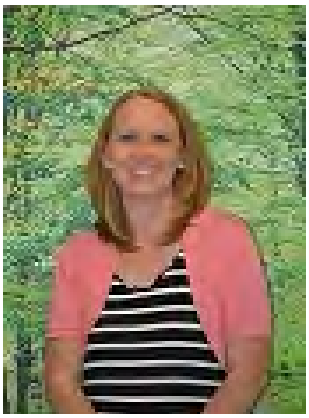
APPENDIX A

EAP Curriculum Vitae



Education

B.Sc. Earth Science, University of Johannesburg, Johannesburg, South Africa, 1998

B.Sc. (Hons) Geography and Environmental Management, University of Johannesburg, Johannesburg, South Africa, 1999

Languages

English – Fluent

Afrikaans – Fluent

Golder Associates Africa (Pty.) Ltd. – Johannesburg

Employment History

Golder Associates Africa – Johannesburg, South Africa
Senior Environmental Scientist (2011 to Present)

International Cyanide Management Code Auditing
Due Diligence Auditing
Compliance / Risk Auditing
Environmental Management Programme Report Performance Assessments
Environmental Management Programme Report Consolidations and Amendments
Project and Finance Management
Integrated Environmental Authorisation Projects
Compliance Projects
Consultation with Interested and Affected Parties and Government Departments

AngloGold Ashanti – Orkney, South Africa
Senior Environmental Coordinator (2006 to 2011)

Implementation and maintenance of an Environmental Management System in accordance with ISO 14001:2004
Consultation with Interested and Affected Parties and Government Departments
Reporting on leading and lagging environmental indicators
Internal Auditing
Environmental Assistance to Metallurgical plants, Laboratories and Tailings departments
Project Management
Budget Management
Coordination and execution of monitoring of key environmental indicators

Oryx Environmental cc – Johannesburg, South Africa
Environmental Consultant (2002 to 2006)

ISO 14001 - Environmental Management System Implementation and Maintenance
Environmental Impact Assessments
Environmental Auditing
Report Writing
Project Management

Gold Fields Ltd - Driefontein Gold Mine – Carletonville, South Africa
Environmental Coordinator (2000 to 2002)

Implemented an Environmental Management System in accordance with the ISO 14001:1996 standard
Internal Auditing
General Environmental Management Duties

PROJECT EXPERIENCE – ENVIRONMENTAL ASSESSMENT

Exxaro Grootegeluk Coal Mine Limpopo, South Africa	Environmental Authorisation Application for the proposed open cast mining pits at the Exxaro Grootegeluk Coal Mine near Lephalale, Limpopo Province.
South 32 Middelburg Colliery Mpumalanga, South Africa	Environmental Authorisation Application for the continuation of activities which commenced unlawfully in terms of Environmental Legislation.
ACWA Power Bokpoort II Solar Development Northern Cape, South Africa	Environmental Authorisation for a proposed Solar Development near Groblershoop, Northern Cape.
Palabora Copper Limpopo, South Africa	Environmental Authorisation for the proposed Magnetite Expansion and Additional Infrastructure Project.
Scaw South Africa (Pty) Ltd Gauteng, South Africa	Various projects to ensure environmental compliance at a number of Scaw South Africa sites.
Exxaro Resources - Grootegeluk Coal Mine Limpopo, South Africa	Compilation of a Consolidated Environmental Management Programme Report for Grootegeluk Coal Mine.
Exxaro Resources - Grootegeluk Coal Mine Limpopo, South Africa	Compilation of a Basic Assessment Report for the proposed New Gate at the Grootegeluk Mine.
Exxaro Resources Limpopo, South Africa	Compilation of an Environmental Management Plan (EMP) Addendum for the proposed New Gate and Cyclic Ponds at the Grootegeluk Mine.
Palabora Mining Company Limpopo, South Africa	Compilation of an Environmental Management Plan (EMP) Addendum for the proposed Iron Beneficiation Plant for Palabora Mining Company.
Palabora Mining Company Limpopo, South Africa	Compilation of an Environmental Management Programme Report Addendum for the South Paddock for Palabora Mining Company.
Palabora Mining Company Limpopo, South Africa	Compilation of a Consolidated Environmental Management Programme (EMP) for Palabora Mining Company.

PROJECT EXPERIENCE – EHS AUDITING

Karpower International DMCC (Karpowership) Nacala Bay, Mozambique	Private Environmental Compliance Audit of the Powership offshore in the Nacala Bay, Mozambique.
Oiltanking GmbH Kuriman, Indonesia	Evaluation of an Environmental and Social Action Plant to determine compliance to IFC Performance Standards and Worldbank EHS Guidelines.
Samancor Chrome Various, South Africa	Independent Environmental Audit of the Samancor Chrome Operations.
AngloGold Ashanti Yatela Gold Plant Kayes Region, Mali	International Cyanide Management Institute Cyanide Code Re-certification Audit.
GammaTec NDT Supplies (Proprietary) Limited Gauteng, South Africa	Phase I Environmental Site Assessment.
Goldfields South Deep Gold Plant Gauteng, South Africa	International Cyanide Management Institute Cyanide Code Re-certification Audit.
Goldfields Damang and Tarkwa Gold Mines Tarkwa, Ghana	International Cyanide Management Institute Cyanide Code Re-certification Audit.
AngloGold Ashanti Siguiri Gold Plant Guinea	International Cyanide Management Institute Cyanide Code Re-certification Audit.
AngloGold Ashanti Noligwa Gold Plant Free State, South Africa	International Cyanide Management Institute Cyanide Code Re-certification Audit.
Barrick Buzwagi, North Mara and Bulyanhulu Gold Mines Tanzania	International Cyanide Management Institute Cyanide Code Re-certification Audit.
Nedbank Capital South Africa	Environmental Assessment in terms of Equator Principles and IFC Standards as part of a comprehensive technical due dilegence for the greenfields mining project in Mpumalanga.
Lonmin Marikana Operations North West, South Africa	Annual Performance Assessment of the Lonmin Marikana Operations' Environmental Management Programme Report.
Lonmin Marikana Concentrator North West, South Africa	Audit in terms of evaluation of compliance for the "Other Requirements" as identified in the Environmental Management System.
Anglo American Platinum South Africa	Independent group tailings environmental risk audit of the Anglo American Platinum Tailings Storage Facilities.

TRAINING

Environmental Management Systems Understanding the Transition to SANS 14001:2015
SABS Training Centre, 2017

ISO 14001:2015 Environmental Management Systems Auditing Based on ISO 19011 and ISO 17021 (SAATCA Approved)
SABS Training Centre, 2017

Project Management Fundamentals
Golder Associates (Internal Training), August 2012

Microsoft Project 2007 Essentials
Bytes Technology Group, 30 November 2011

IEMA Approved Foundation Course in Environmental Auditing (South Africa)
Aspects International, February 2012

Management Review
DQS SA (Pty) Ltd, 2009

Causal Analysis Technique
IRCA Global, 2009

Technical Report Writing
In-house Training for AngloGold Ashanti, 2007

Occupational Health and Safety Law for Managers
North West University, 2003

Project Management
University of Johannesburg, 2003

Internal Environmental Management Auditor Training Course
WSP Walmsley, 2001

Environmental Law
North West University, 2001

Environmental Management Systems (SABS/ISO 14001)
North West University, 2000

PROFESSIONAL AFFILIATIONS

Registered Environmental Assessment Practitioner: Number 2020/1430

Affiliate Member and Environmental Auditor - Institute of Environmental Management and Assessment (IEMA)

Lead and Mining Technical Expert Auditor - Cyanide Management Institute (ICMI)

APPENDIX B

Database of Potentially Interested and Affected Parties

APPLICATION FOR ENVIRONMENTAL AUTHORISATION FOR THE GAMSBERG ZINC MINE NEAR AGGENYS, NORTHENR CAPE			
Title	**NAME**	**SURNAME**	**INSTITUTION**
NATIONAL GOVERNMENT			
Mrs	Nosipho	Ngcaba	Department of Environmental Affairs
Mr	Skumsa	Mancotywa	Department of Forestry, Fisheries and the Environment (DFFE)
MR	Mpho	Tshitangoni	Department of Forestry, Fisheries and the Environment (DFFE)
Ms	Mishelle	Govender	Department of Forestry, Fisheries and the Environment (DFFE)
Dr	Patience	Gwaze	Department of Forestry, Fisheries and the Environment (DFFE)
Mr	Seoka	Lekota	Department of Forestry, Fisheries and the Environment (DFFE)
Mr	Edward	Mahosi	Department of Forestry, Fisheries and the Environment (DFFE)
Mr	Thabo	Mokoena	Department of Mineral Resources and Energy (DMRE)
Mr	Molefe	Morokane	Department of Mineral Resources and Energy (DMRE)
Ms	Ribone	Nkambule	Department of Mineral Resources and Energy (DMRE)
Ms	Mamabefu	Modipa	Department of Mineral Resources and Energy (DMRE)
Ms	Kefilwe	Chibogo	Department of Mineral Resources and Energy (DMRE)
Ms	Michelle	Phenya	Department of Transport
Mr	Tronny	Motsenga	South African National Parks (SANP)
Mr	Thuso	Ndou	Department of Water & Sanitation (DWS) Head Office: Resource Protection & Waste
Ms	Natasha	Higgit	South African Heritage Resources Agency (SAHRA)
REGIONAL GOVERNMENT			
Mr	Leon	October	Department of Agriculture
Mr	Lungi	Modela	Department of Mineral Resources and Energy
Mr	Johannes	Nematatani	Department of Mineral Resources and Energy

Mr	Vincent	Muila	Department of Mineral Resources and Energy
Mr	Ndlelenhle	Zindela	Department of Mineral Resources and Energy
Mrs	Diedre	Karsten	Department of Mineral Resources and Energy
Ms	Lisa	Muller	Department of Social Development
Mr	Shaun	Cloete	Department of Water and Sanitation - Upington
Mr	Tendamudzimu	Rasikhanya	Department of Water and Sanitation - Kimberly
Ms	Lerato	Makhoantle	Department of Water and Sanitation - Kimberly
Mrs	Prudence	Msebenzi	NC District Police
Ms	Margret	Ovengo	South Africa Social Security Agency (SASSA)
PROVINCIAL GOVERNMENT			
Mr	Nico	Cloete	Department of Agriculture, Land Reform and Rural Development
Mr	Shaun	Abrams	Department of Economic Development and Tourism (DEDAT)
Mr	Brian	Fischer	Department of Agriculture, Environmental Agffairs, Rural Development and Land Reform
Mr	O	Gaoraelwe	Department of Agriculture, Environmental Agffairs, Rural Development and Land Reform
Ms	A	Abrahams	Department of Agriculture, Environmental Agffairs, Rural Development and Land Reform
Mr	Wille	De Bruyn	Department of Agriculture, Environmental Agffairs, Rural Development and Land Reform
Ms	B	Lenkoe	Department of Cooperative Governance, Human Settlement and Traditional Affairs
Mr	R	Strydom	Department of Health
Mr	V	Mhlauli	Department of Roads and Public Works
Ms	Claudette	Farmer	Department of Social Development
Ms	Lindi	Ntombela	Department of Transport
DISTRICT MUNICIPALITY			
Mr	Chris	Fortuin	Namakwa District Municipality (NDM)

Mr	Mervin	Cloete	Namakwa District Municipality (NDM)
Mr	Emanual	Smith	Namakwa District Municipality (NDM)
Mr	Denver	Smith	Namakwa District Municipality (NDM)
Ms	Jodine	Cloete	Namakwa District Municipality (NDM)
Mr	Shaun	Abrams	Namakwa District Municipality (NDM)
Ms	Jannie	Loubser	Namakwa District Municipality (NDM)
LOCAL MUNICIPALITY			
Mr	Obakeng J	Isaacs	Khai Ma Municipality
Ms	Estella P	Cloete	Khai Ma Municipality
Mrs	Cacilia	Waterboer	Khai Ma Municipality
Mr	Alexander	Visagie	Khai Ma Municipality
Mr	Pieter	van der Merwe	Khai Ma Municipality - Pofadder
Mr	Nokwakha	Masebeni	Khai Ma Municipality
Mr	Boet	Baker	Khai Ma Municipality
Mr	Hendry	Christian	Khai Ma Municipality
PUBLIC PLACES			
Ms	Petis	Feris	Pofadder Library
Ms	Melissa	Titus	Aggeneys Library
Ms	Shalet	Fredericks	Pella Library
Ms	Maria	Kordom	Khai Ma Municipality/Sending (Onseepkans)
NON-GOVERNMENTAL ORGANISATIONS			

Mr	Danie	Jakob	Agri NamakwaOrganised Agriculture Union - Bushmanland
Mr	Sakkie	Louw	Boesmanland Farmers Union
Ms	Zaiton	Rabaney	Botanical Society of South Africa (BSSA)
Ms	Kotie	Retief	Botanical Society of South Africa (BSSA)
Ms	Melissa	Lewis	Birdlife South Africa
Ms	Melisa	Fourie	Centre for Environmental Rights
Ms	Harriet	Davis-Mostert	Endangered Willdlife Trust (EWT)
Ms	Shelley	Lizzio	Endangered Willdlife Trust (EWT)
Mr	Noel	Oettle	Environmental Monitoring Group
Mr	Stephen	Law	Environmental Monitoring Group
Ms	Rachel	Asante-Owusu	International Union for Conservation of Nature (IUCN)
Ms	Beryl	Wilson	McGregor Museum
Mr	Andy	Pienaar	Namakwaland Action Group/Nago
Ms	Anthea	Stephens	Namakwa Biodiversity Advisory Forum of the South African National Biodiversity Institute (SANBI)
Mr	Peter	Carrick	Namakwa Restoration Institute (NRI)
Mr	Abubakar	Fredericks	National Union of Mineworkers
Mr	Nathan	Williams	Pelladrift Water Board
Mr	Werner Voigt	Werner Voigt	SANBI Karoo Desert National Botanical Garden
Ms	Victoria Wilman	Victoria Wilman	SANBI

Mr	John Manning	John Manning	SANBI
Ms	Shaheeda Davids	Shaheeda Davids	SANBI
Ms	Lubabalo	Ntsholo	SANBI
Mr	Herschelle	Milford	Surplus People Projects
Prof	Andrew	Young	University of Liverpool
Ms	Nikki	Veenstra	Wildlife and Environment Society of South Africa (WESSA)
Ms	Tania	Anderson	WESSA Northern Cape
Mr	J	Brown	WWF
Mr	Edward	Cloete	WYKS Komittee
BUSINESS			
Ms	Anna	Afrikaner	Pella Orange River Resort
Mr	Philip	Desmet	Ecosol
	Dina	Loxton	Working for Water
	Adele	Rossouw	Solidarity
	Abe	Koopman	NAVO Institution
Mr	Eugene	Koeglenberg	Steinweld Supplies
Mr	Pieter	Klaase	Jowells Transport
Ms	Glenda	Goosen	Klein Pella Guest House
Ms	Helene		Trans Oranje Drukkers
Mr	Wimpie		KLK Pofadder
Ms	Vanessa	De Klerk	Botes-Kennedy

Mr	Jaco	Goussard	JCG Water treatment
Mr	Aviv	Garten	Orlight
Mrs	Nirvana	Pillay	Southern Mapping
Mr	Timothy	Ratha	Ngwao Boswa Ya Kapa Bokone (NBKB)
COMMUNITY ENTITIES			
Sr		Van der Colff	Pofadder clinic
Mr	Xavier	Diergaart	Aggeneys Primary School
Mr	Marcillinus	Gail	Pella Community
Mr	Romeo	Ukena	Aggeneys High School
Mr	Ismail	Kolberg	SAPD Forum
Mr	Pieter	Clarke	Community Engagement Forum
Mr	Malcolm	van der Mescht	Futures Forum
Ms	Marie	Felicity	Roman Catholic Church - Pella Projects
Mr	Nico	Jano	Khai Ma Business Forum
Mr	D.J.	Julie	Khai Ma Business Forum
AGGENEYS COMMUNITY			
Mr	Raymond	Harris	Aggeneys Pharmacy
Mrs	Prudence	Cloete	Aggeneys Renovations
Ms	Zenobe	Beukes	IEMAS
Dr	Happy	Shube	Life (BMM Medical Centre)
Mrs	Nicolene	Cloete	NMG

Mr	Steven	Van Niekerk	NMG
Mr	Elmar	Strauss	OK Grocer
Mr	Ryno	Van Niekerk	Build It
Mr	Nico	Maas	Fit IT
Mr	Julian	Bezuidenhoudt	Life (BMM Medical Centre)
Mr	Franz	Exner	Pep Stores
Capt	Elizabeth (Santa)	Plaizier	Police
Ms	Madelein	Visser	Rep & Roer
Father	Angus	Osborne	Roman Catholic Church - Pella
Ms	Lizahn	Louw	Standard Bank
LANDOWNERS/RESIDENTS			
Mr	Alfred	Waterboer	Aggeneys Resident
Mr	Christoffelr	Tienus	Resident
Mr	Abraham	Witbooi	Resident
Mr	Johny C.	Simboya	Transformasie Kommittee
Mr	A.A.	van Wyk	Khai Ma Tourism
Mr	G.P.	Magerman	
Mr	Kasper	Spence	Elneps Konstruksie
Ms	Janice	Links	
Mr	Ronald	Stuurman	Desert Road Inn/ Brabees Portion 2
Mr	Nols	Kennedy	Landowner/Rozynbosch

