines, Venetia Diamond Mine.

**Denotes experience completed at another firm

Recycled Water Re-Use

South Creek Re-Use Capability Assessment, Sydney Water, NSW, Australia (2019-2020) **
Water Resources Specialist and Modeller – Assessed and quantified the irrigation potential for water re-use for irrigation purposes within the proposed Sydney expansion areas. By using available geo-spatial data, the entire study area was categorised based on soil and hydrogeological landscape suitability for irrigation. Local soil and climate data were then used as input to MEDLI models to quantify the potential irrigation capacity throughout the study area. Following the Phase 1 desktop assessment and modelling, an in-field verification exercise was commissioned (currently ongoing). This includes continuous monitoring of groundwater levels, salinity and temperature, as well as the soil moisture content and salinity levels within the first 1m depth at various monitoring sites across the study area. As project manager, Amelia provided day to day management and coordination of contamination, groundwater, salinity and land use planning.

Picton WWTP Expansion IA, Sydney Water, Sydney, Australia (2020) **
Processing and analysing the scenario outputs from an eWater Source model of the Picton Water Recycling Plant, irrigated farm and receiving waterways. The ultimate results included consideration of how much irrigated land would be required to achieve the current EPL requirements, optimal sizing of the associated infrastructure (dams, pumps stations etc.), what would be the expected resultant range of in-stream concentrations as well as frequency and magnitude of expected discharge.

Stormwater Optimisation and Re-Use PFS: Samancor Metalloys, Gauteng, South Africa (2013-2014) **
Constructed and interpreted a stochastic dynamic site wide water balance to assess the potential for re-use of stormwater runoff and reduce the contamination load flowing to the onsite attenuation dam. Basic cost analyses were done to compare different storage and re-use options. Provided recommendations on operational interventions/approaches to limit off site discharge of contaminated runoff.

Bingara Gorge EPL, Water Balance Update, Lendlease, NSW, Australia (2019) **
Water Resources Specialist – Revised the system water balance by determining the local irrigation demand and the potential for recycled water application. Determined the probability of exceed the EPL license requirements related to annual discharge limitations from the recycled water system.

Water Resources / Catchment Management

Olifants River Catchment, DWS, South Africa (2016-2017) **
Surface Water Modeller – Assisted with the development of tools for the South African Department of Water and Sanitation (DWS) to identify critical management units/catchments to focus remediation and regulatory enforcement and so doing ensure the most efficient course of improving the downstream water quality within the catchment.

Liebenbergsvlei SW and GW Interaction Study Mpumalanga, DWS, South Africa (2015-2019) **
Surface Water Engineer – studied the surface and groundwater interaction within the Liebenbergsvlei to determine potential pathways for migrating contaminants.

Hydrology

Hammond Reef Gold Project Water Budget, Osisko Mining Corporation, Northern Ontario, Canada (2013) **
Water Resources Specialist – developed monthly water budget for Marmion Lake, applied the Thornthwaite model to estimate local runoff depths and calculate associated inflow and discharge for the lake. The model was calibrated using actual measured data.

**Denotes experience completed at another firm

Moatize WRD Unsaturated Flow, Vale, Mozambique (2013) **
Developed a 2D unsaturated flow model of the waste rock dump to determine the effectiveness of the proposed base preparation and the sizing of the underdrain system.

Environmental Impact Assessment – Surface Water

Picton WRP LVA Geomorphology and Hydrology REF, Sydney Water, NSW, Australia (2020-2021) **
Surface Water Specialist – To support a Licence Variation Application to allow the Picton Water Recycling Plant (WRP) to increase its discharge to a local creek, an eco-hydraulic assessment was conducted. Following an aquatic ecology survey and the identification of current and potential fauna and flora species, key hydraulic threshold values were identified, such as stream flow velocities and depths. Hydraulic modelling, using the HECRAS platform, was conducted to estimate the change in probability of exceeding these threshold values under the proposed future conditions and subsequently what the impacts would be on the native species.

USC AWRC Surface Water Impact Assessment, Sydney Water, NSW, Australia (2020-2021) **
Surface Water Specialist – Reviewed and documented the current surface water conditions, using available monitoring data, and identified the potential hydrological/surface water impacts that may arise during construction and operations of the proposed project. The project was declared as State Significant Infrastructure and project specific Secretary's Environmental Assessment Requirements (SEARs) were issued. The assessments addressed the standard as well as the projects specific SEARs. Ensuring adherence to the relevant waterway values and objectives was paramount for this project.

Newcastle Power Station Surface Water and Groundwater Assessment, AGL Energy, NSW, Australia (2019) **
Water Specialist – Reviewed the current surface water and groundwater condition, using available monitoring data, and identified the potential hydrological/surface water quality/groundwater impacts that may arise during construction and operations of the proposed project. Assessment and interpretation of local groundwater levels were critical in determining the potential for intersection of interference. The project was declared as Critical State Significant Infrastructure and project specific Secretary's Environmental Assessment Requirements (SEARs) were issued, which were used to further guide the assessment.

Wallerawang Annual GW Reporting, Energy Australia, NSW, Australia (2019) **
Water Specialist – Documentation and assessment of the latest surface water and groundwater quality monitoring data and consideration of historical monitoring results to inform interpretation of trends related to groundwater and surface water resources around the Kerosene Vale Ash Repository (KVAR)

Cliffs Chromite Project, Northern Ontario, Canada (2011-2013) **
Project involved assessment of environmental impacts of proposed new chromite mine, 350 km all weather access road and ferrochrome processing facility. Contributions: Baseline hydrology studies including field investigations (flow monitoring, surveying of cross sections and WQ sample collection), climatology assessment, precipitation and flood frequency analyses and reporting. Environmental impact assessment (hydrology) specifically related to the mine site water balance. Analyses done using HEC-HMS and GoldSim software packages. Main interface environmental assessment (EA) team). Responsible for facilitating information transfer, managing review responsibilities of external documents, assessment, assessment of value engineering impacts on EA as well as document control and general project coordination relating to engineering interaction.

Water Infrastructure Sizing and Design

Westconnex Tunnel Water Treatment Wetland Sizing Review, CDSJV, NSW, Australia (2019) **
Water Specialist – Assessed the reference design wetland sizing using establishing wetland design methods. Consideration was given to the potential for achieving target reduction factors using the latest available water quality and flow estimates.

eMalahleni Mine Water Reclamation Scheme Expansion DFS, Mpumalanga, South Africa (2009-2010) **
Feasibility study for the expansion of the eMalahleni Water Reclamation Scheme. Responsible for the collection, transfer and distribution infrastructure design. Assisted with the water balance calculations as well as conceptualising and designing the infrastructure requirements for post mine closure water management.

Western Utilities Corporation, Acid Mine Drainage Management, Gauteng, South Africa (2009-2010) **
Part of design team for pre-feasibility, feasibility study and detailed design of mine water collection and distribution system. Specifically responsible for the Eastern Basin pipeline and pump station design, transporting acid mine drainage from abandoned mining shaft to treatment plan.

Viljoenskroon Wastewater Treatment Plant, Free State, South Africa (2008-2009) **
Performed status quo analysis on existing works and gap analysis regarding future/expansion requirements.

Memberships and Associations

- Engineers Australia: Chartered Professional Engineer – Civil; Environmental (6242625)
- Engineers Australia: National Engineering Register
- SAICE: Associate member (201400256)

**Denotes experience completed at another firm

MANKOE RALIENGOANE

Hydrologist | Water and Wastewater Engineering |
Johannesburg, South Africa

Mankoe holds an Honours Degree in Geography obtained from Rhodes University, South Africa. Mankoe has 3 years of experience, working as a Hydrological Consultant on projects in the mining and municipality sectors. Mankoe's work experience thus far includes floodline and riparian assessment studies, hydrological data analysis, estimation of design rainfall and flood peaks, impact assessments, static and dynamic water balances, water quality assessments, static and dynamic water balances. Compilation of synoptic hydrological and water quality assessment reports.