Mr	Danie	Luttig	Landowner/Farming Community
Mr	Danie	Jacobs	Landowner
Ms	Hester	Maasdorp	Landowner/Bloemhoek - Gamsberg
Mr	Albertus	Roux	Landowner (Blomhoek Plase Pty Ltd)/Bloemhoek - Gamsberg
Mr	Deon	Maasdorp	Landowner/Zuurwater
Mr	Phillip	Strauss	Landowner/Brabees Portion 1
Mr	Gert	Titus	Landowner/Koerus
Mr	Abri	Van Niekerk	Landowner/Koerus
Mr	Jasper Mosterd	Mosterd	Landowner/Witputs
Mr	Gerhard	Visser	Landowner/Vogelstruishoek
Mr	Pieter-Jan	Pieter-Jan	Landowner
Mr	Deon	Pietersen	Farmer - Rental
Mr	Tertius	Visser	Landowner
Mr	Johan	van Dyk	Landowner
ORGANS OF STATE/PARASTATALS			
Ms	Ethel	Coetzee	Transnet National Ports Authority
Mr	Lyndon	Metcalf	National Ports Authority
Mr	Nicole	Abrahams	SANRAL
BLACK MOUNTAIN MININNG			
Mr	Neil	MacDonald	Black Mountain Mining
Mr	Markus	Schaefer	VZI

Mr	Kobus	Zandberg	Black Mountain Mining
	Clecinda	Clarke	Black Mountain Mining
Mr	Charles	Klopper	Black Mountain Mining
Ms	Anne-marie	Cloete	Black Mountain Mining
Mr	Lance	Williamson	Black Mountain Mining
Mr	Jacobus HL	Smit	Black Mountain Mining
Mr	Westley	Price	Black Mountain Mining
Mr	Alan	Johnson	Black Mountain Mining
Mr	Pieter David	Venter	Black Mountain Mining

APPENDIX C

Stakeholder Letter, Registration and Comment Sheet

May 2022 Project No. 21466019

NOTICE OF THE INTEGRATED REGULATORY PROCESS FOR THE PROPOSED ADDITIONAL INFRASTRUCTURE FOR THE GAMSBERG ZINC MINE 10 MILLION TON PER ANNUM OPERATION NEAR AGGENYS, NORTHERN CAPE PROVINCE

- Draft Basic Assessment Report available for public review

Dear Stakeholder,

Black Mountain Mining (Pty) Ltd. (BMM), a subsidiary of Vedanta Zinc International (VZI), operates the Black Mountain Mining Complex consisting of the underground Black Mountain Mine operations, Deeps, Swartberg, and the opencast Gamsberg Zinc Mine. The Black Mountain Mine complex mines zinc, lead, silver and copper and hoist 1.7 million tonnes (mt) of ore a year with a current production capacity of 90 000 tonnes per annum (tpa) metal-in-concentrate.

The Gamsberg Zinc Mine came into operation in June 2016 and mines approximately 4 million tonnes per annum (mtpa) and produces 250-300 tonnes per annum (tpa) of zinc concentrate per annum.

The mine is situated in the Namakwa District, Northern Cape and is approximately 120 km east of Springbok and approximately 270 km from Upington, between the towns of Aggeneys and Pofadder adjacent to the N14 national road. The Gamsberg Zinc Mine is located over three properties, namely Portion 1 of the farm Bloemhoek 61, Portion 1 of the farm Gams 60 and Portion 0 of farm Aroams 57.

BMM plans to mine a total of 150 mt of ore from the Gamsberg Zinc Mine over the Life of Mine (LoM). Of this expected LoM tonnage, approximately 18 mt of zinc concentrate will be extracted. Based on the relatively low grade of the zinc deposit, the treatment process will generate approximately 132 mt of tailings and approximately 1.5 billion tons of waste rock over the LoM.

The treatment of Run of Mine (ROM) ore at a current rate of 4.5 mt per annum with plans to increase to the planned 10 mt per annum at the processing plant yields about 9 mt per annum of tailings material which is disposed of at a tailings storage facility (TSF) located north of the N14 national road.

FUTURE INFRASTRUCTURE REQUIREMENTS

A number of existing environmental related authorisations are in place for the Gamsberg Zinc Mine. Furthermore, a permitting process was completed for the Gamsberg Smelter in 2020.

The mine currently requires further environmental related applications to authorise additional activities that are required for ongoing operations and which were not included in the previous authorisations, as well as changes

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Reg. No. 2002/007104/07
Directors: RGM Heath, MQ Mokulubete, MC Mazibuko (Mondli Colbert), GYW Ngoma

required in infrastructure layout as a result of optimised planning. These activities require an Environmental Authorisation (EA) as contemplated under Section 24 of the National Environmental Management Act, 1998 (Act 107 of 1998) (NEMA) (as amended), water use authorisation in terms of Chapter 4 of the National Water Act, 1998 (Act 36 of 1998) (NWA) and an Atmospheric Emission Licence (AEL) in terms of Section 38(3)(b) of the National Environmental Management: Ari Quality Act (Act No. 39 of 2004).

PROPOSED INFRASTRUCTURE DEVELOPMENTS

New potable water pipeline

A new above-ground potable water pipeline is proposed to run from the Horseshoe dam to the processing plant. This pipeline will be developed in an existing servitude already in use for pipelines transporting water from Sedibeng Water to the mine. The location where the pipeline is proposed to be developed has already been cleared of vegetation as it is within a road reserve. The proposed pipeline will be installed above-ground and will have an inside diameter of 400 mm, an outside diameter of 460 mm, a throughput of 460 m^3/hour and will be approximately 7 km in length. The entire pipeline will belong to Gamsberg Mine.

Expansion of dangerous goods storage facilities

To support the ongoing operations at Gamsberg Mine, an increase in storage capacity will be required for the following dangerous goods storage facilities:

- Fuel storage capacity which is proposed to increase from 600 m^3 to 1 200 m^3.
- Emulsion storage is proposed to be increased from 2 x 85t silos and 2 x 50t silos to 2 x 100t and 2 x 200t silos respectively.

Clean runoff attenuation system

To minimise pollution from the waste rock dump, ROM pad, crushers and conveyer infrastructure associated with the phase 1 and 2 plant infrastructure, it is proposed that the flow of the ephemeral riverbed that passes between the processing plant and the mining operations be altered.

The clean runoff attenuation system will include the construction of an attenuation weir, diversion berms, two above-ground pipelines for conveying any upstream runoff past the impacted area (processing plant and the mining operations) and an energy dispersion outlet structure. The altered section will be approximately 1.5 km in length.

The alteration will be in place for the duration of the operational phase of the mine and will then be rehabilitated during the decommissioning and closure phase.

The clean water attenuation system will require water use authorisation in terms of Chapter 4 of the NWA.

Refined layout for the waste rock dump and quartzite rock dump/berm

A waste rock dump facility, with a capacity to store 1.5 billion tons of waste rock on an area of 490 ha, is approved in the *Environmental and Social Impact Assessment (ESIA) Report for the Gamsberg Zinc Mine and Associated Infrastructure in the Northern Cape* (June 2013). It constitutes a permissible water use in terms of Gamsberg Zinc Mine, WUL No.14/D82C/ABCGIJ/2654.

In addition to the main waste rock dump facility and in order to mitigate the impacts on biodiversity as a result of the basin/crater mining activities, it was recommended that a rock dump / berm, comprising only quartzite rock, be designed and constructed to shield the remainder of the basin / crater from mining activities. It is

detailed in the *Environmental Management Programme (EMPr) for the Gamsberg Zinc Mine and Associated Infrastructure in the Northern Cape* (May 2013), that the berm should be constructed to the same elevation as the plateau comprising a non-acid leaching rock core and a quartzite rock outer layer. It is further stated that the placement of the barrier must be defined with input from a qualified botanist and the engineering team prior to the placement of the rock.

The Gamsberg Zinc Mine engineering team has refined the layout of the current waste rock to optimise the placement of waste rock, to avoid current mine infrastructure and to ensure safe operation of the facility. The updated waste rock dump layout is based on the storage capacity and footprint as approved in the 2013 ESIA and EMPr.

The 2013 EMPr does not include a final position and layout of the biodiversity protection rock dump / berm. The engineering team, in consultation with the biodiversity specialist has defined the final layout and position.

The updated waste rock dump layout and position of the biodiversity rock dump / berm will be included in the Basic Assessment Report.

The crater berm will form part of the crater storm water management system which is already authorised. This water use constitutes a permissible water use in terms of Gamsberg Zinc Mine WUL, No.14/D82C/ABCGIJ/2654.

Define layout for the crusher and coarse ore stockpile for plant phase 2

The 2013 ESIA states that the full production capacity of the mine will be 10 mtpa ore. This capacity will be reached in a modular approach following the mine ramp-up plan as described in the report. It is stated that the current concentrator plant will be ramped up in three modules to full capacity. It is indicated that the three phases of the concentrator plant will each consist of a concentrator stream with supporting utility and supporting infrastructure.

An amended concentrator plant boundary and shortened conveyor route was approved in the *Gamsberg Mine Environmental Management Programme Amendment* (December 2016). The information was presented at a high level and did not differentiate between the infrastructure components required for the three plant modules.

The Gamsberg Zinc Mine engineering team has defined the phase 2 plant components in preparation for construction. The updated conveyor and phase 2 concentrator plant layout will be included in the Basic Assessment Report.

Project Motivation

Black Mountain Mining (Pty) Ltd Gamsberg Zinc Mine obtained approval for a 10 mtpa open pit zinc mine under the NEMA during 2013 and in its Water Use Licence WUL, No.14/D82C/ABCGIJ/2654, dated 30 September 2014 (as amended) on 14 April 2016. It included approval for a concentrator plant and associated infrastructure, mining workshops and a tailings storage facility.

The open pit was developed in 2016 and the concentrator plant (phase 1) was constructed and commissioned in 2019. The initial mine and infrastructure development, referred to as phase 1, resulted in an operation capable of processing 4.8 mtpa.

Project approval was obtained internally to commence with the implementation of the second phase, referred to as phase 2, which entails the construction of the second stream of the concentrator plant and expanding the tailings storage facility to the full authorized footprint.

To ensure realisation of the full capacity of the approved 10 million ton mine, an environmental authorisation is required for additional infrastructure to improve the efficiency of the mining operations.

Expanding the mine to the full authorised capacity will realise the full social and financial benefit as indicated in the original EIA for the Gamsberg Zinc Mine.

ENVIRONMENTAL AUTHORISATION PROCESS

In terms of the National Environmental Management Act 107 of 1998 (NEMA) (as amended) and the Environmental Impact Assessment Regulations, 2014 (as amended), Gamsberg Zinc Mine is required to undertake a Basic Assessment Process and submit a Basic Assessment Report (BAR) and Environmental Management Programme (EMPr). The EMPr describes the potential environmental impacts of the proposed additional infrastructure and activities and how they will be mitigated and managed, to the competent authority for decision making. The competent authority responsible for the decision on whether to grant environmental authorisation is the Northern Cape Department of Mineral Resources and Energy (DMRE).

Gamsberg Mine also intends to submit an application for water use authorisation to the Department of Water and Sanitation (DWS) for water uses as specified in section 21(c) and (i) of the NWA. These water uses include:

- Section 21 (c) impeding or diverting the flow of water in a watercourse.
- Section 21 (i) altering the bed, banks, course or characteristics of a watercourse.

Additional to the water use licence, Gamsberg Zinc Mine also intends to submit an AEL for the fuel storage capacity on site which is proposed to increase from 600 m^3 to 1 200 m^3, thus triggering *Category 2 (Petroleum Industry, the production of gaseous and liquid fuels as well as petrochemicals from crude oil, coal, gas or biomass), Subcategory 2.4 for Storage and Handling of Petroleum Products*. This pertains to all permanent immobile liquid storage facilities at a single site with a combined storage capacity of greater than 1 000 m^3.

Gamsberg Mine has appointed Golder Associates Africa (Pty) Ltd (Golder), now a member of WSP, an independent environmental and engineering consulting firm, to undertake the environmental authorisation process and application for water use and the AEL authorisation.

Invitation to register as an I&AP, to comment and attend a public meeting

Stakeholders are invited to register as Interested and Affected Parties (I&APs) and to participate in the environmental authorisation process by commenting on the proposed Basic Assessment Process as follows:

- Completing the enclosed Registration and Comment Sheet and return it to the Golder PP Office by post or email.
- Providing comments on the proposed project, draft Basic Assessment Report by contacting the Public Participation Office telephonically, by email or post.

I&APs are invited to register as stakeholders and comment on the draft Basic Assessment Report which is available for public review and comment for a period of 30 days from **Friday, 27 May 2022 until Monday, 27 June 2022**.

Printed copies of the draft Basic Assessment Report are available at the public places listed below. This background information letter and the draft Basic Assessment Report can be downloaded from the following websites: https://www.golder.com/global-locations/africa/south-africa-public-documents/ or https://vedanta-zincinternational.com/sustainability/reports/

Name of Public Place	Contact Number
Pofadder Library, Loop Straat, Pofadder	054 933 0221
Aggeneys Library, Havelock Avenue, Aggeneys	054 983 2551
Pella Library, 129 Cathedral Street, Pella	054 971 0174
Khai-Ma Municipality/Sending (Onseepkans), R C Mission	054 933 1000
Black Mountain Mining, 1 Penge Road, Aggeneys	054 983 9373
Golder Associates Africa, Maxwell Office Park, Magwa Crescent West, Waterfall City	011 254 4800

A Focus Group Meeting is not planned at this stage however, if I&APs request such a meeting, it will be considered.

We would like to encourage you to actively participate in the environmental authorisation process. Should you wish to obtain more information to comment, please contact the Golder Public Participation (PP) office at (011) 254 4800, fax: 086 582 1561 or email: PPoffice@golder.co.za.

WAY FORWARD

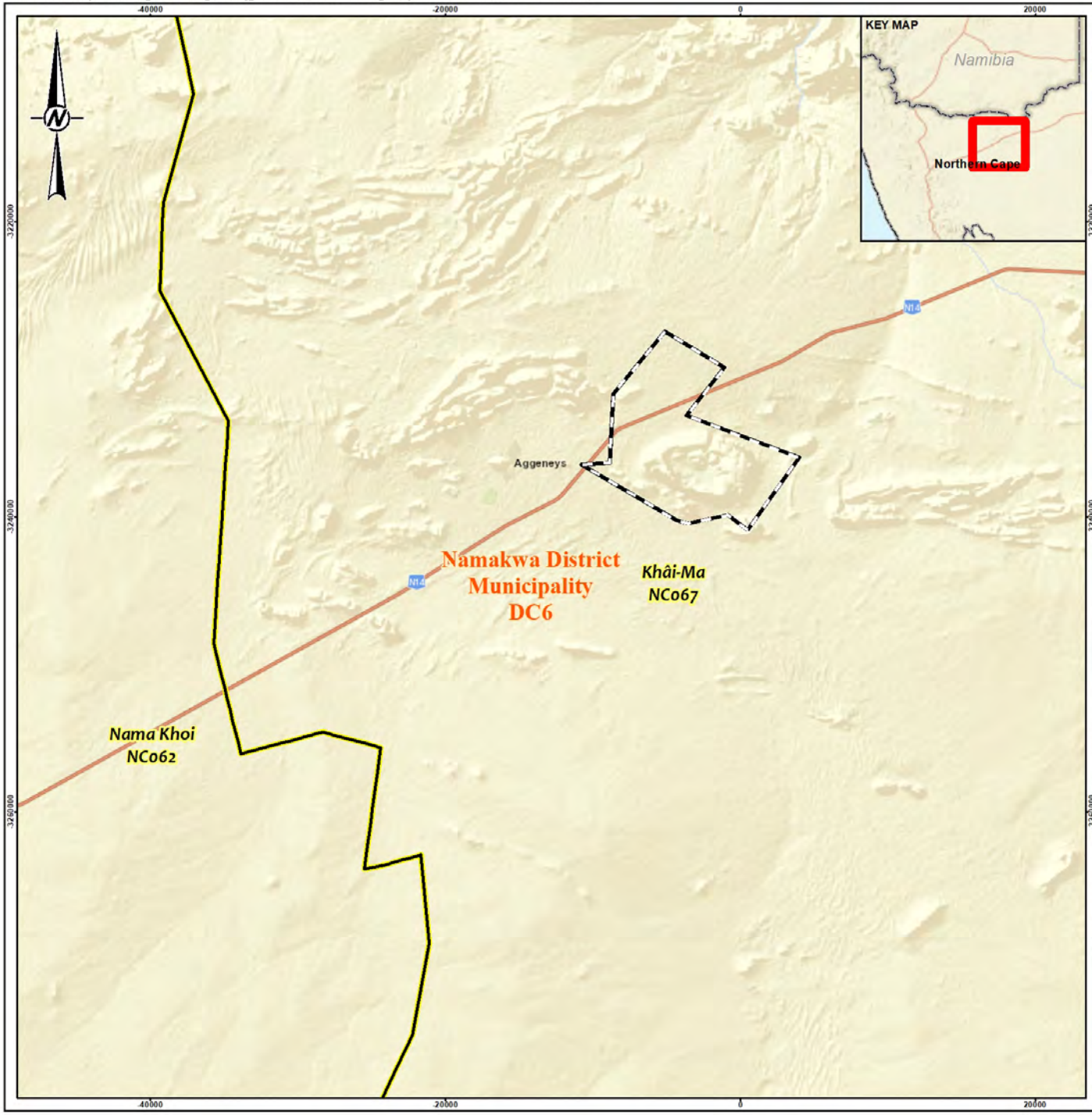
After the public review period on the draft Basic Assessment Report has closed, the report will be updated and submitted to the Northern Cape DMRE for decision making.

Yours sincerely,

Golder Associates Africa (Pty) Ltd.

Attachments: Locality Map
Registration and Comment Sheet

PATH: S:\GIS\Gis Projects\21466019_BlackMountain_Gamsberg_ESIA\MXD\2022\Feb22\21466019_Locality.mxd PRINTED ON: 2022-05-06 AT: 11:08:26 AM



LEGEND

- Gamsberg (ML 5/2000)
- Local Municipalities

0 10 000 20 000

1:400 000 METRES

NOTE(S)

1. LINE NOTES
2. LINE NOTES
3. LINE NOTES

REFERENCE(S)

1. COORDINATE SYSTEM: WGS LO19
2. SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, GARMIN, USGS, INTERMAP, INCREMENT P, NRCAN, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), ESRI KOREA, ESRI (THAILAND), NGCC, (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY

CLIENT
VEDANTA

PROJECT
GAMSBERG ESIA

TITLE
LOCALITY

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022/05/06
DESIGNED	
PREPARED	TS
REVIEWED	NM
APPROVED	MS

PROJECT NO.	CONTROL	REV.	FIGURE
21466019			

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET HAS BEEN MODIFIED FROM: ISO A4

BASIC ASSESSMENT PROCESS AND APPLICATION FOR WATER USE AUTHORISATION AND ATMOSPHERIC EMISSION LICENCE FOR THE PROPOSED ADDITIONAL INFRASTRUCTURE FOR THE GAMSBERG 10 MILLION TON PER ANNUM OPERATION NEAR AGGENYS, NAMAKWA DISTRICT, NORTHERN CAPE

Registration and Comment Sheet

GOLDER MEMBER OF WSP

Draft Basic Assessment Report Review Period: Friday, 27 May 2022 to 27 June 2022

Your comments make an important contribution to these permitting processes. We would like to encourage you to register as an Interested and Affected Party (I&AP) so that we can keep you updated and can respond to any questions or concerns that you may have.

PERSONAL DETAILS			
Name	**Surname**	**Title**	**Organisation / Department / Farm/ Community** ***(If applicable)***

Contact Details	
Mobile Number	
Office Number	
Home Number	
Fax Number	
Email Address	

Postal Address	**Postal code**			

Golder, a member of WSP, will not share personal information with a third party

LANDOWNERS	
If your property is adjacent to Gamsberg Zinc Mine, please tell us your farm name and erf/portion number	

WOULD YOU LIKE TO REGISTER AS AN INTERESTED AND AFFECTED PARTY? (Mark with an X)	**YES**	**NO**

Preferred Method of Communication (Mark with an X)	**Post**	**Email**	**Fax**

In terms of the EIA Regulations, 2014 (as amended), I disclose below any direct business, financial, personal or other interest that I may have in the approval or refusal of the application:	**Date**	
	Signature	

For internal use to confirm capture of stakeholder details into the stakeholder database	
Stakeholder database reference number	Signature of data capturer

COMMENT(S)

You are welcome to use additional pages should you so wish to do so.

I have the following comments to make regarding the proposed project:

Please ask the following of my colleagues / friends to register as Interested and Affected Parties:

NAME	CONTACT DETAILS

PLEASE RETURN THE REGISTRATION AND COMMENT SHEET TO:

Public Participation Office
Golder Associates Africa (Pty) Ltd
PO Box 6001, Halfway House, 1685
Tel: (011) 254 4800; Fax: (086) 582 1561
E-mail: gld.pp@wsp.com
Reference: 21466019

GOLDER
MEMBER OF WSP

THANK YOU

APPENDIX D

Advertisement and Site Notice

NOTICE OF A BASIC ASSESSMENT PROCESS, APPLICATION FOR WATER USE AUTHORISATION AND ATMOSPHERIC EMISSION LICENCE FOR THE PROPOSED ADDITIONAL INFRASTRUCTURE FOR THE GAMSBERG 10 MILLION TON PER ANNUM OPERATION NEAR AGGENYS, NAMAKWA DISTRICT, NORTHERN CAPE PROVINCE

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Black Mountain Mining (Pty) Ltd. (BMM), a subsidiary of Vedanta Zinc International (VZI), operates the Black Mountain Complex mining cluster consisting of the underground Black Mountain Mine operations, Deeps and Swartberg, and the opencast Gamsberg Zinc Mine. Gamsberg Zinc Mine is applying for environmental authorisation to undertake a number of listed activities and water uses at its existing opencast mining operations. The mine is situated in the Namakwa District in the Northern Cape and is approximately 120 km east of Springbok and approximately 270 km from Upington, between the towns of Aggeneys and Pofadder. The Gamsberg Zinc Mine is located over three properties namely, Portion 1 of the farm Bloemhoek 61, Portion 1 of the farm Gams 60 and Portion 0 of farm Aroams 57. Applications for environmental authorisation, water use authorisation and an Atmospheric Emission Licence (AEL) are required before additional infrastructure can be constructed.

This advertisement serves to notify landowners and/or interested and affected parties (I&APs) that, in terms of NEMA and the Environmental Impact Assessment Regulations 2014 (as amended), Gamsberg Zinc Mine is required to undertake a Basic Assessment process and submit a Basic Assessment Report and an Environmental Management Programme (EMPr). These documents will describe the potential environmental impacts of the proposed additional infrastructure and activities and how impacts will be mitigated and managed. The competent authority responsible for the decision regarding environmental authorisation is the Northern Cape Department of Mineral Resources and Energy (DMRE). A Draft Basic Assessment Report is now available for public review and comment.

Gamsberg Zinc Mine also intends to submit an application for water use authorisation to the Department of Water and Sanitation (DWS) for water uses as specified in section 21(c) (and (i) of the National Water Act 36 of 1998 (NWA), associated with the clean runoff attenuation system. These water uses include:

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Gamsberg Zinc Mine has appointed Golder Associates Africa (Pty) Ltd (Golder), now a member of WSP, an independent environmental and engineering consulting firm, to undertake the environmental authorisation process and application for water use authorisation and an AEL.

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Name of Public Place	Contact Number
Pofadder Library, Loop Straat, Pofadder	054 933 0221
Aggeneys Library, Havelock Avenue, Aggeneys	054 983 2551
Pella Library, 129 Cathedral Street, Pella	054 971 0174
Khai-Ma Municipality/Sending (Onseepkans), R C Mission	054 933 1000
Black Mountain Mining, 1 Penge Road, Aggeneys	054 983 9373
Golder Associates Africa, Maxwell Office Park, Magwa Crescent West, Waterfall City	011 254 4800

FOR MORE INFORMATION, PLEASE CONTACT:

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Reference: 21466019

GOLDER
MEMBER OF WSP

Date of the advert: 27 May 2022

KENNISGEWING VAN 'n BASIESE EVALUERINGSPROSES, AANSOEK OM WATERGEBRUIKMAGTIGING EN LUGVRYSTELLINGSLISENSIE VIR DIE VOORGESTELDE BYKOMENDE INFRASTRUKTUUR VIR DIE GAMSBERG 10 MILJOEN TON PER JAAR-BEDRYWIGHEDE, NAMAKWA DISTRIK, NOORD-KAAP PROVINSIE.

Kennisgewing uitgereik ingevolge die Wet op Nasionale Omgewingsbestuur 1998 (Wet 107 van 1998)(NEMA), die Omgewingsimpakstudieregulasies, 2014 (soos gewysig), die Nasionale Waterwet, 1998 (Wet 36 van 1998)(NWA) en die Wet op Nasionale Omgewingsbestuur: Luggehalte, 2004 (Wet 39 van 2004)(NEM:AQA)

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Hierdie advertensie het ten doel om grondeienaars en/of belangstellende en geaffekteerde partye (B&GP'e) in kennis te stel ingevolge die NEMA en die Omgewingsimpakbepalingsregulasies, 2014 (soos gewysig), dat daar van Gamsberg Sinkmyn vereis word om 'n Basiese Evalueringsproses te onderneem en 'n Basiese Evalueringsverslag en Omgewingsbestuursprogram in te dien. Hierdie dokumente beskryf wat die potensiële omgewingsimpakte van die voorgestelde bykomende infrastruktuur en aktiwiteite kan wees en hoe dit versag en bestuur sal word. Die besluitnemende owerheid, verantwoordelik vir die besluit rakende omgewingsmagtiging, is die Noord-Kaapse Departement van Minerale Bronne en Energie (DMRE). 'n Konsep Basiese Evalueringsverslag is nou beskikbaar vir publieke hersiening en kommentaar.

Gamsberg Sinkmyn beoog ook om 'n aansoek om watergebruikmagtiging by die Departement van Water en Sanitasie (DWS) in te dien vir watergebruike soos gespesifiseer in Artikel 21(c) en (i) van die Nasional Waterwet. Hierdie watergebruike sluit in:

- Artikel 21 (c) die belemmering of afleiding van die vloei van water in 'n river.
- Artikel 21 (i) verandering van die bedding, walle, loop of kenmerke van 'n river.

Bykomend tot die watergebruikslisensie, beoog Gamsberg Sinkmyn ook om 'n aansoek vir 'n Lugvrystellingslisense in te dien vir die vergroting van die huidige brandstof en emulsie bergingsinfrastruktuur van 600 m^3 tot 1200 m^3 te vermeerder, ingevolge *Kategorie 2 (Petroleumnywerheid, die produksie van gasvormige en vloeibare brandstowwe asook petrochemikalieë uit ru-olie, steenkool, gas of biomassa), Subkategorie 2.4 vir Berging en Hantering van Petroleumprodukte*. Dit het betrekking op alle permanente onbeweeglike vloeistofbergingsfasiliteite op 'n enkele perseel met 'n gesamentlike bergingskapasiteit van meer as 1000 m^3.

Gamsberg Myn het Golder Associates Africa (Edms) Bpk (Golder), nou 'n lid van WSP, 'n onafhanklike omgewings- en ingenieursadviesfirma, aangestel om die omgewingsmagtigingsproses en aansoek vir watergebruik en die Lugvrystellingslisensie te onderneem.

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OPENBARE PLEK	KONTAK NOMMER
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VIR MEER INLIGTING, KONTAK ASSEBLIEF:
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Posbus 6001, Halfway House, 1685
Tel: (011) 254 4800; Faks: (086) 582 1561
E-pos: gld.pp@wsp.com
Verwysing: 21466019

GOLDER
MEMBER OF WSP

Datum van advertensie: 27 May 2022

NOTICE

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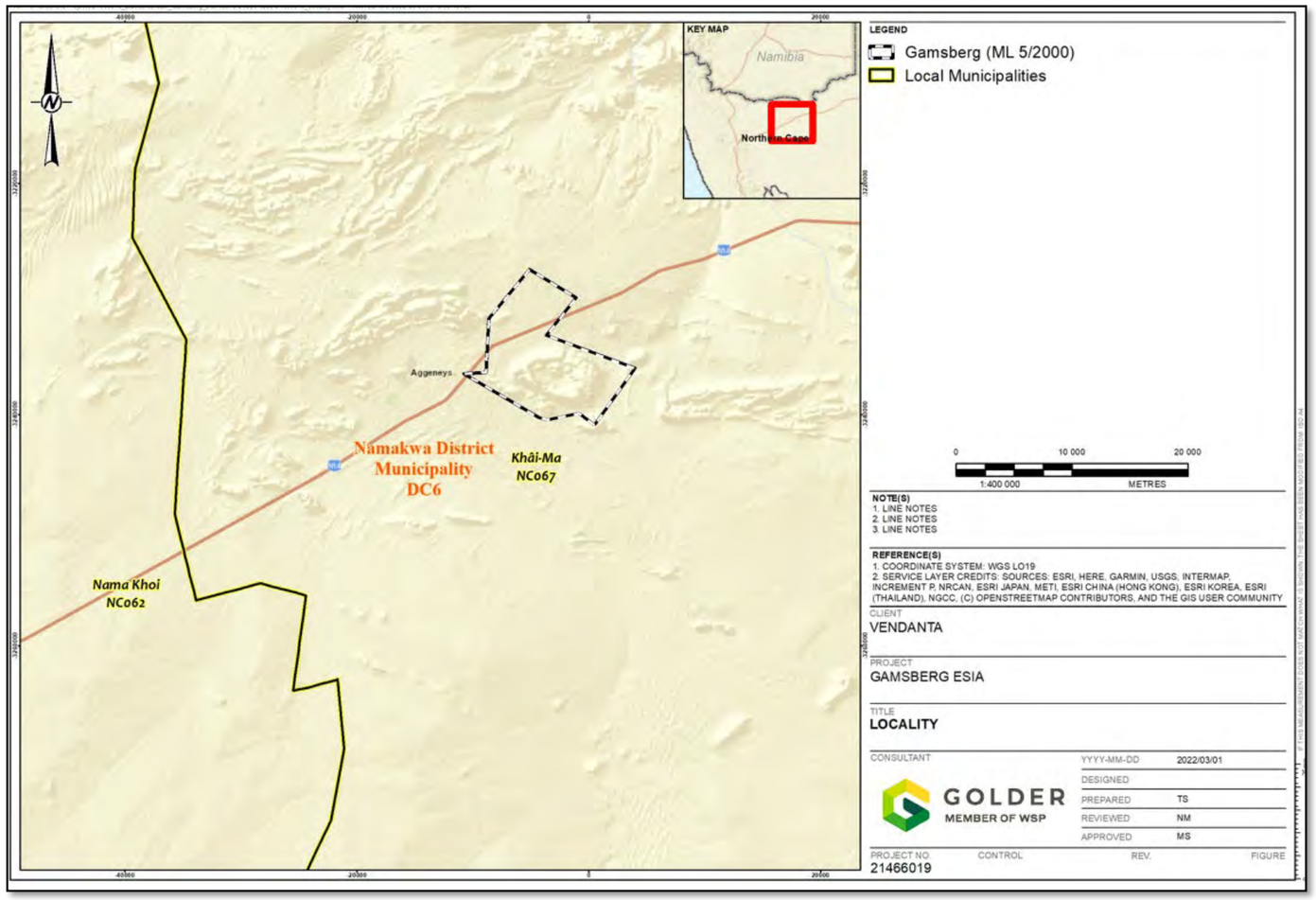

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Date of notice: 27 May 2022

KENNISGEWING

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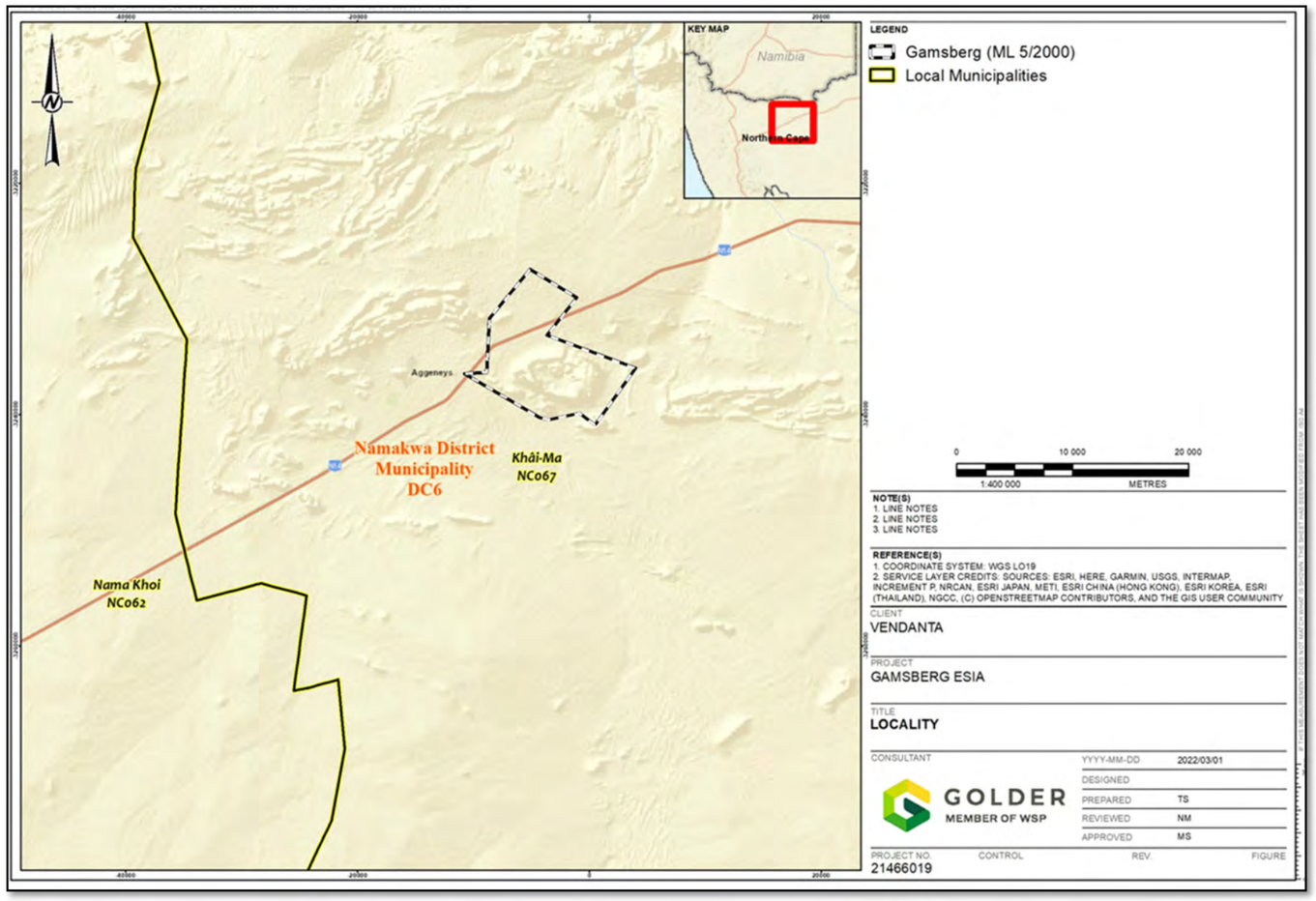

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Gedrukte kopieë van die konsep Basiese Assesseringsverslag is beskikbaar by die openbare plekke hieronder gelys.