Education

- MSc Civil Engineering, University of the Witwatersrand (in progress)
- BSc (Hons) Geography, Rhodes University (2021)
- BSc Hydrology and Water Resources Management, Central University of Technology, Bloemfontein (2019)

Project Experience

NamWater, SLR (2023-ongoing)
SLR Environmental Consulting Namibia (Pty) Ltd (SLR) is appointed by Namibia Water Corporation Limited (NamWater) to undertake the Environmental and Social Impact Assessment (ESIA) and Environmental Social Management Plan (ESMP) for Supply Scenario 1 of the Desalination Plant and Water Carriage System to secure water to the Central Coast of Namibia.

Mankoe described the receiving environment and baseline conditions in the study area, identified the sensitive areas, assessed the potential impacts of the proposed project activities on the environment and is compiling an EIA.

Mphahlele, SLR (2023-ongoing)
SLR Environmental Consulting (Pty) Ltd (SLR) has been appointed by Tameng Mining and Exploration (Pty) Ltd to undertake a surface water specialist study to support a revised Environmental Impact Assessment (EIA) and Water Use Licence Application (WULA). The scope of work includes desktop study, baseline hydrology, surface water quality analysis, site visit, floodline assessment, impact assessment and mitigation measures.

Mankoe has undertook a desktop study to describe the receiving hydrological environment, reviewed the previous reports, aerial photos, topographical maps, satellite imageries of the site and determined the baseline hydrological.

QMSD Sudan, SLR (2023-ongoing)
SLR Consulting Limited (SLR), was retained by QMSD Mining Co Ltd (QMSD), a wholly owned subsidiary of Doha-based Qatar Mining (QM) to design an access road to Jebel Ohier Block 62 Copper/Gold Porphyry Project located in Red Sea State of the Republic Sudan (Sudan).

Mankoe has worked on catchment delineation and determined catchment parameters using ArcGIS. Sourced rainfall data and analyzed it and determined storm depths/design rainfall using general statistical spreadsheet models. Estimated design flood peaks.

Malingunde, SLR (2023)
Malingunde Graphite Project (Malingunde), owned by Sovereign, invited SLR to undertake a Dam Break Assessment (DBA) for the proposed Tailings Storage Facility (TSF) of the Sovereign Metals Limited (Sovereign) Malingunde Graphite Project located in Lilongwe District of the Central Administrative Region in Malawi.

Mankoe undertook catchment delineation and determined catchment parameters using ArcGIS. Calculated flood peaks in Utility Programs for Drainage and HydroCAD.

Ferney and Champagne Power Stations, SLR (2023-2023)
Aquarius Consulting invited SLR to undertake hydrological assessment for the water mobilisation, treatment, and pipework's downstream of Ferney and Champagne power stations in Mauritius.

Mankoe worked on rainfall data analysis. Determined average daily, monthly average rainfall, annual rainfalls, wettest and driest months. Calculated catchment parameter and catchments peak flows in HydroCAD.

Brakkenfontein, SLR (2022-ongoing)
Interwaste (Pty) Ltd Is planning to develop a waste management facility (WMF) in the Western Cape and has commissioned SLR to undertake a hydrological impact assessment study in support of the Scoping and Environmental Impact Assessment (S&EIA) for the project's Waste Management Licence and Water Use Licence applications for the proposed Wesco WMF.

Undertook catchment delineation and determined catchment parameters using ArcGIS, and calculated flood peaks.

Jindal TSF EIA & WULA, SLR (2022-ongoing)
SLR is providing the client with impact Assessment process for input into the Water Use Licence and Waste Management Licence Applications for the selected Tailings Storage Facilities. The project includes the hydrological characterisation - Calculating all storm events (1:10- to 1: 10 000-year and Probable Maximum Precipitation).

Mankoe worked on rainfall data analysis. Undertook catchment delineation and determined flood peaks. Also, conducted an impact assessment.

Karee, SLR (2022-2023)
Karee Tailings Dam Complex Dam Break Assessment

Mankoe worked on rainfall data analysis. undertook catchment delineation and determined catchment parameters using ArcGIS. Determined 1:50-year and 1:100-year floodlines using HEC-RAS and ArcGIS softwares and calculated flood peaks in Utility Programs for Drainage and HydroCAD.

Baobab, SLR (2022-2023)
SLR was commissioned in 2021 by Anglo American Platinum - Rustenburg Platinum Mines Limited (Mogalakwena Division) (AAP) to undertake a high-level water balance. The objective of the study was to develop a daily dynamic water balance.

Worked on desktop review of existing information, analysed rainfall and flow data for input into Goldsim software and facilitated in setting up Goldsim model.

La Mercy, SLR (2022-ongoing)
SLR Consulting has been commissioned by Tongaat Hulett Property to undertake hydrological assessment services to facilitate the development of the La Mercy Memorial Park in eThekwini Municipality in KwaZulu-Natal Province (KZN).

Worked on rainfall data analysis. undertook catchment delineation and determined catchment parameters using ArcGIS. Determined 1:50-year and 1:100-year floodlines using

HEC-RAS and ArcGIS softwares and calculated flood peaks in Utility Programs for Drainage and HydroCAD. Also, conducted impact assessment.

Northam Eland GN704 Audit (2022)
SLR was commissioned is commissioned to undertake an audit of the Eland and Maroelabult Mine with regards to the GN704.

Worked on rainfall data analysis. undertook catchment delineation and determined catchment parameters using ArcGIS. Determined 1:50-year and 1:100-year floodlines using HEC-RAS and ArcGIS softwares and calculated flood peaks in Utility Programs for Drainage and HydroCAD.

Compilation of a brief Hydrological Synoptic Report, AquaLinks (2021-2022) **
AquaLinks Research and Implementation (PTY) Ltd undertook the compilation of a brief synoptic report of the 2020-2021 seasonal (Annual) surface water hydrology of the Orange-Senqu River basin and the production of a template for annual reporting for the surface water hydrology committee for the Orange-Senqu River Commission (Botswana, Lesotho, Namibia, and South Africa).

Mankoe assisted with reviewing annual hydrological reports generated by each ORASECOM member state for their country's hydrological year report. Interviewing surface water hydrology committee members from each state (country) and compiled meeting minutes. Downloading monthly maps of precipitation, reference, and actual evapotranspiration for the 2020-2021 hydrological year from the Food and Agricultural Organization of the United Nations (FAO-WAPOR) website and creating maps in QGIS. Processing flow and reservoir and compiling graphs in Excel and interpreting those graphs for the draft surface water synoptic report. Assistance by reviewing and editing the draft template for annual reporting for the surface water hydrology committee.

Olifantspoort Weir Upgrade, SD Hydrological Services (2021) **
Working with design flood estimation spreadsheet model and distribution fit spreadsheet to calculate peak flows for the upgrade of the weir.

Ledig Electrification Project, SD Hydrological Services (2020) **
Foodline and Riparian Assessment Study.

Site visits and riparian vegetation assessment for flood line determination. Hydrological data analysis and baseline hydrological assessment. Working with design flood estimation spreadsheet model and distribution fit spreadsheet to calculate peak flows for the design of abstraction tower in the river.

Southern Protein Wastewater Risk Assessment, SD Hydrological Services (2020) **
Water quality assessment and production of a risk assessment report for Southern Proteins Wastewater Treatment.

Memberships and Associations

- Water Resources Science (Certificated Natural Scientist), South African Council for Natural Scientific Professions

Additional Training

- PCSWMM + EPA SWMM5 TRAINING WORKSHOP (2022)

NOMPUMELELO DUBE, Pr. Sci. Nat.

Associate Hydrologist | Water and Wastewater Engineering | Johannesburg, South Africa

Nompumelelo has 16 years of experience working in the private and public sectors. She has worked for the department of Water Affairs as a Hydrologist focusing on surface water monitoring and flood risk assessments. She worked for SRK Consulting working with a wide range of clients including property developers, municipalities and mines. Her focus areas during this time were stormwater master planning, flood lines and risk assessments. Before joining SLR Consulting she worked for the African Risk Capacity, the specialised agency of the African Union. She was involved in the development of a flood model that is used for underpinning parametric insurance at sovereign level. Throughout her career as a Senior Hydrologist, she was using hydrological software and models including but not limited to PCSWMM, HEC-RAS, HydroCAD, HY8 and Utility Programs for Drainage.