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VIR MEER INLIGTING, KONTAK ASSEBLIEF:

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GOLDER
MEMBER OF WSP

Datum van kennisgewing: 27 Mei 2022

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APPENDIX E

Comments and Response Report

(will be included in Final BAR)

APPENDIX F

Air Quality Impact Assessment Report

REPORT

Atmospheric Baseline and Impact Assessment Report for the Gamsberg Expansion Project

Black Mountain Mining (Pty) Ltd

Submitted to:

Black Mountain Mining (Pty) Ltd
1 Penge Road
Aggeneys
8893

Submitted by:

Golder Associates Africa (Pty) Ltd.

Building 1, Maxwell Office Park, Magwa Crescent West, Waterfall City, Midrand, 1685, South Africa
P.O. Box 6001, Halfway House, 1685

+27 11 254 4800

21466019-351699-2

May 2022

Distribution List

1 x electronic copy to Black Mountain Mining (Pty) Ltd

1 x electronic copy to Project Reports@golder.co.za

Record of Issue

Author	Reviewer	Version	Date Issued	Method of Delivery
Novania Reddy	Marie Schlechter	Draft	7 April 2022	Electronic Copy
Novania Reddy	Marie Schlechter	Final	12 April 2022	Electronic Copy
Novania Reddy	Marie Schlechter	Final	04 May 2022	Electronic Copy

Executive Summary

Overview

Black Mountain Mining (Pty) Ltd. (BMM), a subsidiary of Vedanta Zinc International (VZI), operates the Black Mountain Complex cluster consisting of the underground Black Mountain Mine operations, Deeps and Swartberg, and the opencast Gamsberg Zinc Mine. The Black Mountain Mine complex mines zinc, lead, silver and copper and hoists 1.7 million tonnes (mt) of ore a year with a current production capacity of 90 000 tonnes per annum (tpa) metal-in-concentrate. The Gamsberg Zinc Mine came into operation in June 2016 and mines approximately 4 million tonnes per annum (mta) and produces 250-300 tpa of zinc concentrate per annum.

Gamsberg Zinc Mine is located over three properties, which are owned by BMM. The mine is situated in the Namakwa District, Northern Cape and is approximately 120 km east of Springbok and approximately 270 km from Upington, between the towns of Aggeneys and Pofadder.

A number of existing environmental related authorisations are in place for the Gamsberg Zinc Mine. Furthermore, a permitting process was recently completed for the proposed Gamsberg Smelter. The mine currently requires further environmental related applications to authorise additional activities that are required for ongoing operations and were not included in the previous authorisations.

These proposed activities require regulatory approval prior to commencement. BMM has therefore requested that Golder Associates Africa (Pty) Ltd (Golder), a member of WSP Group Africa (Pty) Ltd (WSP), to undertake the required regulatory approval process. As part of this process, an Atmospheric Emission Licence (AEL) Amendment, with appended Air Quality Impact Assessment (AQIA), in the prescribed Atmospheric Impact Report (AIR) format, for the proposed activity changes, are required. This report therefore presents the AIR undertaken in support of the process.

Method

The approach to the AIR included the following key activities:

- Compilation of a baseline assessment which included a geographic overview and a review of available meteorological and ambient data.
- Development of an emissions inventory for the identified key pollutants from the proposed Gamsberg Mine additional infrastructure and activities.
- Dispersion simulations were undertaken with the Level 2 atmospheric dispersion model, AERMOD, to calculate predicted ambient air concentrations at specified sensitive receptors as a result of the proposed additional infrastructure and activities.
- The predicted short-term and long-term average concentrations were then compared with the relevant National Ambient Air Quality Standards (NAAQS) and National Dust Control Regulations (NDCR).
- Recommended practical mitigation measures were proposed to reduce the impacts to within acceptable levels where required.

Previous Assessment and Current Results

Modelling simulations to determine particulate matter of aerodynamic diameter 10 and 2.5 microns (PM_{10} and $PM_{2.5}$), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), zinc (Zn), lead (Pb) concentrations and dust fallout from the Gamsberg Mine project activities was undertaken in 2020 by Airshed for the proposed Gamsberg Smelter project. Two scenarios were simulated, namely baseline mining operations and cumulative baseline and

proposed project operations, in order to understand the incremental increase in impacts due to the proposed Gamsberg Smelter project. The following was deduced from the results:

- The incremental increase in $PM_{2.5}$, PM_{10} concentrations and total dust deposition from baseline to proposed project operations was negligible;
- Cumulative $PM_{2.5}$ and PM_{10} concentrations were in compliance with the NAAQS at all sensitive receptors within the study area for all averaging periods;
- Cumulative dust fallout levels were within the dust control guidelines for residential areas at all sensitive receptors within the study area;
- Simulated Pb, NO_2 and SO_2 concentrations due to project activities, were within the NAAQS at all sensitive receptors within the study area for all averaging periods;
- The highest Zn concentrations were below the most stringent health effect screening levels;
- The highest concentrations for dioxins due to the project was 1.2 E-09 µg/m³ which was considered to be “very low”; and
- No recent background concentrations were available for Pb, NO_2, SO_2 and dioxins. As such cumulative impacts for these pollutants could not be determined. However, given the type of existing sources within the project study it is likely that the cumulative impacts will be insignificant/minimal.

Given the proposed Gamsberg Mine additional infrastructure and activities project (i.e the implementation of the ore stockpile, crusher for the 2nd phase of the concentrator plant and expansion of the fuel storage on site), dust fallout, PM_{10}, $PM_{2.5}$ and volatile organic compounds (VOCs) will be emitted into the atmosphere. As such, only the dust fallout, PM_{10}, $PM_{2.5}$ and VOCs were modelled in this current assessment as the previous results, as per the Gamsberg Smelter AQIA i(Airshed, 2020), will still apply for all other pollutants associated with the Gamsberg Mine operations.

The following were noted from the proposed Gamsberg Mine additional infrastructure and activities:

- Dust fallout levels:
  - The highest predicted offsite dust fallout rate was well below the Residential Dust Control Regulations of 600 mg/m^2/day.
  - Predicted dust fallout rates were well below the Residential Dust Control Regulations at all sensitive receptors.
  - The background dust fallout rates from the Gamsberg Smelter AQIA undertaken in 2020 by Airshed (i.e. mining operations inclusive of the smelter operations) indicated dust fallout rates that were below the Residential Dust Control Regulations of 600 mg/m^2/day beyond the Gamsberg boundary. As such, with the minimal increase of the additional infrastructure and activities, cumulative impacts are also expected to be below the Residential Dust Control Regulations at all receptors.
- Particulate matter concentrations:
  - The highest predicted offsite 99th percentile (P99) 24-hour average and annual average PM_{10} and $PM_{2.5}$ concentrations were below their PM_{10} and $PM_{2.5}$ NAAQS.
  - Predicted PM_{10} and $PM_{2.5}$ concentrations were also below their NAAQS for PM_{10} and $PM_{2.5}$ at all sensitive receptors for all assessment periods.

- The background PM_{10} and $PM_{2.5}$ concentrations from the Gamsberg Smelter AQIA undertaken in 2020 by Airshed (i.e. mining operations inclusive of the smelter operations) indicated PM_{10} and $PM_{2.5}$ concentrations that were below their relevant NAAQS beyond the Gamsberg Mine boundary. As such, with the low increase of the additional infrastructure and activities, cumulative impacts are also expected to be below the NAAQS.

- VOC concentrations:
  - The highest predicted offsite annual average VOC concentrations for both the existing and proposed scenarios were well below the annual average benzene (C_6H_6) NAAQS of 5 µg/m^3 (C_6H_6 standard was used in the absence of a VOC specific standard).
  - Predicted annual average VOC concentrations for both scenarios were also below the annual average C_6H_6 NAAQS at all surrounding sensitive receptors.
  - VOC cumulative impacts will therefore be insignificant/minimal.

Impacts

Impacts from the proposed Gamsberg Mine additional infrastructure and activities are expected to be low.

Recommendation

Given the low impacts predicted at the sensitive receptors during the operational phase of the project, Golder's professional opinion is that this project can be authorised, with the recommended mitigation measures being considered and maintained throughout the project lifecycle.

List of Abbreviations and Terms	
AEL	Atmospheric Emission License
AIR	Atmospheric Impact Report
AQIA	Air Quality Impact Assessment
BMM	Black Mountain Mining (Pty) Ltd
CO	Carbon Monoxide
CO_2	Carbon Dioxide
EA	Environmental Authorisation
EIA	Environmental Impact Assessment
EMPr	Environmental Management Programme
Golder	Golder Associates Africa (Pty) Ltd
HAP	Hazardous Air Pollutant
LoM	Life of Mine
MES	Minimum Emission Standard
MRI	Mining Right Area
NAAQS	National Ambient Air Quality Standard
NEM:AQA	National Environmental Management: Air Quality Act (Act no. 39 of 2004)
NEMA	National Environmental Management Act, 1998 (Act 107 of 1998)
NO_2	Nitrogen Dioxide
NO_x	Oxides of Nitrogen
Pb	Lead
ROM	Run-of-mine
SANAS	South African National Accreditation System
SO_2	Sulphur Dioxide
STRM	Shuttle Radar Topography Mission
TSF	Tailings Storage Facility
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound
VZI	Vedanta Zinc International
WRF	Weather Research and Forecasting
WSP	WSP Group Africa (Pty) Ltd
Zn	Zinc

Table of Contents

TABLES

FIGURES

APPENDICES

APPENDIX A
Impact Assessment Criteria

APPENDIX B
Document Limitations

APPENDIX C
Formal Declarations

1.0 INTRODUCTION

Black Mountain Mining (Pty) Ltd. (BMM), a subsidiary of Vedanta Zinc International (VZI), operates the Black Mountain Complex cluster consisting of the underground Black Mountain Mine operations, Deeps and Swartberg, and the opencast Gamsberg Zinc Mine. The Black Mountain Mine complex mines zinc, lead, silver and copper and hoists 1.7 million tonnes (mt) of ore a year with a current production capacity of 90 000 tonnes per annum (tpa) metal-in-concentrate. The Gamsberg Zinc Mine came into operation in June 2016 and mines approximately 4 million tonnes per annum (mta) and produces 250-300 tpa of zinc concentrate per annum.

Gamsberg Zinc Mine is located over three properties, which are owned by BMM. The mine is situated in the Namakwa District, Northern Cape and is approximately 120 km east of Springbok and approximately 270 km from Upington, between the towns of Aggeneys and Pofadder.

A number of existing environmental related authorisations are in place for the Gamsberg Zinc Mine. Furthermore, a permitting process was recently completed for the Gamsberg Smelter. The mine currently requires further environmental related applications to authorise additional infrastructure and activities that are required for ongoing operations and were not included in the previous authorisations.

These proposed activities require regulatory approval prior to commencement. BMM has therefore requested that Golder Associates Africa (Pty) Ltd (Golder), a member of WSP Group Africa (Pty) Ltd (WSP), to undertake the required regulatory approval process. As part of this process, an Atmospheric Emission Licence (AEL) Amendment, with appended Air Quality Impact Assessment (AQIA), in the prescribed Atmospheric Impact Report (AIR) format, for the proposed activity changes, are required. This report therefore presents the AIR undertaken in support of the process.

2.0 ENTERPRISE DETAILS

2.1 Enterprise and contact details

Details of the BMM operations are provided in Table 1.

Table 1: Enterprise and contact details

Enterprise Name	Black Mining Mountain (Pty) Ltd
Trading As	Black Mining Mountain (Pty) Ltd
Name of Operation	Gamsberg Zinc Mine
Enterprise Registration Number (Registration Numbers if Joint Venture)	2005/040096/07
Registered Address	1 Penge Road, Aggeneys, 8893
Postal Address	Private Bag X01, Aggeneys, 8893
Telephone Number (General)	054 983 9256
Fax Number (General)	054 983 9353
Industry Sector	Zinc Mining Industry
Name of Responsible Officer	Mr Pieter Venter
Name of Emission Control Officer	Mr Pieter Venter
Telephone Number	054 983 9256
Cell Phone Number	082 851 3091
Fax Number	054 983 9353

Enterprise Name	Black Mining Mountain (Pty) Ltd
Email Address	pdventer@blackmountain.co.za
After Hours Contact Details	082 851 3091
Land Use Zoning as per Town Planning Scheme	Mining
Land Use Rights if outside Town Planning Scheme	The site currently operates an opencast mine

2.2 Location and extent of plant

The location and extent of the site is described in Table 2 and illustrated in Figure 1.

Table 2: Location and extent of plant

Enterprise Name	Black Mining Mountain (Pty) Ltd
Physical Address of the Premises	Not Applicable
Description of Site (Erf)	The Gamsberg Zinc Mine and associated infrastructure are located approximately 15 km east of Aggeneys, south of the N14 National Road. The Mining Right Area (MRA) is located across four properties, which are owned by BMM, namely; Bloemhoek 61, Portion 1, Gams 60, Portion 1, Aroams 57, RE and Gams 60, Portion 4.
Coordinates of Approximate Centre of Operations	Latitude: (North-south): S29°14'55 Longitude (East-west): E18°50'41
Extent (km²)	154
Elevation Above Mean Sea Level (m)	The elevation of the proposed Gamsberg Zinc Mine site varies and can reach approximately 1 150 m above mean sea level (i.e., approximately 220 m above the surrounding landscape)
Province	Northern Cape
Metropolitan/District Municipality	Namakwa District Municipality
Local Municipality	Khai Ma Local Municipality
Designated Priority Area	Not Applicable

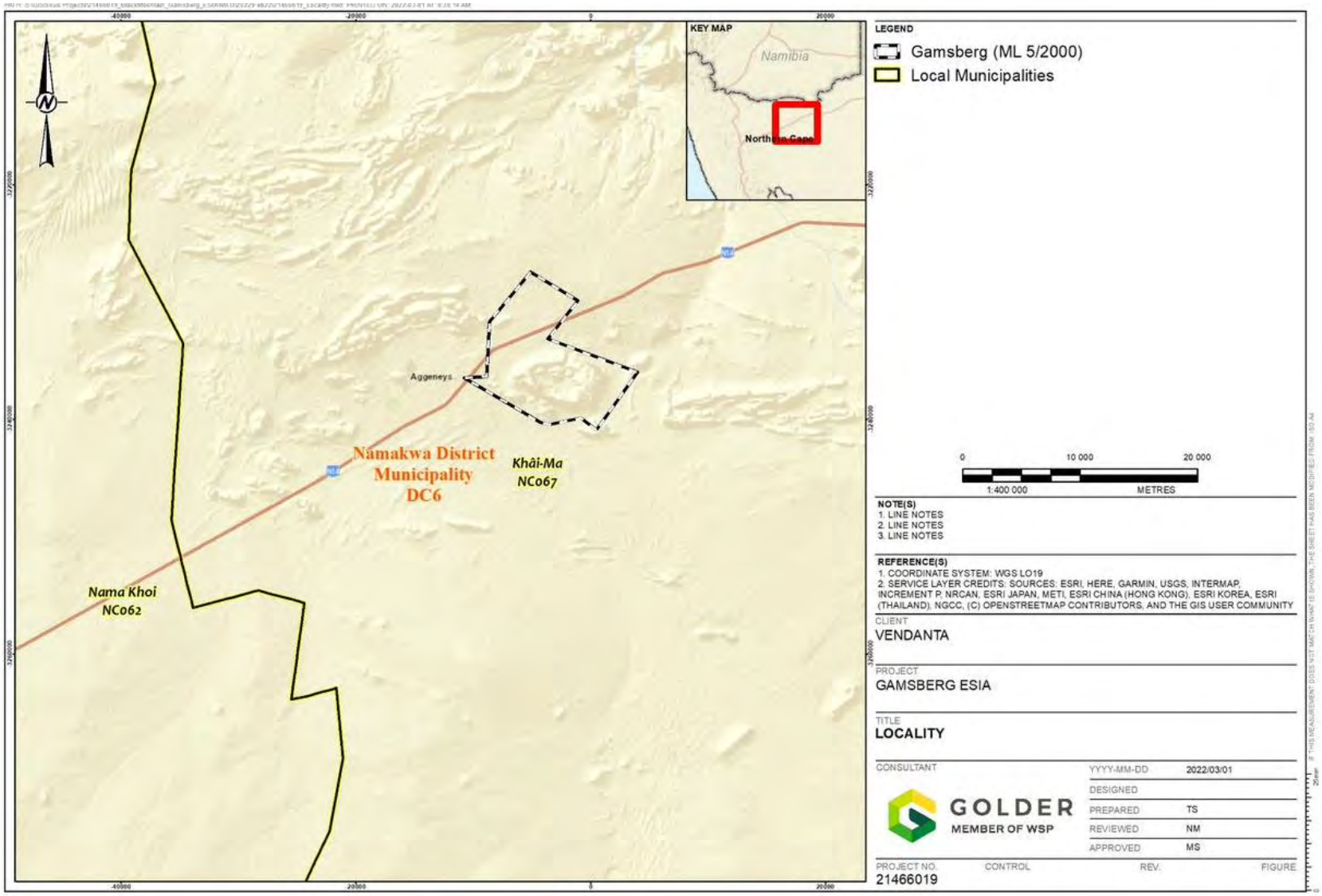


Figure 1: Locality map of the Gamsberg Zinc Mine

2.3 Description of surrounding land use

Gamsberg is located south of the N14 between Springbok (~ 114 km west) and Pofadder (~ 65 km east) in the Namakwa District Municipality and the Khai-Ma Local Municipality. The area surrounding Gamsberg Mine is mostly privately owned and used for extensive, low-intensity small stock farming.

Sensitive receptors are defined by the United Stated Environmental Protection Agency (USEPA) as areas where occupants are more susceptible to the adverse effects of exposure to pollutants. These areas include but are not limited to residential areas, hospitals/clinics, schools and day care facilities and elderly housing.

The following sensitive receptors for the Gamsberg Mine operations were identified within a 10km radius and are presented in Table 3 and Figure 2.

Table 3: Sensitive receptors for the Gamsberg Mine operations

No.	Sensitive Receptor Name	Coordinates		Distance from Site Boundary (km)	Direction from Site
		Longitude	Latitude		
1	Residential Area 1	18.847	-29.239	4.27	West
2	Residential Area 2	18.880	-29.249	1.14	West
3	Residential Area 3	18.888	-29.247	0.40	West
4	Residential Area 4	18.907	-29.221	0.27	North-west
5	Residential Area 5	18.900	-29.238	0.90	West
6	Residential Area 6	18.894	-29.238	1.47	West
7	Residential Area 7	18.891	-29.238	1.79	West
8	Residential Area 8	18.911	-29.200	0.19	North-north-west
9	Residential Area 9	18.843	-29.253	4.53	West
10	Residential Area 10	18.834	-29.272	6.45	West-south-west
11	Residential Area 11	19.060	-29.288	4.69	South-east
12	Residential Area 12	19.067	-29.265	4.37	East-south-east
13	Residential Area 13	19.021	-29.231	0.38	East
14	Residential Area 14	19.025	-29.214	2.46	East-north-east
15	Residential Area 15	18.845	-29.207	6.59	North-west

2.4 Atmospheric emission licence

BMM is currently undertaking an AEL application process associated with the proposed Gamsberg smelter project. The AEL will authorise a number of listed activities which may result in atmospheric emissions, as per Section 21 of the National Environmental Management: Air Quality Act 39 of 2004 (NEM:AQA), GNR. 893 of 22 November 2013. Activities for the existing Gamsberg Mine operations are classified, as a listed activity in terms of *Subcategory 4.14 Production and Processing of Zinc, Nickel and Cadmium, Subcategory 4.16 Smelting and Converting of Sulphide Ores and Subcategory 7.4 Production, Use in Production or Recovery of Antimony, Arsenic, Beryllium, Cadmium, Chromium, Cobalt, Lead, Mercury, and or Selenium, by the Application of Heat.*

Given the proposed future changes to the process description and additional fuel storage on site (the current project), an AEL amendment will be required. The proposed changes will trigger an additional Subcategory 2.4 Storage and Handling of Petroleum Products. This AIR has therefore been compiled in accordance with the prescribed AIR format in terms of Regulation 747, dated 11 October 2013 as amended, in support of the AEL application.

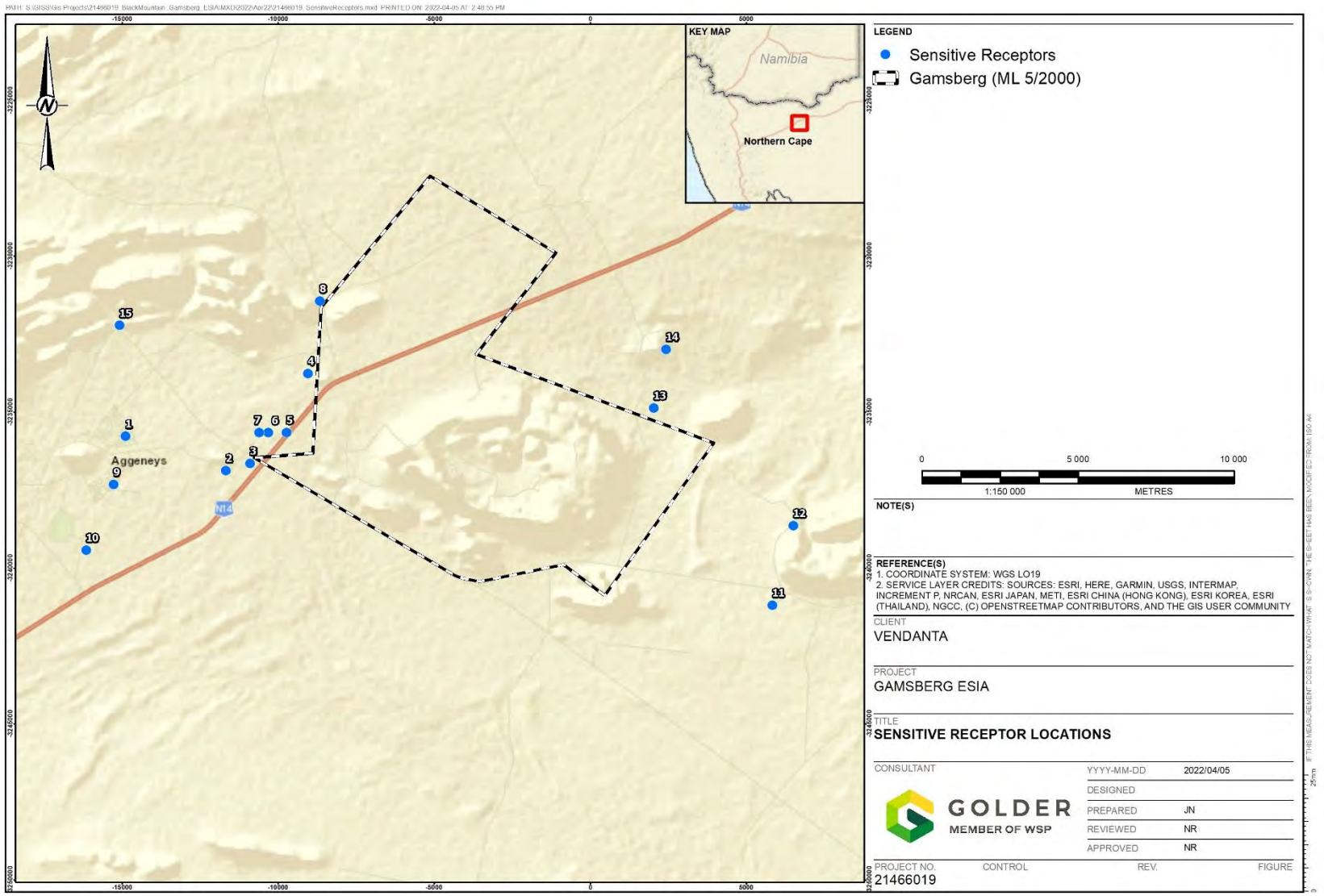


Figure 2: Sensitive receptors for the proposed Gamsberg Mine Additional Infrastructure and Activities Project

3.0 NATURE OF PROCESS

3.1 Listed activities

Listed activities and associated minimum emission standards (MES) were published in Government Notice 248 of 2010, Government Gazette 33064 in-line with Section 21 of the NEM:AQA. An amended list of activities was published in Government Notice 893 of 2013, Government Gazette 37054, Government Notice 551 of 2015, Government Gazette 38863 and further in Government Notice 1207 of 2018, Government Gazette 42013. Activities for the existing Gamsberg Mine operations are classified, as a listed activity in terms of *Subcategory 4.14 Production and Processing of Zinc, Nickel and Cadmium, Subcategory 4.16 Smelting and Converting of Sulphide Ores and Subcategory 7.4 Production, Use in Production or Recovery of Antimony, Arsenic, Beryllium, Cadmium, Chromium, Cobalt, Lead, Mercury, and or Selenium, by the Application of Heat*.

Given the proposed future changes to the process description and additional fuel storage on site, an AEL amendment will be required. The proposed changes will trigger an additional *Subcategory 2.4 Storage and Handling of Petroleum Products*. The listed activities are detailed in Table 4.

Table 4: Listed activities applicable to the Gamsberg operations

Category of Listed Activity	Sub-category of Listed Activity	Description of the Listed Activity
Existing Activities		
Category 4	Subcategory 4.14	The extraction, processing and production of zinc, nickel or cadmium by the application of heat excluding metal recovery
	Subcategory 4.16	Processes in which sulphide ores are smelted, roasted calcined or converted (excluding inorganic chemicals-related activities regulated under Category 7)
Category 7	Subcategory 7.4	Production, use or recovery of antimony, arsenic, beryllium, cadmium, chromium, cobalt, lead, mercury, selenium, thallium and their salts not covered elsewhere, excluding their use as catalyst
Proposed Activities		
Category 2	Subcategory 2.4	All permanent immobile liquid storage facilities at a single site with a combined storage capacity of greater than 1 000 m^3

3.2 Process description

3.2.1 Current operations

BMM plans to mine a total of 150 000 000 tons of ore from the Gamsberg Zinc Mine over a 19-year Life of Mine (LoM). Of this expected LoM tonnage, approximately 18 000 000 tons of zinc concentrate will be extracted.

Based on the relatively low grade of the zinc deposit, the treatment process will generate approximately 132 000 000 tons of tailings and approximately 1.5 billion tons of waste rock over the LoM.

The Gamsberg zinc deposit is a tabular relatively thin mineralised lens dipping to the southeast. The South Pit was developed to initially extract the ore reserve found closest to surface. Following this, a process of sequentially excavating push backs were undertaken to gain depth and access to deeper reserves. The final open pit is expected to cover an area of 600 ha, with a final depth of 650 m, and a width and length of 2 220 m and 2 700 m respectively.

Loading and hauling of ore and overburden is performed in the pit using a fleet of large capacity shovels, loaders, excavators, haul trucks and other service equipment. The ore is hauled to the primary crusher and overburden to the waste rock dump using large capacity haul trucks (typically between 220 ton (t) and 300 t capacity). The primary crusher is located adjacent to the open pit on a flat point of the V-cut access road along the northern slope of the inselberg. The crushed ore is transported from the primary crusher and the Run of Mine (ROM) stockpile to the processing plant via a conveyor system.

An estimated 1.5 billion tons of waste rock will be generated during the LoM. The haul trucks transport the waste material to the edge of the inselberg where it is tipped over the edge to form a waste rock dump expected to cover 490 hectares.

The processing plant is currently located between the N14 national road and the Gamsberg inselberg and consists of the following components:

- Milling circuit;
- ROM stockpiles;
- Flotation circuit;
- Dewatering, filtration and zinc concentrate handling circuits;
- Tailings circuit;
- Material lay down and storage areas;
- Equipment wash areas; and
- Bulk fuel storage facilities.

The treatment of ROM ore at a current rate of 4.5 Mt per annum with plans to increase to the planned 10 Mt per annum at the processing plant yields about 9 Mt per annum of tailings material which is disposed at a tailings storage facility (TSF) located north of the N14 national road. The tailings are sent to a thickener to reduce the water content before being pumped to the TSF. The percolated water from the TSF is collected and returned to the return water dam where it is pumped and reused in the concentrating process.

3.2.2 Future infrastructure requirements

A number of existing environmental related authorisations are in place for the Gamsberg Zinc Mine. Furthermore, a permitting process was recently completed for the Gamsberg Smelter.

The mine currently requires further environmental related applications to authorise additional activities that are required for ongoing operations and were not included in the previous authorisations, and authorise changes required in infrastructure due to the conflicting placement of infrastructure due to the phase 1 development. These activities require an Environmental Authorisation (EA) as contemplated under Section 24 of the National Environmental Management Act, 1998 (Act 107 of 1998) (NEMA) (as amended).

3.2.2.1 Proposed infrastructure developments

New potable water pipeline

A new above-ground potable water pipeline is proposed to run from the Horseshoe dam to the processing plant. This pipeline will be developed in an existing servitude already use for pipelines transporting water from Sedibeng Water to the mine. The location where the pipeline is proposed to be developed has already been cleared of vegetation as it is within a road reserve. The proposed pipeline will be installed above-ground and will have an inside diameter of 400 mm, an outside diameter of 460 mm, a throughput of 460 m_3/hour and will be approximately 7 km in length. The entire pipeline will belong to Gamsberg Mine.

Expansion of dangerous goods storage facilities

To support the ongoing operations at Gamsberg Mine, an increase in storage capacity will be required for the following dangerous goods storage facilities:

- Fuel storage capacity which is proposed to increase from 600 m^3 to 1 200 m^3; and
- Emulsion storage is proposed to be increased from 2 x 85t silos and 2 x 50t silos to 2 x 100t and 2 x 200t silos respectively.

River diversion

To minimise pollution from the waste rock dump, ROM pad and crushers and conveyer infrastructure associated with the phase 1 and 2 plant infrastructure, it is proposed that the ephemeral riverbed that passes between the processing plant and the mining operations, be altered.

The diversion will include the construction of an attenuation weir, diversion berms, two above-ground pipelines for conveying any upstream runoff past the impacted area (processing plant and the mining operations) and an energy dispersion outlet structure. The altered section will be approximately 1.5 km in length.

The alteration will be in place for the duration of the operational phase of the mine and will be rehabilitated during the decommissioning and closure phase.

Refined layout for the waste rock dump and quartzite rock dump/berm

A waste rock dump facility, with a capacity to store 1.5 billion tons of waste rock on an area of 490 ha, is approved in the *Environmental and Social Impact Assessment Report for the Gamsberg Zinc Mine and Associated Infrastructure in the Northern Cape* (June 2013).

In addition to the main waste rock dump facility and in order to mitigate the impacts on biodiversity as a result of the basin/crater mining activities, it was recommended that a rock dump / berm, comprising only quartzite rock, be designed and constructed to shield the remainder of the basin / crater from mining activities. It is detailed in the *Environmental Management Programme for the Gamsberg Zinc Mine and Associated Infrastructure in the Northern Cape* (May 2013), that the berm should be constructed to the same elevation as the plateau comprising a non-acid leaching rock core and a quartzite rock outer layer. It is further stated that the placement of the barrier must be defined with input from a qualified botanist and the engineering team prior to the placement of the rock.

The Gamsberg Mine engineering team has refined the layout of the current waste rock to optimise the placement of waste rock and to avoid current mine infrastructure and to ensure safe operation of the facility. The updated waste rock dump layout is based on the storage capacity and footprint as approved in the 2013 Environmental Impact Assessment (EIA) and Environmental Management Programme (EMPr).

The 2013 EMPr does not include a final position and layout of the biodiversity protection rock dump / berm. The engineering team, in consultation with the biodiversity specialist has defined the final layout and position.

The updated waste rock dump layout and layout and position of the biodiversity rock dump / berm will be included in the Basic Assessment Report.

Crusher and Coarse Ore Stockpile for Plant Phase 2

The 2013 EIA states that the full production capacity of the mine will be 10 Mtpa ore. This capacity will be reached in a modular approach following the mine ramp up plan as described in the report. It is stated that the current concentrator plant will be ramped up in three modules to full capacity. It is indicated that the three phases of the concentrator plant will each consist of a concentrator stream with supporting utility and supporting infrastructure.

An amended concentrator plant boundary and shortened conveyor route was approved in the *Gamsberg Mine Environmental Management Programme Amendment* (December 2016). The information was presented at a high level and did not differentiate between the infrastructure components required for the three plant modules.

The Gamsberg Mine engineering team has defined the phase 2 plant components in preparation for construction. The updated conveyor and phase 2 concentrator plant layout will be included in the Basic Assessment Report.