Education

- Post Graduate Diploma in Business Administration, University (2015)
- BSc (Hons) Hydrology, University (2001)
- BSc Hydrology, University (2000)

Project Experience

Development of Fluvial Flood Risk Model for Underwriting Parametric Insurance at Sovereign Level, African Risk Capacity (2018-2022)
In the role as a Lead Hydrologist, co-ordinating the project with external consultants, developing reference datasets for model validation, presenting the flood model to African Union Member States, Facilitation of in-country capacity building program, providing training to in-country Technical Working Groups on the flood model and Flood Early Warning Systems.

Development of Tropical Cyclone Risk Model for Underwriting Parametric Insurance at Sovereign Level, African Risk (2018-2020)
In the role as a Risk Analyst, collating, analysing data, provide due diligence on open-source dataset to be used in the Tropical Cyclone Model and Early Warning Systems. Testing of Early Warning Platforms to be used by AU member countries for monitoring the cyclone seasons in the South-West Indian Ocean.

Ekurhuleni Metropolitan Municipality, City of Tshwane, Stellenbosch Municipality, Nelson Mandela Metropolitan, eThekwini Metropolitan Municipality Flood Disaster Studies, SRK Consulting (2010-2014)
In the role as a Senior hydrologist & project manager. I undertook Flood Disaster Management Studies, that involves identification of high-risk areas and compilation of Disaster Management and Contingency Plans for high-risk areas.

SOWETO Stormwater Master Planning, SRK Consulting (2015)
Modelling major storm water drainage network in various areas in SOWETO, assessing network capacities, prioritization of recommended system upgrades and related costing.

Buffalo City Stormwater Management Plan and Flood Risk Assessment, SRK Consulting (2015)
As a Senior Hydrologist I was involved in floodline modelling, modelling and assessment of stormwater network, assessing flood risk hazard based on on velocity/depth methodology and risk mapping.

Ngadu Housing Development in Zambia, SRK Consulting (2015)
Managed and undertook the updating of surface water hydrology for the development site, identify new instream flow monitoring points. Conducting floodline study.

**Denotes experience completed at another firm

DUBE Township Stormwater Upgrade, SRK Consulting (2014)
As a Lead Hydrologist and a Project Manager, I was involved in the conceptual designs in the upgrading of major stormwater system for the proposed township extension, hydrological and hydraulic modelling of the rivers in the site.

Twickenham Platinum Mine Surface Water Study, SRK Consulting (2014)
Conduct a surface water hydrology component of consolidated Water Use Licence application for Modikwa Platinum Mine.

Anglo American Platinum Limited Surface Water Study, SRK Consulting (2014)
Involved in the calculation of extreme rainfall event and climate analysis for different landuse scenarios to inform mine related infrastructure sizing.

BMW- Rosslyn Flood Remedial Measures, SRK Consulting (2014)
Assessing flood risk in the BMW plant in Pretoria North, design conceptual flood remedial measures to mitigate flooding in the area.

Twickenham Platinum Mine Surface Water Study, SRK Consulting (2014)
Assess the compliance of the site in relation to Regulation 704 conditions.

Chatty & Swartkops River Flood Hazard Assessment, SRK Consulting (2013)
As a Senior Hydrologist, I was involved in the flood risk modelling of the major basins in the Nelson Mandela Bay Municipality, assessing flood risk levels for developments & settlements along the rivers and low-lying areas within the two basins.

Memberships and Associations

- Professional Natural Scientist (Pr. Sci. Nat. 400108/10), South African Council for Scientific Professions
- Institute for Water Scientist, Water Institute of Southern Africa

APPENDIX D: DECLARATION OF INDEPENDENCE

The Independent Environmental Assessment Practitioner I, **Nompumelelo Dube**, declare that I:
• Act as an independent Hydrologist for the Jindal Iron Ore Project • Do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the Environmental Impact Assessment Regulation, 2014 (as amended 2017). • Have no and will not have any vested interest in the proposed activity proceeding. • Have no and will not engage in conflicting interests in the undertaking of the activity • Undertake to disclose, to the competent authority, any material information that has or may have the potential to influence the decision of the competent authority or objectivity of any report, plan or document required in terms of the Environmental Impact Assessment Regulation, 2014. • Will ensure that the information containing all relevant facts in respect of the application are distributed or made available to interested and affected parties and public.
Signature of Specialist: 
Date: 30 June 2023

APPENDIX E: STORMWATER INFRASTRUCTURE SIZING

Name	Inlet Node	Outlet Node	Type of Conduit	Length (m)	Roughness	Cross-Section	Height (m)	Width (m)	Barrels	Slope (m/m)	Max. |Flow| (m^3/s)
C1	J16	J17	BERM&TRENCH	9225.9	0.01	CIRCULAR	1	0	1	0	0
C1_1	J7	J12	BERM&TRENCH	372.024	0.01	TRAPEZOIDAL	1	50	1	0	3.917
C1_2	J10	J7	BERM&TRENCH	1245.223	0.01	TRAPEZOIDAL	1	50	1	0	6.225
C1_3	J8	J10	BERM&TRENCH	1804.669	0.01	TRAPEZOIDAL	1	50	1	0	1.153
C1_4	J11	J8	BERM&TRENCH	1183.066	0.01	TRAPEZOIDAL	1	50	1	0	6.48
C1_5	J15	J13	BERM&TRENCH	1356.22	0.01	TRAPEZOIDAL	1	50	1	0.11204	11.744
C1_6	J14	J13	BERM&TRENCH	1246.54	0.01	TRAPEZOIDAL	1	50	1	0.12914	11.676
C1_7	J12	J11	BERM&TRENCH	1526.025	0.01	TRAPEZOIDAL	1	50	1	0	1.534
C1_8	J13	WRD_PCD	PIPE	83.071	0.01	CIRCULAR	1	0	1	0.0603	7.108
C2	J3	OF1	CULVERT	155.721	0.015	RECT_CLOSED	1.5	2.5	2	0.17605	136.585
C4	J2	PIT_PCD	PIPE	2414.909	0.015	CIRCULAR	3	0	1	0.00538	26.087
C5	J1	OF7	BERM	9097.574	0.08	TRAPEZOIDAL	1.5	100	1	0.03621	215.77
C6	J53	OF4	CULVERT	71.322	0.015	RECT_CLOSED	1.5	2.5	1	0.02805	23.18
C7	J51	OF6	CULVERT	178.63	0.015	RECT_CLOSED	1.5	2.5	10	0.01507	145.101
C8	J49	OF5	CULVERT	163.821	0.015	RECT_CLOSED	1.5	2.5	2	0.00453	13.327
C9	J6	OF2	CULVERT	141.77	0.015	RECT_CLOSED	1.5	2.5	5	0.0726	129.414

APPENDIX F: HECRAS TABLE

HEC-RAS Plan: Plan 02 River: River 28 Reach: Reach 28-Lower1- Profile: 1:100-Year

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach 28-Lower1-	9711	1:100-Year	2026.80	144.00	148.33	148.33	149.75	0.011168	5.29	383.49	135.09	1.00
Reach 28-Lower1-	9536	1:100-Year	2026.80	142.29	147.92	146.33	148.36	0.002164	2.96	708.26	206.13	0.47
Reach 28-Lower1-	9336	1:100-Year	2026.80	141.43	147.53		147.95	0.001896	2.93	736.17	201.49	0.44
Reach 28-Lower1-	9136	1:100-Year	2026.80	141.29	147.21		147.56	0.001786	2.73	790.97	222.44	0.43
Reach 28-Lower1-	8936	1:100-Year	2026.80	140.26	146.96		147.24	0.001291	2.39	892.39	245.98	0.37
Reach 28-Lower1-	8736	1:100-Year	2026.80	140.24	146.91		147.03	0.000532	1.64	1356.49	362.39	0.24
Reach 28-Lower1-	8536	1:100-Year	2026.80	140.09	146.72		146.90	0.000720	2.01	1106.82	265.79	0.28
Reach 28-Lower1-	8349	1:100-Year	2026.80	140.37	146.17		146.65	0.002381	3.22	696.65	212.38	0.50
Reach 28-Lower1-	8138	1:100-Year	2026.80	139.00	144.91		145.88	0.005359	4.37	473.25	149.66	0.72
Reach 28-Lower1-	7951	1:100-Year	2026.80	138.02	144.10		144.91	0.004622	4.01	518.59	172.19	0.67
Reach 28-Lower1-	7740	1:100-Year	2026.80	138.02	143.80		144.14	0.002080	2.71	822.34	308.51	0.45
Reach 28-Lower1-	7527	1:100-Year	2026.80	137.98	143.65		143.82	0.000861	1.90	1131.25	310.11	0.30
Reach 28-Lower1-	7330	1:100-Year	2026.80	137.75	143.57		143.66	0.000505	1.44	1463.15	379.10	0.23
Reach 28-Lower1-	7161	1:100-Year	2026.80	137.49	143.51		143.59	0.000393	1.41	1614.68	524.53	0.21
Reach 28-Lower1-	6935	1:100-Year	2026.80	137.00	143.14		143.43	0.001459	2.59	913.48	369.93	0.39
Reach 28-Lower1-	6740	1:100-Year	2026.80	136.95	142.14	142.14	142.91	0.005479	4.23	633.98	490.74	0.73
Reach 28-Lower1-	6542	1:100-Year	2026.80	136.00	141.19	140.65	141.43	0.002078	2.80	1145.82	769.41	0.45
Reach 28-Lower1-	6327	1:100-Year	2026.80	136.39	141.02		141.13	0.000838	1.70	1394.83	561.92	0.29
Reach 28-Lower1-	6124	1:100-Year	2026.80	136.00	140.52		140.85	0.002256	2.68	832.75	298.73	0.46
Reach 28-Lower1-	5971	1:100-Year	2026.80	135.50	140.00	138.67	140.46	0.002561	3.09	698.66	271.88	0.50
Reach 28-Lower1-	5726	1:100-Year	2026.80	135.10	140.00		140.08	0.000621	1.50	1671.35	652.23	0.25
Reach 28-Lower1-	5542	1:100-Year	2026.80	134.52	139.79		139.92	0.001058	1.79	1320.59	590.67	0.32
Reach 28-Lower1-	5369	1:100-Year	2026.80	134.54	139.66		139.76	0.000768	1.65	1518.10	597.05	0.27
Reach 28-Lower1-	5157	1:100-Year	2026.80	134.51	139.54		139.63	0.000543	1.51	1507.11	472.05	0.24
Reach 28-Lower1-	4936	1:100-Year	2026.80	132.97	137.78	137.78	139.20	0.010580	5.28	387.90	147.10	0.98
Reach 28-Lower1-	4736	1:100-Year	2026.80	113.04	115.29	117.76	131.60	0.340164	17.88	113.33	83.24	4.89
Reach 28-Lower1-	4536	1:100-Year	2026.80	107.63	112.63	111.12	112.96	0.002008	2.68	823.84	316.48	0.44
Reach 28-Lower1-	4323	1:100-Year	2026.80	106.61	112.44		112.62	0.000952	1.96	1156.73	465.41	0.31
Reach 28-Lower1-	4142	1:100-Year	2026.80	105.77	112.23		112.45	0.000966	2.17	1083.48	380.61	0.32
Reach 28-Lower1-	3941	1:100-Year	2026.80	105.57	111.40		112.08	0.003424	3.79	588.18	185.82	0.59
Reach 28-Lower1-	3736	1:100-Year	2026.80	105.35	110.56		111.27	0.004770	3.77	557.21	192.06	0.67
Reach 28-Lower1-	3536	1:100-Year	2026.80	104.49	110.07		110.48	0.002631	2.98	750.96	287.09	0.51
Reach 28-Lower1-	3336	1:100-Year	2026.80	104.16	109.78		110.04	0.001513	2.43	975.48	387.52	0.39
Reach 28-Lower1-	3136	1:100-Year	2026.80	103.52	109.43		109.71	0.001777	2.55	940.99	455.69	0.42
Reach 28-Lower1-	2936	1:100-Year	2026.80	104.14	109.04		109.32	0.002139	2.60	952.43	503.40	0.45
Reach 28-Lower1-	2736	1:100-Year	2026.80	103.24	108.75		108.96	0.001439	2.27	1101.66	479.04	0.38
Reach 28-Lower1-	2535	1:100-Year	2026.80	102.57	108.57		108.72	0.000846	1.93	1315.89	486.58	0.30
Reach 28-Lower1-	2329	1:100-Year	2026.80	102.76	108.12		108.43	0.002419	2.78	869.02	362.86	0.48
Reach 28-Lower1-	2136	1:100-Year	2026.80	102.04	107.86		108.05	0.001388	2.11	1135.34	504.08	0.36
Reach 28-Lower1-	1929	1:100-Year	2026.80	101.95	107.39		107.70	0.002049	2.64	898.30	433.91	0.45
Reach 28-Lower1-	1748	1:100-Year	2026.80	101.37	107.16		107.38	0.001294	2.34	1109.45	515.38	0.36
Reach 28-Lower1-	1525	1:100-Year	2026.80	101.63	106.79		107.05	0.001642	2.50	1054.68	552.88	0.41
Reach 28-Lower1-	1336	1:100-Year	2026.80	101.70	106.45		106.71	0.001854	2.54	987.09	504.87	0.43
Reach 28-Lower1-	1111	1:100-Year	2026.80	100.96	106.48		106.53	0.000236	1.07	2156.10	619.27	0.16
Reach 28-Lower1-	911	1:100-Year	2026.80	100.23	106.44		106.49	0.000233	1.00	2151.81	563.66	0.16
Reach 28-Lower1-	739	1:100-Year	2026.80	99.62	106.38		106.44	0.000291	1.17	1794.16	419.90	0.18
Reach 28-Lower1-	554	1:100-Year	2026.80	99.73	106.21		106.36	0.000562	1.77	1258.17	332.34	0.25

HEC-RAS Plan: Plan 02 River: River 28 Reach: Reach 28-Lower1- Profile: 1:100-Year