The layout of the Gamsberg Mine additional infrastructure and activities are illustrated in Figure 3.

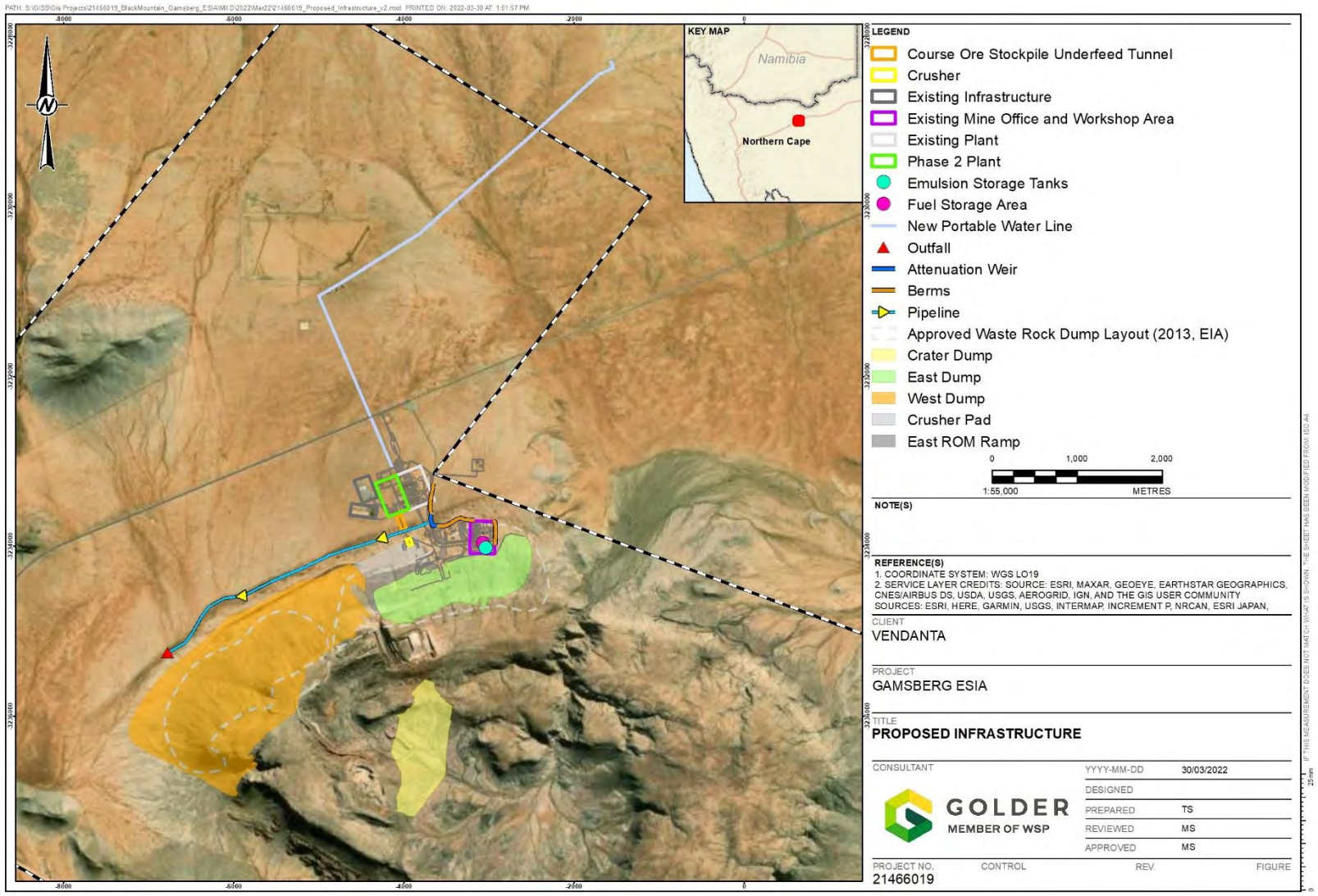


Figure 3: Proposed infrastructure layout of the Gamsberg Mine additional infrastructure and activities

The processes associated with the Gamsberg Mine operations are tabulated below in Table 5.

Table 5: Unit processes for the Gamsberg operations

Unit Process	Unit Process Function	Batch or Continuous Process
Production and Processing of Zinc, Nickel and Cadmium	Production and processing	Continuous
Smelting and Converting of Sulphide Ores	Smelting	Continuous
Production, Use in Production or Recovery of Antimony, Arsenic, Beryllium, Cadmium, Chromium, Cobalt, Lead, Mercury, and or Selenium, by the Application of Heat	Production	Continuous
Storage and Handling of Petroleum Products	Storage and handling	Continuous

4.0 TECHNICAL INFORMATION

4.1 Raw material used

Table 6 provides the raw materials used at Gamsberg Mine.

Table 6: Raw materials used at the Gamsberg Mine operations

Raw Material Type	Maximum Permitted Consumption Rate (Quantity)	Units (Quantity / period)
Diesel	264 000	m^3/year
Zinc & lead ore phase 1	4 800 000	T/annum
Zinc & lead ore phase 1 & 2	10 000 000	T/annum
Waste stripping	63 000 000	T/annum
Explosives phase 1	13 957	T/annum
Explosives phase 1 & 2	31 000	T/annum
Zinc concentrate	350 000	T/annum

4.2 Appliances and abatement equipment control technology

No appliances and abatement equipment control technology are installed at Gamsberg Mine.

5.0 ATMOSPHERIC EMISSIONS

As a result of the operations at Gamsberg Mine, stationary emissions are likely to arise from the proposed acid plant, casting, dross treatment and zinc dust plant stacks associated with the Gamsberg Smelter whilst fugitive emissions are likely to arise from the existing storage tanks, material handling, wind erosion, drilling, blasting, crushing and paved and unpaved roads.

As a result of the proposed additional infrastructure and activities, emissions are likely to arise from the proposed additional fuel and emulsion storage tanks as well as the operation of thecrusher and ore stockpile. The following sections detail these emissions.

5.1 Point sources

The physical parameters of the stacks were obtained from Gamsberg Mine data. The variables used to calculate the emissions rates from the stacks are presented in Table 7.

Table 7: Physical parameters of the stacks at Gamsberg Mine

Source Name	Height of Release above Ground (m)	Diameter at Stack Tip/Vent Exit (m)	Actual Gas Exit Temperature (°C)	Normal Volumetric Flow (Nm^3/s)	Actual Gas Velocity (m/s)
Acid Plant Stack	70	2.5	70	78.1	20
Casting Stack	30	2	60	18.0	7
Dross Treatment Stack	20	1	50	3.3	5
Zn Dust Plant Stack	20	1	50	3.3	5

5.2 Point source maximum emission rates (normal operating conditions)

As per Section 21 of the NEM:AQA, the maximum permitted emission rates for point sources at Gamsberg Mine are presented in Table 8.

Table 8: Point source emission rates under normal operating conditions

Point Source Code	Pollutant Name	Maximum Release Rate			Duration of Emissions
		(mg/Nm^3)	Date to be Achieved By	Average Period	
Acid Plant Stack	Particulate matter (PM)	50	New	Daily	24
		100	Existing	Daily	24
	Sulphur dioxide (SO_2 (feed SO_2 < 5% SO_2))	1200	New	Daily	24
		3500	Existing	Daily	24
	SO_2 (feed SO_2 > 5% SO_2)	1200	New	Daily	24
		2500	Existing	Daily	24
	Nitrogen oxides (NO_x expressed as nitrogen dioxide (NO_2))	350	New	Daily	24
		2000	Existing	Daily	24
Casting Stack	PM	50	New	Daily	24
		100	Existing	Daily	24
	SO_2	500	New	Daily	24
		500	Existing	Daily	24
	NO_x expressed as NO_2	500	New	Daily	24
		500	Existing	Daily	24
	Mercury (Hg)	0.2	New	Daily	24
		1.0	Existing	Daily	24

Point Source Code	Pollutant Name	Maximum Release Rate			Duration of Emissions
		(mg/Nm^3)	Date to be Achieved By	Average Period	
	Dioxins (PCDD/PCDF)	0.1 ng TEQ	New	Daily	24
		No standard proposed	Existing	Daily	24

5.3 Point source maximum emission rates (start-up, shut-down, upset and maintenance conditions)

A start-up duration of 40 hours is expected for the roaster start up stack and a start-up duration of 5-10 minutes, twice a year for the acid plant stack.

5.4 Fugitive emissions (area/line sources)

Fugitive emissions from Gamsberg Mine have the potential to arise from the following existing sources:

- Materials handling activities.
- Wind erosion from stockpiles.
- Drilling and blasting activities.
- Crushing activities.
- Paved and unpaved roads.
- Storage tanks.

The existing emissions inventory (i.e., for these sources listed above) can be found in the Gamsberg Smelter AQIA undertaken in 2020 by Airshed.

Given the proposed additional infrastructure at the Gamsberg Mine, the following must be noted:

- New potable water pipeline: This will have no impact on air quality emissions and thus has been excluded in the current assessment.
- Additional fuel storage on site to increase from 600 m^3 to 1 200 m^3: An increase in volatile organic compounds (VOC) emissions are likely to occur.
- Emulsion storage is proposed to be increased from 2 x 85t silos and 2 x 50t silos to 2 x 100t and 2 x 200t silos respectively: Emissions are considered to be negligible and within a confined enclosed space and has thus been excluded from this assessment.
- River diversion: This will have no impact on air quality emissions and thus has been excluded in this assessment.
- A refined layout for the waste rock dump and quartzite rock dump/berm: This will have no change in the air quality emissions and thus has been excluded in this assessment; and
- Operation of the crusher and coarse ore stockpile for plant phase 2: This will result in an increase in particulate matter emissions.

The emissions calculations for the proposed additional infrastructure and activities at Gamsberg Mine is provided in the sections below.

5.4.1 Storage tanks

Emissions from these fuel storage tanks may typically be obtained using actual sampling at the point of emission, estimating it from mass and energy balances and/or emission factors which have been established at other, similar operations. However, Gamsberg Mine does not have an available set of locally derived emission factors for their facility. As such, quantification of all simulated storage tank emissions, were made using the USEPA AP-42 emission estimation calculations and *TANKS* software. *TANKS* (version 4.09D) is a software program that estimates VOCs and hazardous air pollutant (HAP) emissions from storage tanks. *TANKS* is based on the emission estimation procedures from the USEPA's Compilation of Air Pollutant Emission Factors (AP-42), Chapter 7 (Liquid Storage Tanks). Physical parameters of the storage tanks were obtained from Client data. The variables and the emissions rates from the storage tanks are presented in Table 9.

Table 9: Physical properties and emission rates of the storage tanks

Parameter	Unit	Existing operations		Proposed Operations	
		80 m^3 Diesel Tanks	67 m^3 Diesel Tanks	80 m^3 Diesel Tanks	67 m^3 Diesel Tanks
Number of Tanks	NA	**4**	**2**	**4**	**2**
Tank Type	NA	Horizontal Tank	Horizontal Tank	Horizontal Tank	Horizontal Tank
Shell Length	m	12.26	2.896	12.26	2.896
Shell Diameter	m	2.882	5.43	2.882	5.43
Working Volume	m^3	80	67	80	67
Heated Tank	NA	No	No	No	No
Underground	NA	No	No	No	No
Shell Colour	NA	White/Steel Grey	White/Steel Grey	White/Steel Grey	White/Steel Grey
Shell Condition	NA	Good	Good	Good	Good
Roof Colour	NA	-	-	-	-
Roof Condition	NA	-	-	-	-
Turnovers per Year	NA	375	90	375	90
Net Throughput per Tank	m^3/yr	30000	6000	30000	6000
VOC Emission Rate per Tank	g/s	0.0009	0.0004	0.0009	0.0004

The following was assumed and utilized in the model only, as per the modelling regulations:

- The tank temperatures were modelled at ambient temperature for all storage tanks.
- The tanks were modelled using parameters that were set with a gas exit velocity of 0.001 m/s and a diameter of 0.001 m for all storage tanks.
- Horizontal tanks were modelled as a single point source.

5.4.2 Wind erosion

Fugitive emissions due to the erosion of open storage piles and exposed areas occur when the threshold wind speed is exceeded (Cowherd *et al*., 1988; EPA, 1995). The threshold wind speed is dependent on the erosion potential of the exposed surface, which is expressed in terms of the availability of erodible material per unit area (mass/area). Any factor which binds the erodible material or otherwise reduces the availability of erodible material on the surface, thus decreases the erosion potential of the surface. Studies have shown that when the threshold wind speeds are exceeded, emission rates tend to decay rapidly due to the reduced availability of erodible material (Cowherd *et al*., 1988).

The default particulate emission factors for wind erosion over open areas are calculated using the below equation (NPI, 2012):

$E_{TSP} = 0.4\ \mathrm{kg}/ha/hour$

$E_{PM10} = 0.2\ \mathrm{kg}/ha/hour$

$PM_{2.5}$ emissions were assumed to equal 15% of total suspended particulates (TSP (USEPA, 2006)) in the absence of a $PM_{2.5}$ emission factor. A 50% control efficiency for the use of wet suppression was applied as an environmentally conservative approach (NPI, 2012) for the stockpile that will be mitigated. Source parameters for areas subject to wind erosion are given in Table 10. Emission rates were applied to the various stockpiles and are presented in Table 11.

Table 10: Source parameters for the stockpiles subject to wind erosion

Source	Height (m)	Area (m^2)	Control efficiency (%)
Ore Stockpile	28.5	8 615	50%

Table 11: Emission rates for wind erosion for the stockpiles

Source	Emission Rate (g/s/m^2)		
	TSP	PM_{10}	$PM_{2.5}$
Ore Stockpile	5.56E-06	2.78E-06	4.17E-07

5.4.3 Crushing

The following default emission factors for crushing (high moisture ore) were used to calculate particulate emissions respectively (NPI, 2012):

Primary crushing:

$E_{TSP} = 0.01\ \mathrm{kg}/tonne$

$E_{PM10} = 0.004\ \mathrm{kg}/tonne$

$PM_{2.5}$ emissions were assumed to equal 30% of TSP (USEPA, 2006 particle size distribution for crushing) in the absence of a $PM_{2.5}$ emission factor. A 50% control efficiency was applied for the use of water sprays (NPI, 2012). Importantly, crushing emission factors include emissions from the screens, the crusher, feeder, and conveyor belt transfer points that are integral to the crusher (NPI, 2012). Physical parameters and calculated emission rates for crushing are given in Table 12 and Table 13, as per Client data.

Table 12: Source parameters for crushing

Source	Throughput (tons/hr)
Primary Crushing	2 420

Table 13: Emission rates for crushing

Source	Emission Rate (g/s)		
	TSP	PM_{10}	$PM_{2.5}$
Primary Crushing	3.36	1.34	0.40

5.4.4 Material Handling

Materials handling operations predicted to result in fugitive emissions include the transfer of material by means of tipping, loading and offloading. The quantity of dust which will be generated from such loading and off-loading operations will depend on various climatic parameters, such as wind speed and precipitation, in addition to non-climatic parameters such as the nature (moisture content) and volume of the material handled. Fine particulates are more readily disaggregated and released to the atmosphere during the material transfer process as a result of exposure to strong winds. Increase in the moisture content of the material being transferred would decrease the potential for dust emissions since moisture promotes the aggregation and cementation of fines to the surfaces of larger particles (USEPA, 2006).

The following default emission factors were used to calculate particulate emissions respectively (NPI, 2012):

$E_{TSP} = 0.005 \text{ kg}/tonne$

$E_{PM10} = 0.002 \text{ kg}/tonne$

$PM_{2.5}$ emissions were assumed to equal 5.3% of TSP (USEPA, 2006) in the absence of a $PM_{2.5}$ emission factor. Various control measures are applied to the materials handling activities (NPI, 2012). Importantly, material handling from crushing activities (transfer of material) are excluded (to prevent double accounting of emissions) as the crushing emission factors include emissions from the screens, the crusher, feeder, and conveyor belt transfer points that are integral to the crusher (NPI, 2012). Physical parameters and calculated emission rates for materials handling are given in Table 14 and Table 15, as per Client data.

Table 14: Source parameters for materials handling activities

Source	Control Efficiency (%)	Total Throughput (Tons/hr)
Offloading of material onto ore stockpile	50% - for use of water sprays	2 420

Table 15: Emission rates for materials handling activities

Source	Emission Rate (g/s)		
	TSP	PM_{10}	$PM_{2.5}$
Offloading of material onto ore stockpile	6.41E-01	3.03E-01	4.59E-02

5.5 Emergency incidents

In the last two years, Gamsberg Mine have not recorded any air quality related emergency incidents.

6.0 IMPACT OF THE ENTERPRISE ON THE RECEIVING ENVIRONMENT

6.1 Analysis of emissions impact on human health

6.1.1 General overview of key pollutants and associated health effects

A description of the key pollutants of concern identified for the facility, as well as the associated health effects are provided in Table 16. The pollutant applicable for the proposed additional infrastructure and activities at Gamsberg Mine however are associated with PM_{10}, $PM_{2.5}$ and VOCs only.

Table 16: Key pollutants and associated health effects

Pollutant	Description	Health effects
Particulate matter (Dust fallout, PM_{10} and $PM_{2.5}$)	Can be classified by their aerodynamic properties into coarse particles, PM_{10} (particulate matter with an aerodynamic diameter of less than 10 µm) and fine particles, $PM_{2.5}$ (particulate matter with an aerodynamic diameter of less than 2.5 µm). The fine particles contain the secondarily formed aerosols such as combustion particles, sulphates, nitrates, and re-condensed organic and metal vapours. The coarse particles contain earth crust materials and fugitive dusts from roads and industries (Fenger, 2002).	Dust fallout is a nuisance and is unlikely to result in health effects. PM_{10} and $PM_{2.5}$ area associated with: - Airway allergic inflammatory reactions & a wide range of respiratory problems. - Increase in medication usage related to asthma, nasal congestion and sinuses problems. - Adverse effects on the cardiovascular system
NO_2	Formed though the oxidation of nitric oxide in the atmosphere, it is a primary pollutant emitted from the combustion of stationary point sources and from motor vehicles. It is toxic by inhalation. However, as the compound is acrid and easily detectable by smell at low concentrations, inhalation exposure can generally be avoided.	Effects on pulmonary function, especially in asthmatics. Increase in airway allergic inflammatory reactions.
SO_2	One of a group of highly reactive gasses known as “oxides of sulphur.” Anthropogenic sources include; fossil fuel combustion (particularly coal burning power plants) industrial processes such as wood pulping, paper manufacture, petroleum and metal refining, metal smelting (particularly from sulphide containing ores, e.g. lead, silver and zinc ores) and vehicle tailpipe emissions.	Reduction in lung function Respiratory symptoms (wheeze and cough).
Volatile organic compounds (in the form of Benzene, Toluene, Ethyl-benzene and Xylene)	Organic compounds that easily vaporise at room temperature and are colourless. VOCs are released from vehicle exhaust gases either as unburned fuels or as combustion products and are also emitted by the evaporation of solvents and motor fuels.	Adverse effects on the cardiovascular system and central nervous system. Long term exposure can lead to neurological and cardiovascular system damage and increased prevalence of carcinomas in the community

6.1.2 Applicable Legislation, Guidelines and Standards

6.1.2.1 National Environmental Management: Air Quality Act (Act No. 39 of 2004)

The NEM:AQA approach to air quality management is based on the control of the receiving environment. The main objectives of the act are to protect the environment by providing reasonable legislative and other measures that (i) prevent air pollution and ecological degradation, (ii) promote conservation and (iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development alignment with Sections 24a and 24b of the Constitution of the Republic of South Africa.

6.1.2.1.1 South African Ambient Air Quality Standards

The South African ambient air quality standards for common pollutants prescribe the allowable ambient concentrations of pollutants which are not to be exceeded during a specified time period in a defined area (Table 17). If the standards are exceeded, the ambient air quality is defined as poor and potential adverse health impacts are likely to occur. As such, the Gamsberg Mine emission contributions to the ambient air quality levels must not exceed or cause exceedances of the ambient air quality standards.

Table 17: South African Ambient Air Quality Standards for criteria pollutants

Pollutant	Averaging Period	Limit Value ($\mu g/m^3$)	Frequency of Exceedance	Compliance Date
NO_2	1 hour	200	88	Immediate
	1 year	40	0	Immediate
PM_{10}	24 hours	75	4	Immediate
	1 year	40	0	Immediate
$PM_{2.5}$	24 hours	40	4	1 January 2016 – 31 December 2029
	24 hours	25	4	1 January 2030
	1 year	20	0	1 January 2016 – 31 December 2029
	1 year	15	0	1 January 2030
Ozone (O_3)	8 hours	120	11	Immediate
Lead (Pb)	1 year	0.5	0	Immediate
Carbon Monoxide (CO)	1 hour	30 000	88	Immediate
	8 hours	10 000	11	Immediate
Benzene (C_6H_6)	1 year	5	0	Immediate
SO_2	10 minutes	500	526	Immediate
	1 hour	350	88	Immediate
	24 hours	125	4	Immediate
	1 year	50	0	Immediate

6.1.2.1.2 National Dust Control Regulations

The National Dust Control Regulations (NDCR) were published on 25th May 2018, Government Gazette No. 41650. The dust fallout standard, applicable to this study, defines acceptable dust fallout rates in terms of the presence of residential and non-residential areas (Table 18).

Table 18: Acceptable dust fallout rates

Restriction Areas	Dust Fall Rate (mg/m²/day over a 30-day average)	Permitted Frequency of Exceedance
Residential areas	Dust fall <600	Two per annum (not in sequential months)
Non-residential areas	600 < Dust fall <1 200	Two per annum (not in sequential months)

Note: *The method to be used for measuring dust fall rate and the guideline for locating sampling points shall be ASTM D1739*

6.1.2.2 Listed Activities and Minimum Emissions Standards

The NEMA:AQA makes provision for the setting and formulation of national ambient air quality and emission standards. On a provincial and local level, these standards can be set more stringently if the need arises. The control and management of emissions in NEMA:AQA relates to the listing of activities that are sources of emission and the issuing of AELs. In terms of Section 21 of the NEMA:AQA, a listed activity is an activity which 'results in atmospheric emissions that are regarded to have a significant detrimental effect on the environment, including human health'. Activities for the existing Gamsberg Mine operations are classified, as a listed activity in terms of *Subcategory 4.14 Production and Processing of Zinc, Nickel and Cadmium, Subcategory 4.16 Smelting and Converting of Sulphide Ores and Subcategory 7.4 Production, Use in Production or Recovery of Antimony, Arsenic, Beryllium, Cadmium, Chromium, Cobalt, Lead, Mercury, and or Selenium, by the Application of Heat*.

Given the proposed future changes to the process description and additional fuel storage on site an AEL amendment will be required. The proposed changes will trigger an additional *Subcategory 2.4 Storage and Handling of Petroleum Products*. The listed activities are detailed below.

6.1.2.2.1 Existing activities

Table 19: Minimum emission standards for Subcategory 4.14: Production and Processing of Zinc, Nickel and Cadmium

Description:	**The extraction, processing and production of zinc, nickel or cadmium by the application of heat excluding metal recovery**		
Applications:	**All installations**		
Substance or Mixture of Substances		**Plant Status**	**mg/Nm³ under normal conditions of 10% O_2, 273 Kelvin and 101.3 kPa.**
Common Name	**Chemical Symbol**		
Particulate matter	N/A	New	50
		Existing	100
Sulphur dioxide	SO_2	New	500
		Existing	500
Oxides of nitrogen	NO_x expressed as NO_2	New	500
		Existing	500
Mercury	Hg	New	0.2
		Existing	1.0
Dioxins	PCDD/PCDF	New	0.1 ng TEQ
		Existing	No standard proposed

Table 20: Minimum emission standards for Subcategory 4.16: Smelting and Converting of Sulphide Ores

Description:	**Processes in which sulphide ores are smelted, roasted calcined or converted (excluding inorganic chemicals-related under Category 7)**		
Applications:	**All installations**		
Substance or Mixture of Substances		**Plant Status**	**mg/Nm^3 under normal conditions of 10% O_2, 273 Kelvin and 101.3 kPa.**
Common Name	**Chemical Symbol**		
Particulate matter	N/A	New	50
		Existing	100
Oxides of nitrogen	NO_x expressed as NO_2	New	350
		Existing	2 000
Sulphur dioxide (feed SO_2 < 5% SO_2)	SO_2	New	1 200
		Existing	3 500
Sulphur dioxide (feed SO_2 > 5% SO_2)	SO_2	New	1 200
		Existing	2 500

Table 21: Minimum emission standards for Subcategory 7.4: Production, Use in Production or Recovery of Antimony, Arsenic, beryllium, Cadmium, Chromium, Cobalt, Lead, Mercury, and or Selenium, by the Application of Heat

Description:	**Production, use or recovery of antimony, arsenic, beryllium, cadmium, chromium, cobalt, lead, mercury, selenium, thallium and their salts not covered elsewhere, excluding their use as catalyst**		
Applications:	**All installations producing or using more than 1 ton per month**		
Substance or Mixture of Substances		**Plant Status**	**mg/Nm^3 under normal conditions of 10% O_2, 273 Kelvin and 101.3 kPa.**
Common Name	**Chemical Symbol**		
Particulate matter	N/A	New	10
		Existing	25

6.1.2.2.2 Proposed activities

Table 22: Minimum emission standards for Subcategory 2.4 Storage and Handling of Petroleum Products

Applications:	**All permanent immobile liquid storage facilities at a single site with a combined storage capacity of greater than 1 000 m^3**
True vapour pressure of contents at product storage temperature	**Type of tank or vessel**
Type 1: Up to 14 kPa	Fixed-roof tank vented to atmosphere, or as per type 2 and 3
Type 2: Above 14 kPa and up to 91 kPa with a throughput of less than 50 000 m^3 per annum	Fixed-roof tank with Pressure Vacuum Vents fitted as a minimum, to prevent “breathing” losses, or as per Type 3
Type 3: Above 14 kPa and up to 91 kPa with a throughput greater than 50 000 m^3 per annum	a) External floating-roof tank with primary rim seal and secondary rim seal for tank with a diameter greater than 20 m, or b) Fixed-roof tank with internal floating deck / roof fitted with primary seal, or c) Fixed-roof tank with vapour recovery system
Type 4: Above 91 kPa	Pressure vessel

6.1.3 Baseline assessment

6.1.3.1 Regional climatic overview

The Gamsberg Mine operations are situated in the subtropical high-pressure belt. The mean circulation of the atmosphere over the subcontinent is anticyclonic throughout the year (except for near the surface) (Preston-Whyte and Tyson, 1997). The synoptic patterns affecting the typical weather experienced in the region owe their origins to the subtropical, tropical and temperate features of the general atmospheric circulation over Southern Africa (Figure 4).

This results in Southern African countries being divided into two Köppen-Geiger climatic groups (Rubel and Kottek, 2010). Class B (dry climates) countries include those that border Kalahari Desert i.e. Angola, Botswana, Zimbabwe, Namibia and South Africa. Class C (moist mid-latitude climates) countries are East African nations that experience mild winters (i.e., Tanzania, Malawi, Mozambique, Swaziland, Lesotho and the Indian Ocean islands), with climatic conditions ranging from dry to moist subtropical mid-latitude conditions (Ker *et al*., 1978).

The subtropical control is introduced via the semi-permanent presence of the South Indian Anticyclone (HP cell), Continental High (HP cell) and the South Atlantic Anticyclone (LP cell) located in the high-pressure belt located approximately 30°S of the equator (Preston-Whyte and Tyson, 1997). The tropical controls are introduced via tropical easterly flows (LP cells) (from the equator to the southern mid-latitudes) and the occurrence of the easterly wave and lows (Preston-Whyte and Tyson, 1997).

The temperature control is introduced by perturbations in the westerly wave, leading the development of westerly waves and lows (LP cells) (i.e., cold front from the polar region, moving into the mid-latitudes) (Preston-Whyte and Tyson, 1997).

Seasonal variations in the positioning and intensity of the HP cells determine the extent to which the westerly waves and lows impact the atmosphere over the region:

- In winter, the high-pressure belt intensifies and moves northward while the westerly waves in the form of a succession of cyclones or ridging anticyclones moves eastwards around the South African coast or

across the country. The positioning and intensity of these systems are thus able to significantly impact the region; and

- In summer the anticyclonic HP belt weakens and shifts southwards, and the influence of the westerly waves and lows weakens.

Anticyclones (HP cells) are associated with convergence in the upper levels of the troposphere, strong subsidence throughout the troposphere, and divergence near the surface of the earth. Air parcel subsidence, inversions, fine conditions and little to no rainfall occur because of such airflow circulation patterns (i.e. relatively stable atmospheric conditions). These conditions are not favourable for air pollutant dispersion, especially with regard to those emissions emitted close to the ground.

Westerly waves and lows (LP cells) are characterised by surface convergence and upper-level divergence that produce sustained uplift, cloud formation and the potential for precipitation. Cold fronts, which are associated with the westerly waves, occur predominantly during winter. The passage of a cold front is characterised by pronounced variations in wind direction and speed, temperature, humidity, pressure and distinctive cloud bands (i.e. unstable atmospheric conditions). These unstable atmospheric conditions bring about atmospheric turbulence which creates favourable conditions for air pollutant dispersion.

The tropical easterlies and the occurrence of easterly waves and lows affect Southern Africa mainly during the summer months. These systems are largely responsible for the summer rainfall pattern and the north easterly wind component that occurs over the region (Preston-Whyte and Tyson, 1988).

In summary, the convective activity associated with the easterly and westerly waves disturbs and hinders the persistent inversion which sits over Southern Africa. This allows for the upward movement of air pollutants through the atmosphere leading to improved dispersion and dilution of accumulated atmospheric pollution.

South Africa experiences a large amount of downwelling air to the HP cell located towards the northern parts of the country. When this HP is combined with cloudless nights it creates an atmosphere with several layers which reduces vertical mixing. This restriction to vertical mixing combined with counter clockwise circulation (especially during winter) may keep polluted air in the same place for weeks at a time. Significant variability in precipitation events between summer and winter further affect the amounts of pollution in the air as rainfall brings pollutants down with it.

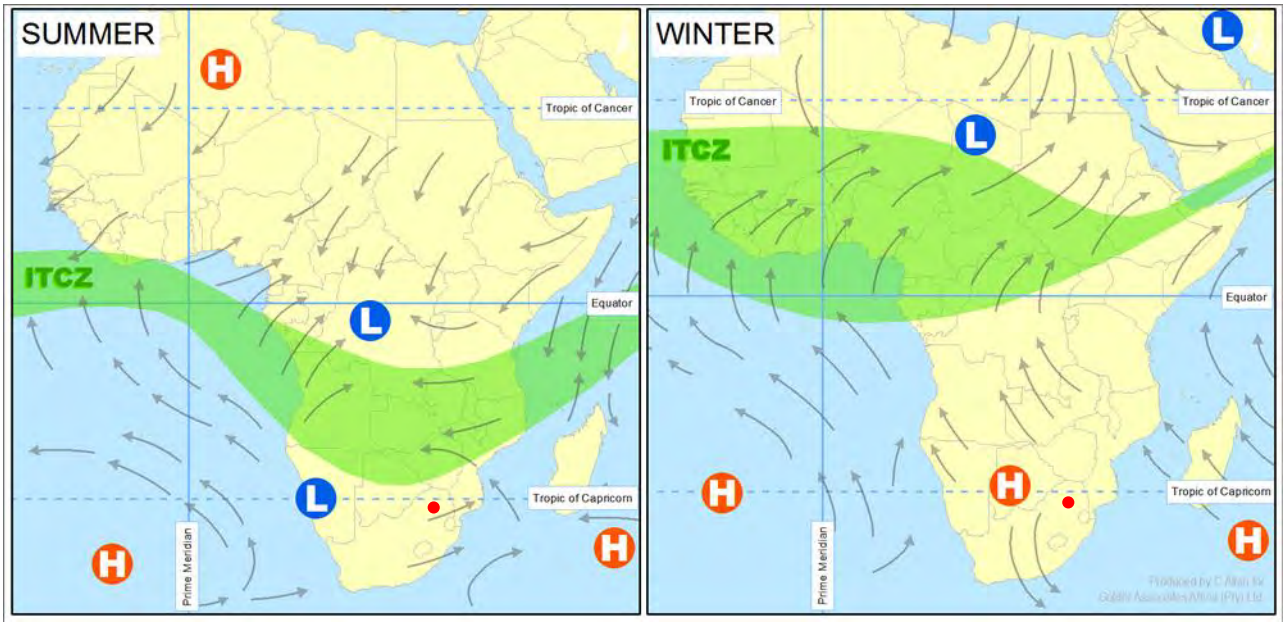


Figure 4: Seasonal circulation patterns affecting the regional climate

6.1.3.2 Meteorological overview

To assess ambient meteorological conditions, local meteorological data from the Gamsberg weather station on site was obtained for the most recent year (January to September 2021). Due to the limited data set, yielding a data recovery of 52% for the year (below the minimum data recovery of 90% as prescribed by the South African National Accreditation System (SANAS, 2012) TR 07-03 standards for the dataset to be deemed representative), site-specific modelled MM5 meteorological data was also purchased from Lakes Environmental Software for the period January 2019 to December 2021 to provide an understanding of surface and upper air dispersion characteristics. The data coverage is centred over the Gamsberg facility (Latitude: -29.227428°S; Longitude: 18.964253°E) with a grid cell dimension of 12 km x 12 km over a 50 km x 50 km domain. The data is assumed and expected to be representative of the actual experienced meteorological conditions onsite and is further recommended in terms of the South African Regulations Regarding Air Dispersion Modelling (2014). The percentage recovery for parameters recorded is 100 % and is thus considered reliable for use in this assessment. The meteorological conditions for the site using the Gamsberg weather station and modelled MM5 data is discussed in the following sections.