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach 28-Lower1-	9711	1:100-Year	2026.80	144.00	148.33	148.33	149.75	0.011168	5.29	383.49	135.09	1.00
Reach 28-Lower1-	9536	1:100-Year	2026.80	142.29	147.92	146.33	148.36	0.002164	2.96	708.26	206.13	0.47
Reach 28-Lower1-	9336	1:100-Year	2026.80	141.43	147.53		147.95	0.001896	2.93	736.17	201.49	0.44
Reach 28-Lower1-	9136	1:100-Year	2026.80	141.29	147.21		147.56	0.001786	2.73	790.97	222.44	0.43
Reach 28-Lower1-	8936	1:100-Year	2026.80	140.26	146.96		147.24	0.001291	2.39	892.39	245.98	0.37
Reach 28-Lower1-	8736	1:100-Year	2026.80	140.24	146.91		147.03	0.000532	1.64	1356.49	362.39	0.24
Reach 28-Lower1-	8536	1:100-Year	2026.80	140.09	146.72		146.90	0.000720	2.01	1106.82	265.79	0.28
Reach 28-Lower1-	8349	1:100-Year	2026.80	140.37	146.17		146.65	0.002381	3.22	696.65	212.38	0.50
Reach 28-Lower1-	8138	1:100-Year	2026.80	139.00	144.91		145.88	0.005359	4.37	473.25	149.66	0.72
Reach 28-Lower1-	7951	1:100-Year	2026.80	138.02	144.10		144.91	0.004622	4.01	518.59	172.19	0.67
Reach 28-Lower1-	7740	1:100-Year	2026.80	138.02	143.80		144.14	0.002080	2.71	822.34	308.51	0.45
Reach 28-Lower1-	7527	1:100-Year	2026.80	137.98	143.65		143.82	0.000861	1.90	1131.25	310.11	0.30
Reach 28-Lower1-	7330	1:100-Year	2026.80	137.75	143.57		143.66	0.000505	1.44	1463.15	379.10	0.23
Reach 28-Lower1-	7161	1:100-Year	2026.80	137.49	143.51		143.59	0.000393	1.41	1614.68	524.53	0.21
Reach 28-Lower1-	6935	1:100-Year	2026.80	137.00	143.14		143.43	0.001459	2.59	913.48	369.93	0.39
Reach 28-Lower1-	6740	1:100-Year	2026.80	136.95	142.14	142.14	142.91	0.005479	4.23	633.98	490.74	0.73
Reach 28-Lower1-	6542	1:100-Year	2026.80	136.00	141.19	140.65	141.43	0.002078	2.80	1145.82	769.41	0.45
Reach 28-Lower1-	6327	1:100-Year	2026.80	136.39	141.02		141.13	0.000838	1.70	1394.83	561.92	0.29
Reach 28-Lower1-	6124	1:100-Year	2026.80	136.00	140.52		140.85	0.002256	2.68	832.75	298.73	0.46
Reach 28-Lower1-	5971	1:100-Year	2026.80	135.50	140.00	138.67	140.46	0.002561	3.09	698.66	271.88	0.50
Reach 28-Lower1-	5726	1:100-Year	2026.80	135.10	140.00		140.08	0.000621	1.50	1671.35	652.23	0.25
Reach 28-Lower1-	5542	1:100-Year	2026.80	134.52	139.79		139.92	0.001058	1.79	1320.59	590.67	0.32
Reach 28-Lower1-	5369	1:100-Year	2026.80	134.54	139.66		139.76	0.000768	1.65	1518.10	597.05	0.27
Reach 28-Lower1-	5157	1:100-Year	2026.80	134.51	139.54		139.63	0.000543	1.51	1507.11	472.05	0.24
Reach 28-Lower1-	4936	1:100-Year	2026.80	132.97	137.78	137.78	139.20	0.010580	5.28	387.90	147.10	0.98
Reach 28-Lower1-	4736	1:100-Year	2026.80	113.04	115.29	117.76	131.60	0.340164	17.88	113.33	83.24	4.89
Reach 28-Lower1-	4536	1:100-Year	2026.80	107.63	112.63	111.12	112.96	0.002008	2.68	823.84	316.48	0.44
Reach 28-Lower1-	4323	1:100-Year	2026.80	106.61	112.44		112.62	0.000952	1.96	1156.73	465.41	0.31
Reach 28-Lower1-	4142	1:100-Year	2026.80	105.77	112.23		112.45	0.000966	2.17	1083.48	380.61	0.32
Reach 28-Lower1-	3941	1:100-Year	2026.80	105.57	111.40		112.08	0.003424	3.79	588.18	185.82	0.59
Reach 28-Lower1-	3736	1:100-Year	2026.80	105.35	110.56		111.27	0.004770	3.77	557.21	192.06	0.67
Reach 28-Lower1-	3536	1:100-Year	2026.80	104.49	110.07		110.48	0.002631	2.98	750.96	287.09	0.51
Reach 28-Lower1-	3336	1:100-Year	2026.80	104.16	109.78		110.04	0.001513	2.43	975.48	387.52	0.39
Reach 28-Lower1-	3136	1:100-Year	2026.80	103.52	109.43		109.71	0.001777	2.55	940.99	455.69	0.42
Reach 28-Lower1-	2936	1:100-Year	2026.80	104.14	109.04		109.32	0.002139	2.60	952.43	503.40	0.45
Reach 28-Lower1-	2736	1:100-Year	2026.80	103.24	108.75		108.96	0.001439	2.27	1101.66	479.04	0.38
Reach 28-Lower1-	2535	1:100-Year	2026.80	102.57	108.57		108.72	0.000846	1.93	1315.89	486.58	0.30
Reach 28-Lower1-	2329	1:100-Year	2026.80	102.76	108.12		108.43	0.002419	2.78	869.02	362.86	0.48
Reach 28-Lower1-	2136	1:100-Year	2026.80	102.04	107.86		108.05	0.001388	2.11	1135.34	504.08	0.36
Reach 28-Lower1-	1929	1:100-Year	2026.80	101.95	107.39		107.70	0.002049	2.64	898.30	433.91	0.45
Reach 28-Lower1-	1748	1:100-Year	2026.80	101.37	107.16		107.38	0.001294	2.34	1109.45	515.38	0.36
Reach 28-Lower1-	1525	1:100-Year	2026.80	101.63	106.79		107.05	0.001642	2.50	1054.68	552.88	0.41
Reach 28-Lower1-	1336	1:100-Year	2026.80	101.70	106.45		106.71	0.001854	2.54	987.09	504.87	0.43
Reach 28-Lower1-	1111	1:100-Year	2026.80	100.96	106.48		106.53	0.000236	1.07	2156.10	619.27	0.16
Reach 28-Lower1-	911	1:100-Year	2026.80	100.23	106.44		106.49	0.000233	1.00	2151.81	563.66	0.16
Reach 28-Lower1-	739	1:100-Year	2026.80	99.62	106.38		106.44	0.000291	1.17	1794.16	419.90	0.18
Reach 28-Lower1-	554	1:100-Year	2026.80	99.73	106.21		106.36	0.000562	1.77	1258.17	332.34	0.25

HEC-RAS Plan: Plan 02 River: River 28 Reach: Reach 28-Lower2 Profile: 1:100-Year

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach 28-Lower2	11731	1:100-Year	205.10	153.87	155.33	155.33	155.83	0.016076	3.14	65.36	66.24	1.01
Reach 28-Lower2	11627	1:100-Year	205.10	151.82	154.37	153.75	154.55	0.004022	1.89	108.79	83.72	0.53
Reach 28-Lower2	11527	1:100-Year	205.10	151.85	154.07		154.21	0.002811	1.66	123.53	88.12	0.45
Reach 28-Lower2	11376	1:100-Year	205.10	150.77	152.78	152.78	153.33	0.015733	3.27	62.64	58.55	1.01
Reach 28-Lower2	11198	1:100-Year	205.10	149.19	151.59	150.24	151.61	0.000386	0.68	300.40	186.60	0.17
Reach 28-Lower2	11071	1:100-Year	205.10	148.50	150.82	150.82	151.41	0.015441	3.41	60.16	52.11	1.01
Reach 28-Lower2	10927	1:100-Year	205.10	147.56	150.09	149.23	150.19	0.002428	1.40	146.69	121.18	0.41
Reach 28-Lower2	10779	1:100-Year	205.10	146.45	150.07		150.09	0.000194	0.61	337.18	145.99	0.13
Reach 28-Lower2	10640	1:100-Year	205.10	146.41	150.02		150.05	0.000472	0.82	249.08	133.07	0.19
Reach 28-Lower2	10463	1:100-Year	205.10	144.11	150.04		150.04	0.000002	0.10	2333.61	623.47	0.01
Reach 28-Lower2	10330	1:100-Year	205.10	143.95	150.04		150.04	0.000004	0.15	1586.04	633.77	0.02
Reach 28-Lower2	10173	1:100-Year	205.10	143.73	150.04		150.04	0.000007	0.18	1261.02	344.16	0.03
Reach 28-Lower2	10106	1:100-Year	205.10	143.32	150.03		150.04	0.000008	0.21	1089.96	275.10	0.03

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
SO2	Tributary	830	1:100-Year	16.80	489.89	490.45	490.64	491.06	0.071964	3.47	4.84	17.33	2.10
SO2	Tributary	753	1:100-Year	16.80	477.66	478.23	478.69	480.93	0.290721	7.28	2.31	7.66	4.24
SO2	Tributary	670	1:100-Year	16.80	471.38	471.90	472.03	472.32	0.046957	2.90	5.80	19.77	1.71
SO2	Tributary	568	1:100-Year	16.80	455.56	455.92	456.33	459.71	0.759578	8.62	1.95	10.41	6.37
SO2	Tributary	475	1:100-Year	16.80	427.97	428.56	428.94	430.24	0.168472	5.73	2.93	9.28	3.26
SO2	Tributary	397	1:100-Year	16.80	406.80	407.13	407.46	409.36	0.482231	6.62	2.54	14.33	5.03
SO2	Tributary	273	1:100-Year	16.80	379.97	380.37	380.54	381.04	0.134882	3.62	4.64	24.96	2.68
SO2	Tributary	186	1:100-Year	16.80	353.42	353.63	353.87	356.01	0.952414	6.83	2.47	23.61	6.55
SO2	Tributary	127	1:100-Year	16.80	333.68	334.18	334.47	335.48	0.176771	5.05	3.33	13.30	3.22
SO2	Tributary	79	1:100-Year	16.80	315.92	315.42	315.85	319.46	0.940900		1.89	10.98	0.00
S01	Tributary	1277	1:100-Year	33.60	532.56	533.12	533.12	533.39	0.010705	1.34	15.26	28.59	0.81
S01	Tributary	1209	1:100-Year	33.60	515.66	515.50	516.06	529.46	3.760621		2.03	13.57	0.00
S01	Tributary	1118	1:100-Year	33.60	488.80	489.32	489.57	490.39	0.152271	4.91	7.33	30.37	3.02
S01	Tributary	1018	1:100-Year	33.60	464.38	464.44	464.93	468.08	0.444940	1.89	4.01	16.14	3.57
S01	Tributary	905	1:100-Year	33.60	443.85	444.12	444.52	445.74	0.108782	2.60	6.11	16.36	2.28
S01	Tributary	780	1:100-Year	33.60	423.59	423.89	424.17	425.38	0.294504	5.40	6.22	33.06	3.97
S01	Tributary	667	1:100-Year	33.60	402.17	403.03	403.50	404.91	0.121813	6.06	5.54	12.66	2.92
S01	Tributary	541	1:100-Year	33.60	389.98	390.99	391.42	392.52	0.080297	5.49	6.12	11.81	2.43
S01	Tributary	398	1:100-Year	33.60	374.13	374.81	375.34	377.10	0.151050	6.70	5.02	11.59	3.25
S01	Tributary	278	1:100-Year	33.60	361.84	362.80	363.24	364.32	0.076424	5.47	6.14	11.43	2.39
S01	Tributary	156	1:100-Year	33.60	352.09	352.74	353.12	354.08	0.092549	5.13	6.55	15.72	2.54
S01	Tributary	92	1:100-Year	33.60	340.74	341.23	341.63	343.66	0.334782	6.89	4.87	19.75	4.43
S01	Tributary	54	1:100-Year	33.60	331.17	331.80	332.23	333.98	0.203513	6.81	5.22	16.61	3.66
Kwasengeni	Reach 3	2363	1:100-Year	232.10	327.76	330.46	330.46	331.17	0.007892	3.95	64.59	44.73	0.94
Kwasengeni	Reach 3	2313	1:100-Year	232.10	326.56	328.88	329.38	330.48	0.023775	6.21	43.42	37.46	1.58
Kwasengeni	Reach 3	2268	1:100-Year	232.10	326.54	327.53	328.03	329.18	0.033571	4.74	41.23	40.70	1.69
Kwasengeni	Reach 3	2223	1:100-Year	232.10	326.83	327.88	327.88	328.61	0.008331	1.85	63.32	45.15	0.80
Kwasengeni	Reach 3	2184	1:100-Year	232.10	326.81	327.42	327.58	328.36	0.011643	1.43	54.87	39.42	0.84
Kwasengeni	Reach 2	1957	1:100-Year	239.50	319.31	321.61	322.62	325.27	0.066797	8.47	28.26	24.67	2.53
Kwasengeni	Reach 2	1884	1:100-Year	239.50	319.22	320.78	321.12	322.04	0.020968	4.86	48.18	39.55	1.43
Kwasengeni	Reach 2	1838	1:100-Year	239.50	316.67	319.48	319.95	321.00	0.019243	6.08	44.81	31.42	1.44
Kwasengeni	Reach 2	1760	1:100-Year	239.50	316.87	316.89	317.71	319.66	0.056534	0.34	32.49	31.41	1.07
Kwasengeni	Reach 2	1683	1:100-Year	239.50	310.41	312.94	313.97	316.45	0.054236	8.30	28.86	22.03	2.32
Kwasengeni	Reach 1	1463	1:100-Year	246.30	291.54	293.75	295.17	300.24	0.121147	11.28	21.83	19.23	3.38
Kwasengeni	Reach 1	1341	1:100-Year	246.30	288.63	290.18	290.81	292.18	0.031320	6.28	39.67	33.14	1.77
Kwasengeni	Reach 1	1241	1:100-Year	246.30	278.68	280.90	282.30	286.86	0.088376	11.14	23.44	19.27	3.00
Kwasengeni	Reach 1	1134	1:100-Year	246.30	269.58	271.10	272.20	275.97	0.112745	9.78	25.19	26.51	3.20
Kwasengeni	Reach 1	1010	1:100-Year	246.30	261.27	262.82	263.59	265.45	0.058528	7.17	34.33	35.22	2.32
Kwasengeni	Reach 1	874	1:100-Year	246.30	252.82	254.35	255.09	256.97	0.066246	7.16	34.40	38.95	2.43
Kwasengeni	Reach 1	753	1:100-Year	246.30	245.90	247.61	248.31	249.95	0.050440	6.79	36.29	36.25	2.17
Kwasengeni	Reach 1	609	1:100-Year	246.30	236.57	237.91	238.71	240.94	0.078711	7.71	31.94	36.83	2.64
Kwasengeni	Reach 1	523	1:100-Year	246.30	231.20	232.74	233.50	235.29	0.052326	7.09	35.22	36.74	2.22
Kwasengeni	Reach 1	423	1:100-Year	246.30	227.08	228.74	229.33	230.67	0.038608	6.33	40.96	42.14	1.93
Kwasengeni	Reach 1	313	1:100-Year	246.30	224.13	225.84	226.28	227.24	0.023573	5.39	48.68	46.17	1.54
Kwasengeni	Reach 1	198	1:100-Year	246.30	217.35	218.53	219.35	221.99	0.108202	8.37	30.47	43.55	3.04
Kwasengeni	Reach 1	68	1:100-Year	246.30	213.26	214.76	215.09	215.86	0.021768	5.11	54.46	55.22	1.47

APPENDIX G: REPORT ON WATER REQUIREMENTS FOR JINDAL MINE FOR USE BY JINDAL AND STAKEHOLDERS

REPORT ON WATER REQUIREMENTS FOR JINDAL MINE FOR USE BY JINDAL AND STAKEHOLDERS

April 2022 – Norman Ward B.Sc. Civ. Eng.

1. BACKGROUND

1.1 BACKGROUND OF THE JINDAL MINE

The document S&EIA for the proposed Melmoth Iron ore Project gives extensive details of the proposed mine. There is a proposal for open cast mining of magnetic iron ore with crushing plant and magnetic extraction of iron concentrate. The bulk of the water requirement is for two main demands: Water left within the pores of the tailings dam, and water evaporated from the surface of the tailings dam. There will be a return flow pipeline from the tailings dam with some recovery of water from the tailings dam and rainfall recovered from the tailings dam may augment this in normal years. The mine intends applying for 15 million m^3 water per annum to be assured of all the demands, but the projected use is somewhat lower as shown in the table below.

Jindal Iron Mine Water usage per year	Cubic Meters
Tailings dam-interstitial water	6 000 000
Tailings dam- evaporation and drainage	6 000 000
Water in concentrate railed to Port	750 000
Dust abatement on mine roads and rock dump	400 000
Potable water	50 000
Total	**13 200 000**

1.2 BACKGROUND OF THE MHLATHUZE CATCHMENT

The catchment is quite complex both in terms of demands and supplies. The largest user is the Irrigation sector, abstracting from the river at different points. Next is the municipal, mining, and industrial sector, abstracting from the Mhlathuze Weir as well as several coastal lakes. During normal conditions as well as the many minor droughts experienced, the Mhlathuze River and the coastal lakes supply a significant portion of the water used, and Goedertrouw dam supplies the smaller portion of this use. As a result, the dam appears relatively full and underutilised.

The entire system consists of nine quaternary sub-catchments. Only two of these feed the Goedertrouw dam. Another 3.5 quaternary catchments feed the river down to the Mhlathuze weir, thus supplying the bulk of the users directly without much need for releases from the dam. The remainder of the catchment feeds the coastal lakes.

When a major drought hits the catchment, the lakes reach a low point where abstraction must be reduced and, in some cases, stopped. This causes the demand on Goedertrouw dam to escalate, and the dam drops like a stone. The local operator is used to receiving complaints when the river is low, but not when it is high, so there is a tendency to release more than necessary and leave the flow unchanged when rain occurs.

In fact, it is necessary to manage the dam releases closely, as well as monitor the future rainfall on the internet, especially during drought conditions. It is not enough to cut the release when the river rises, but significant savings can be made by cutting releases before the rain arrives.

2. WATER SOURCES FOR JINDAL MINE

2.1 GROUNDWATER:

The option of local groundwater was looked at briefly by studying the extensive work done on groundwater sources by WRP consultants in the 2021 Reconciliation study. In the geological formation around the mine area, they report that only 4% to 5% of boreholes deliver in excess of 5 litres/sec – an insignificant amount for a venture of this size.

2.2 GOEDERTROUW DAM:

The Goedertrouw dam remains the only viable alternative. Water could be pumped from the basin below the dam, or an agreement could be undertaken to abstract directly from one of the existing pipelines from the dam, thus saving a considerable pumping head during most of the duration of abstraction.

The Mhlathuze System is currently in deficit to the amount of 9 million m^3, so a new application of 15 million m^3 may not be welcomed by either the DWS or the other stakeholders in the catchment. Further augmentation of the system is on the cards but then Jindal will have to compete with any other new users, including the growing Municipal demand, or contribute to solving the water deficit by increasing the yield of the system by as much or more than the water requested.

Most of the future augmentation schemes are large and require significant capital. Some also have high operating costs. There is no telling when they will be implemented because the economy has had a severe knock through the Covid epidemic and KZN has had a disastrous flood, which will also put strain on the fiscus. Thus, it is recommended that Jindal look at one or two of the smaller interventions to which they may be able to contribute and/or put pressure on role-players to implement.

To get a full picture, let us look at the catchment water balance and augmentation options.

3. MHLATHUZE SYSTEM WATER BALANCE

The Mhlathuze System was seriously out of balance in the past. This led to an exercise called **compulsory licensing**. In modelling the system, the water balance was first analysed using the catchment without the Tugela Transfer scheme. The reason for this was that the transfer scheme was paid-for by the large industries in Richards Bay, and their tariffs have been adjusted to pay for the operating costs of this scheme. It was agreed that the agricultural sector would not have access to this pumped water. It is too expensive for them anyway.

To bring the system into balance without the transfer scheme, the demands had to be reduced by 40%. Thus, it was proposed to reduce the irrigation sector to 60% of previous quotas. There was a huge outcry over the social and economic consequences of this. Eventually DWS negotiated to grant 66% of quota with a higher assurance of supply, but the irrigation sector is not pleased by this development.

The model was again run with the transfer scheme on, and the result was that industrial and municipal use had to be cut by 10%. This demand has since grown, thus putting the system into deficit again.

4 AUGMENTATIONS TO THE MHLATHUZE SYSTEM

4.1 AUGMENTATION CURRENTLY UNDERWAY – TUGELA TRANSFER PHASE 2

The original Tugela transfer scheme was built during the 1993 drought under pressure from a group of large industries in Richards Bay who also helped to fund it. It was completed almost too late to help the drought and then not used for 20 years. (except for regular test runs.) When the 2014 drought hit, many of the electrical components were problematic and obsolete. This scheme operated for a time but has not been able to operate since 2018 to date. This scheme delivers 1.08 cumec at a cost of R6 million for nine months and R10 million for 3 months, based on electricity costs at 2017 prices. Other costs such as maintenance are unknown.

The phase 2 transfer scheme was begun because of the 2014 drought, but also only begun late in the drought cycle. The contractor declared bankruptcy as the scheme passed the 50% completion mark, and the DWS has now earmarked funding for its completion and appointed a contractor. The latest information is that completion is scheduled for December 2023, however the contractor has not moved on site, so this could be subject to review. **After allowing for the current deficit, the Jindal application will take up over third of this new surplus.**

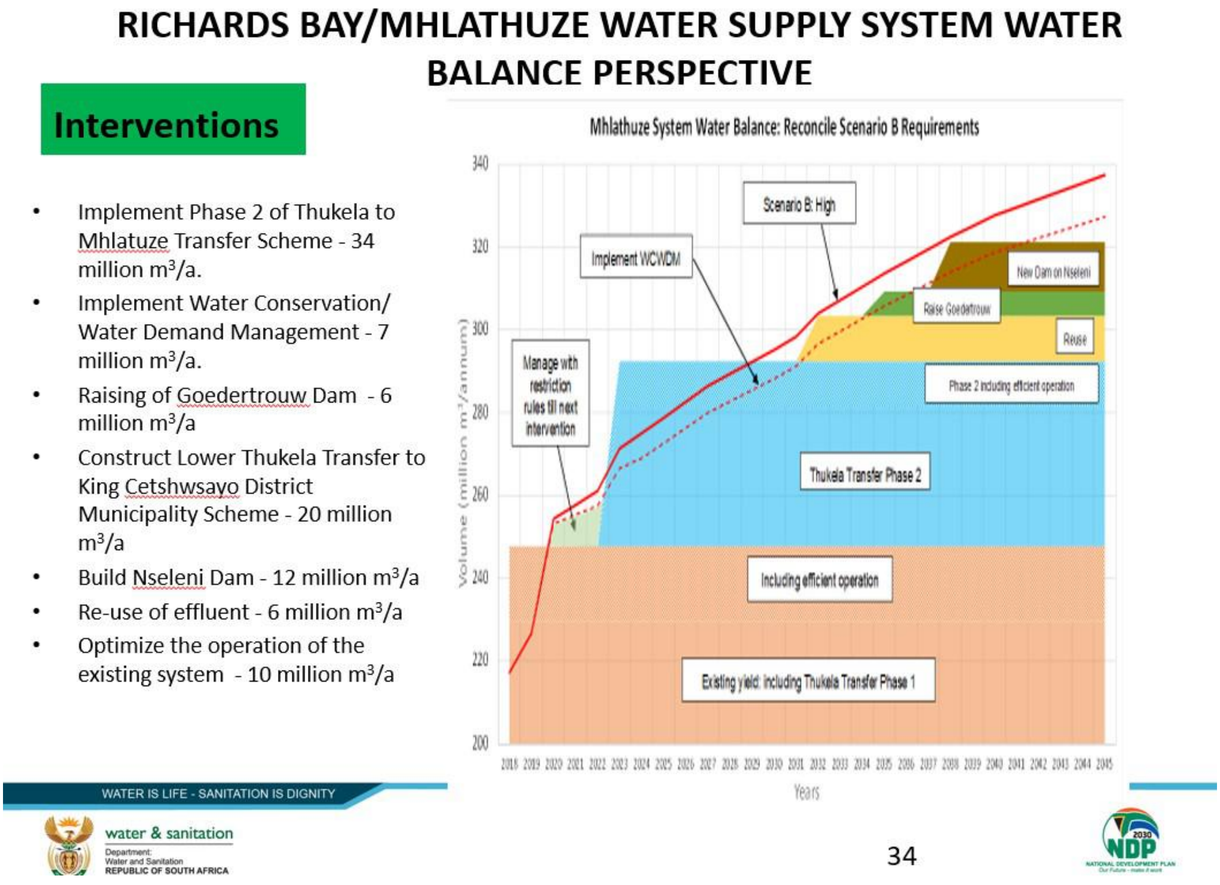
The transfer schemes are operated by Mhlathuze Water under agreement with DWS. As a Government Department, DWS cannot budget every year for operating expenses as funding which is not utilized cannot be rolled over. Thus, when a drought occurs it is difficult to get budget for pumping costs at short notice and even more so for a multi-year drought.

4.2 AUGMENTATION OPTIONS INTO THE FUTURE

The graphs and information following were obtained from the 2021 Richards Bay reconciliation strategy studies. Very detailed analyses of the system are undertaken every three years, showing present as well as future demands and supply options. Here is a chart showing the growth of demand up until 2045. Possible augmentation options are shown.

Risks and challenges for each option are unique. In addition, circumstances are dynamic and may lead to changes in the order of implementation depending on actual growth demands and availability of capital.

Before the drought, the duplication of the Tugela Mhlathuze transfer scheme was not the preferred first option, but pressure from the major industries in Richards Bay forced DWS to begin implementation as it was deemed to be the quickest way to obtain extra water. The scheme has still not been completed owing to contractual issues, but the DWS has now committed funds for its completion. A contractor has been appointed but not yet moved on to site. Previous projections were for completion in December 2023.



Source: Ricard's Bay Reconciliation Strategy 5 done for DWS by WRP consultants.

(See detailed discussion on some of these options further on).

Below is a table of augmentation options for the catchment, with costs as identified in the reconciliation report of 2021. **(The last two have been added by me. Whereas the optimization of the operation of the existing system is reported as yielding only 10 Mm^3/annum, a professionally run operation involving stakeholders and a consulting engineering company could achieve at least 18 Mm^3/annum.)**

TABLE OF AUGMENTATION OPTIONS

AUGMENTATION	Yield in Mm^3 per annum	Cost or Unit reference value per m^3	COMMENT
Phase 2 of the Tugela Mhlathuze transfer scheme as currently in progress	**34**	R2.47 for electricity alone.	Risks: Operating costs are very high, but intermittent, thus hard to budget for. (R84 million pa for 5 years out of 25) The duplicated scheme will be an even greater problem. Both phases will cost R168 million p.a. to operate (Based on current phase and 2017 prices)
Water conservation	**7**	Varies.	This is an ongoing project, reliant on the municipalities for funding and implementation. If stopped, the gains are lost in a few years.
Raising of Goedertrouw dam	**6**	R2.05	Small yield, but a relatively low cost per m^3. Cost is once off and doesn't rely on future funding. Requires immediate capital of R127 Million. See also comment on funding for the transfer scheme.
Build Nseleni dam	**12**	R2.56	Capital funding may be problematic, however Mhlathuze Water may be able and willing to fund it on their balance sheet.
Re-use of effluent	**6**	Still being studied. But may be high.	The fact that industries such as Mondi have spent so much effort to analyse this shows that it is not a simple or cheap option.
Optimize operation of existing system	**10**	Unknown capital costs but not excessive.	As visualized by the consultants this requires building of measuring stations in tributaries as well as infrastructure to convey this data to the internet. No details as to who would use it. Vandalism is a problem.
Optimize operation of existing system using PSP	**18**	R0.04	Use of a professional service provider (PSP) with an agreement with the Infrastructure Branch of DWS to allow release instructions directly to the operator. PSP would be covered by indemnity insurance protecting DWS against claims from users. PSP would employ an engineer with experience who would train future successors
Duplication of the pipeline from Mhlathuze Weir to Nsezi WTP	**24**	Capital cost recovered through electricity savings.	This project was studied independently by Norman Ward as well as Mhlathuze Water. There was agreement to implement during the 2016 drought, but the contract stalled due to a court challenge by an unsuccessful bidder. Capital to be supplied by Mhlathuze Water.

5. OBJECTIONS AND RISKS TO THE JINDAL APPLICATION

The result of all the above history is that there is tension between the user groups with irrigators feeling that they had to make huge sacrifices to the other sectors. They are likely to be strongly opposed to the Jindal mine, as they see this as reducing their water security. The completion of the Tugela transfer scheme phase two, will not allay this fear. **After allowing for the current deficit, the Jindal application will take up over a third of this new surplus.**

The first level of restrictions (which affects the irrigators more than industry) is likely to be imposed whenever the transfer scheme is operated, as they are not entitled to any of this water, and cannot afford to pay for it. **The extra demand from Jindal will make the pumping and restrictions more prevalent.**

Industry may also object, on the grounds that the increase in pumping costs, will not be carried by Jindal alone but spread over the whole user group.

6. OPTIONS FOR JINDAL TO GENERATE EXTRA WATER

To overcome these objections, Jindal could contribute to one of the other reconciliation options above. Many involve large capital contributions and may take years to materialize owing to the current strain on the fiscus. Most of the schemes are under the control of DWS, others are within the operations of the municipality. Therefore, they are outside the control of Jindal. The last two are the only options that I can see as viable for Jindal involvement, and which can be used to allay objections.

6.1 OPTIMIZE OPERATION OF EXISTING SYSTEM USING A PSP

Jindal could make use of a professional service provider (PSP) with an agreement with the Infrastructure Branch of DWS to allow release instructions directly to the operator of the Goedertrouw Dam. The PSP would be covered by indemnity insurance protecting DWS against claims from users. The PSP would employ an engineer with experience (Norman Ward) who would train future successors within the company to ensure continuity.

Motivation: During the 2014 to 2018 drought Norman Ward of the DWS Regional Office reduced the spillage at the Mhlathuze weir by 0.6 m^3/sec compared to the operator at the dam. This amounts to an annual saving of 18 million m^3. This was during a critical drought. During a wetter cycle the savings would have been significantly higher and would ensure that the dam would be close to full at the start of a serious drought. (In June 2014 the dam was already below 80%)

This careful management of releases was done using the internet for frequent weather updates, up to twice a day, as well as interaction with stakeholders along the river using a whatsapp group. Spillages were reduced but nobody was without water.

After Mr Ward's retirement there have been instances when the dam was not adjusted for up to six weeks with large spillages to sea and then a shortage of water in the river. Mondi and other key users were without water and lost production, causing embarrassment with their overseas customers. This is still an ongoing claim.

Risks: Reluctance on the part of DWS to accept suspensive conditions on a licence application. The DWS will be reluctant to hand over control of their infrastructure to an external individual. Therefore, I suggest that Jindal hire a smallish consultant to take on the responsibility rather than an individual such as myself. That way DWS is protected against legal claims from users, as the PSP has indemnity insurance. **Getting agreement from the Infrastructure Branch at Midmar Office may take considerable effort, but I suggest that this be agreed in principle before any water use licence meeting is set up to strengthen your application from the start.**

Advantage: Jindal could have an agreement to fund this control for the life of the mine. This is the most cost-effective source of extra yield available by far. No capital input is required from any party. The PSP should be able to get co-operation from all stakeholders with more attention to detail.

6.2 DUPLICATION OF THE PIPELINE FROM MHLATHUZE WEIR TO NSEZI WTP

Motivation: During both droughts RBM were drawing most of their water from Lake Nsezi next to the Nsezi WTP. From time to time, with local rainstorms, there were still significant spillages over the Mhlathuze weir in excess of what the estuary requires. During the 1983 drought, whenever there was some rain in the catchment, the Mhlathuze pump station could pump the excess into Lake Nsezi and build up a reserve for when the river was low. (At this stage of a drought RBM draw the bulk of their water from the lake, as their other sources are depleted).

In the last drought Lake Mzingazi was too low to allow abstraction. Thus, Richards Bay had to rely 100% on the Nsezi WTP. The Mhlathuze pump station was therefore running at maximum capacity and could not utilize any excess flow. In fact, at the depths of the drought Lake Nsezi was dropping below its ideal minimum level, as the pumps could not keep up. This caused RBM to close down one of its smelters at huge cost to the company.

Norman Ward calculated that an additional pumping capacity of 1,25 cumec could save spillages of 24 million m^3 for transfer to Lake Nsezi. On discussing this with the Technical Director of Mhlathuze Water, he said that they were already looking at duplicating the pipeline from the weir to the WTP. He said that the friction in the line is high and that at current pumping levels the saving on electricity would pay off the capital cost of the pipeline over 20 years. This scheme would therefore cost very little in the long run.

He said the current variable speed pumps could deliver the additional 1,25 cumec at the lower pressure, and that all that was needed was the pipeline and an upgraded transformer to pump the full additional water. Current electricity tariffs are significantly higher than at the time the feasibility study was done, therefore savings from this scheme could pay off the pipeline even faster.

Mhlathuze Water proceeded to go to tender for the pipeline and after the tenderer was appointed there was an objection from an unsuccessful tenderer and the matter had to go to arbitration or to court. Throughout the drought the drought committee would enquire about this project, but nothing came of it.

Opportunity: Jindal could approach Mhlathuze Water to proceed with this project once again and offer to contribute a portion of the costs or pay for a specific component, subject to the success of their WUL (Water User's Licence).

Risks: Unwillingness on the part of Mhlathuze Water's current management to proceed. Perception that there is no benefit. Argument by other stakeholders that this was due to go ahead anyway, but this can be countered that without Jindal financial support, it would not have been implemented immediately. Reluctance on the part of DWS to accept suspensive conditions on a licence application.

6. CONCLUSION

Both the options 6.1 and 6.2 should be vigorously pursued. They both require negotiations with other parties and there is no certainty that either will be successful.

Norman Ward

B.Sc. Civ. Eng.

All information in this report is from the Richards Bay Reconciliation Strategy number 5 (2021) by WRP consultants and from my own knowledge of the catchment and stakeholders.

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