6.1.3.2.1 Temperature, rainfall and humidity

Temperature, rainfall and humidity are key influencing factors in ambient air quality:

- Over the period January to September 2021, the Gamsberg weather station recorded an average temperature of approximately 17 °C. The total rainfall received for the Gamsberg area was 62 mm during this period and the relative humidity was fairly moderate, with an average of 44 % over this period; and
- Using the MM5 data an average temperature of approximately 18 °C, 18 °C and 17 °C was recorded for 2019, 2020 and 2021. Average maximum temperatures ranged from 35 °C to 37 °C over the period with minimum temperatures ranging from 0.3 °C to 1 °C. Gamsberg receives most of its rainfall during summer (Figure 6). Total rainfall received for 2019, 2020 and 2021 was 71 mm, 120 mm and 288 mm, respectively. Relative humidity was generally moderate, with values of 54 %, 56% and 58 % for 2019, 2020 and 2021, respectively.

Importantly, given the limited data set from the Gamsberg weather station, only the MM5 data has been displayed using graphs.

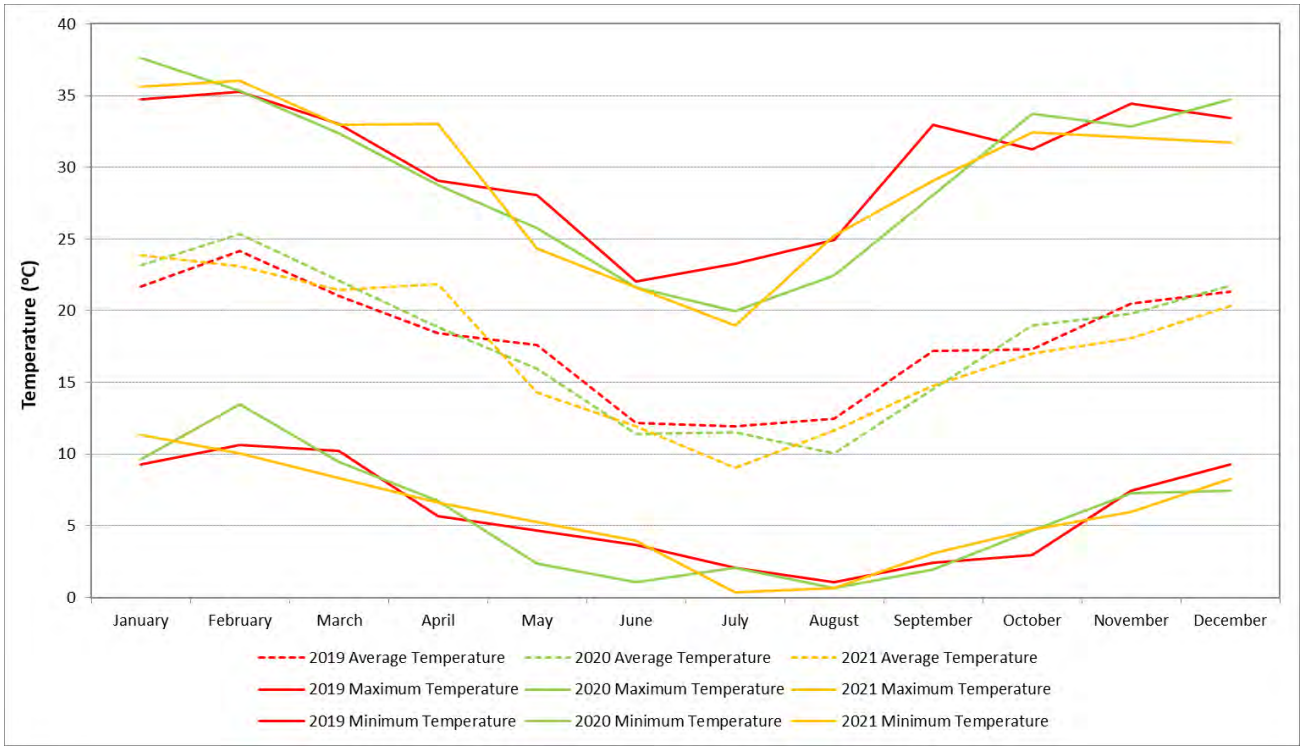


Figure 5: Average, maximum and minimum temperatures for 2019 to 2021 (MM5 data)

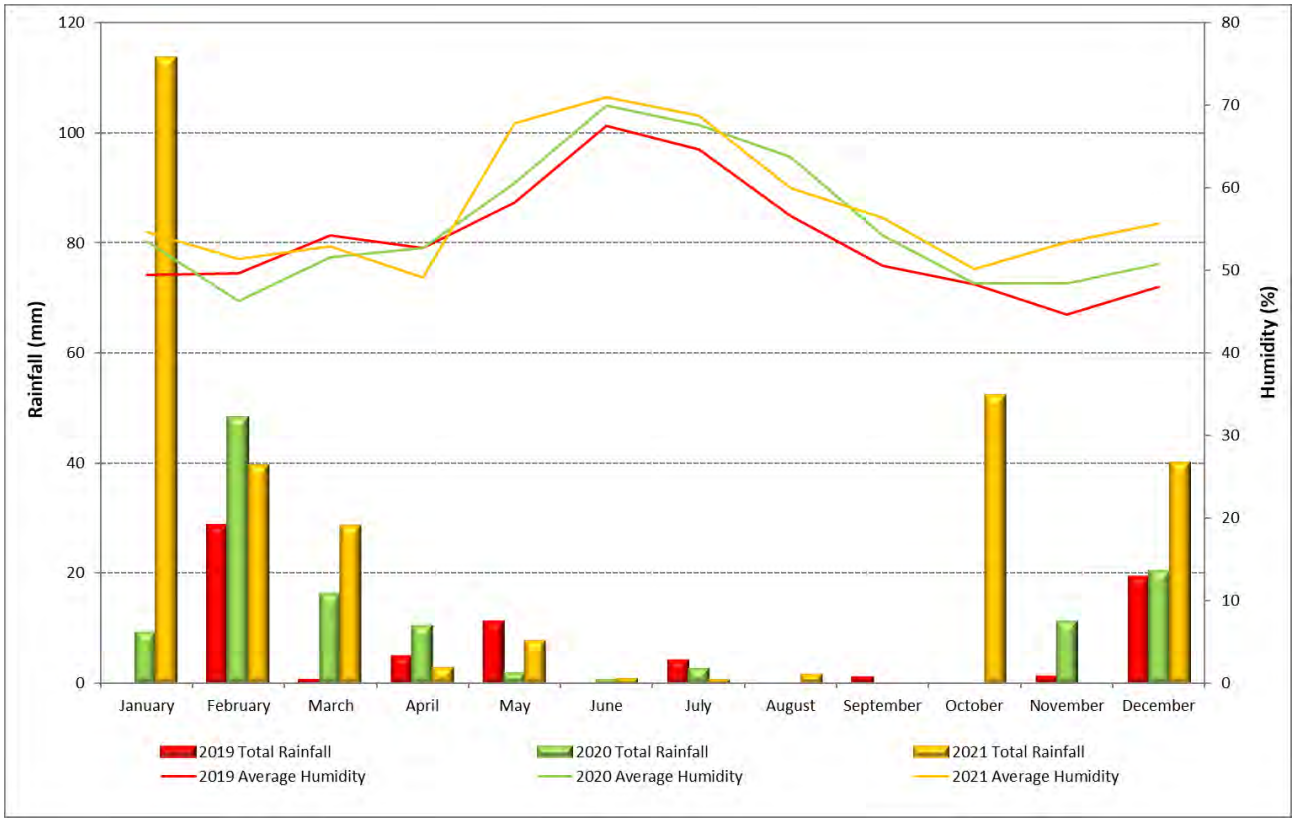


Figure 6: Monthly rainfall and average humidity for 2019 to 2021 (MM5 data)

6.1.3.2.2 Wind field

Wind roses summarise the occurrence of winds at a specified location by representing their strength, direction and frequency. Calm conditions are defined as wind speeds of less than 1 m/s which are represented as a percentage of the total winds in the centre circle. Each directional branch on a wind rose represents wind originating from that specific cardinal direction (16 cardinal directions). Each cardinal branch is divided into segments of different colours which represent different wind speed classes. Period, seasonal and diurnal wind roses using modelled MM5 is presented below (Figure 8). Given the limited data set from the Gamsberg station for the 2021 period (i.e from January to September 2021), only the period wind rose is presented (Figure 7). The following can be observed from the wind roses:

- Gamsberg station data:
  - Light to strong winds from the east southeast prevailed in the region as indicated in the station data, with calm conditions occurring 16 % of the time during the January to September 2021 period.
- MM5 data:
  - Light to strong winds from the south and north east prevailed in the region, with calm conditions occurring infrequently (6 % of the time) during the full period (January 2019 to December 2021);
  - During the day, winds are predominantly from the north east while at night, winds shift completely and are predominantly from the south. Winds speeds are generally moderate to strong with higher wind speeds noted during the day; and
  - During the summer and spring months, winds are dominant from the south. In autumn and winter, a shift in winds is observed, with winds originating predominantly from the northeast. Wind speeds are moderate to strong during all months. Higher wind speeds are noted during summer.
- Based on the observations, the Gamsberg station data and MM5 indicate similar degrees of variability (north easterly and southerly directions). It must be noted however that the Gamsberg station data has a low data recovery and should be viewed with caution.

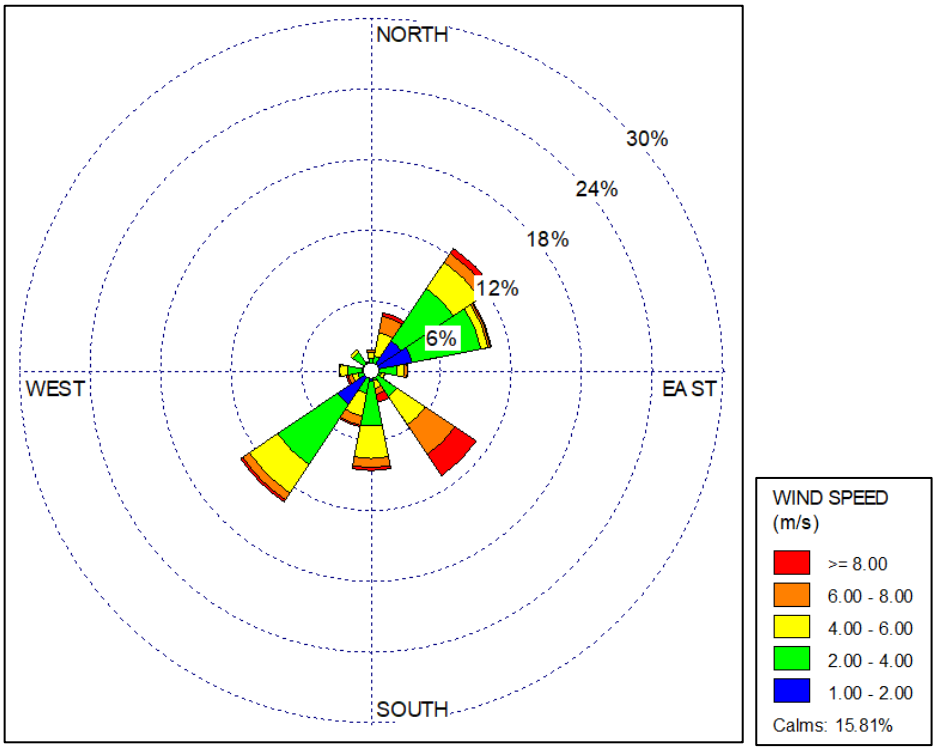


Figure 7: Wind conditions using Gamsberg data for the period January to September 2021

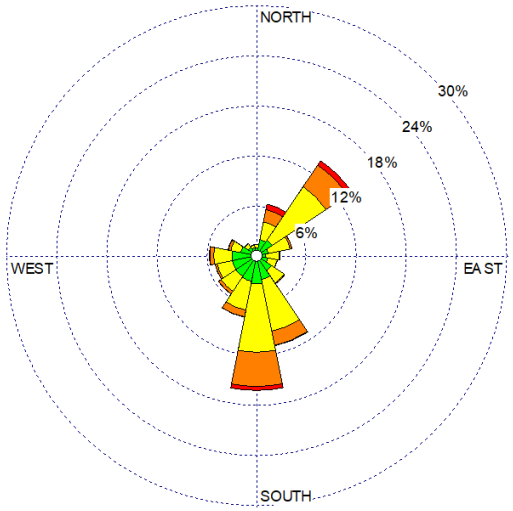
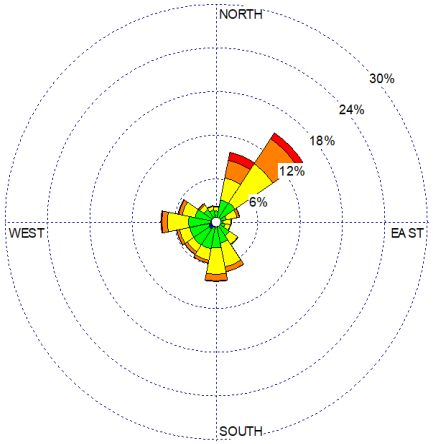
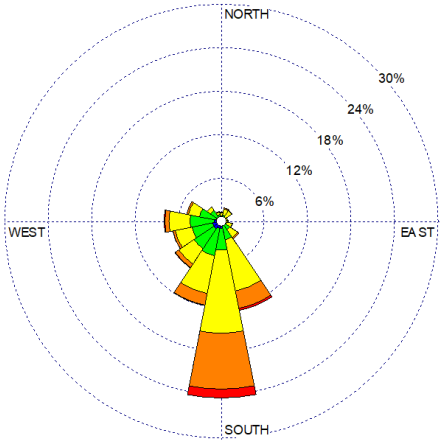
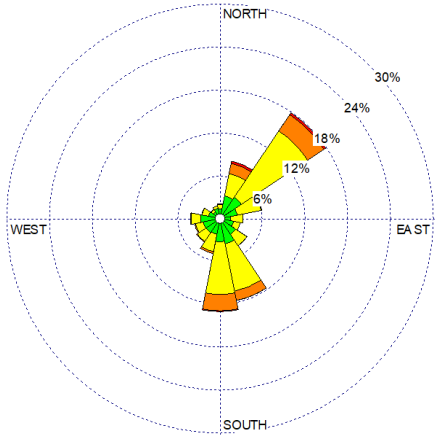
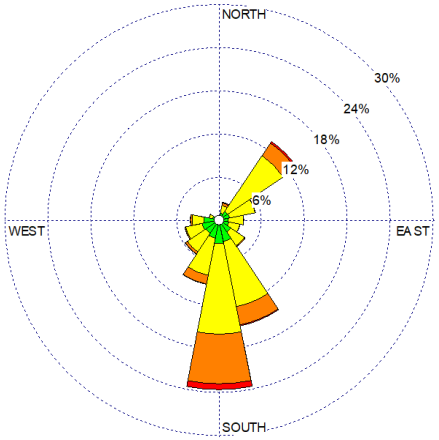
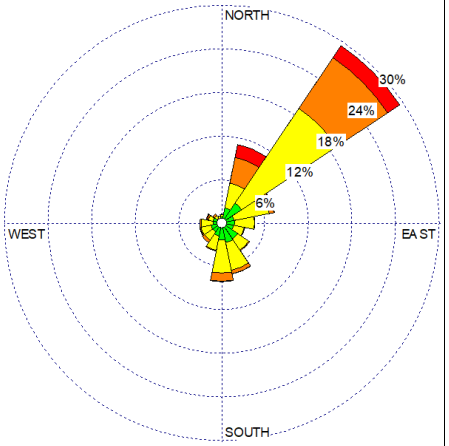
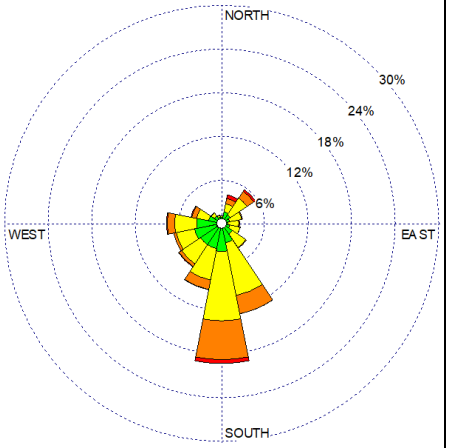
MM5 AERMET Data	Day	Summer	Autumn
January 2019 – December 2021	06h00 – 18h00	December, January & February	March, April & May
			
Calms = 6.14%	Calms = 9.66%	Calms = 7.55%	Calms = 6.79%
WIND SPEED (m/s) >= 8.0; 6.0 - 8.0; 4.0 - 6.0; 2.0 - 4.0; 1.0 - 2.0			
	Night	**Winter**	**Spring**
	18H00 – 06H00	June, July & August	September, October & November
			
	Calms = 2.19%	Calms = 4.17%	Calms = 6.06%

Figure 8: Wind conditions using MM5 data for the period January 2019 to December 2021

6.1.3.3 Ambient air quality overview

Existing sources of air pollution within the area have been identified to include:

- Agricultural activities.
- Mining activities.
- Vehicle emissions.

6.1.4 Agricultural activities

Emissions from agricultural activities are difficult to control due to the seasonality of emissions and the large surface area producing emissions (USEPA, 1995). Most of the agricultural activities in the region appear to be the small stock farming. As such, agricultural emissions are not expected to significantly influence the air quality in the area.

6.1.5 Mining activities

Mining is likely to be the largest sources of particulates (PM_{10}, $PM_{2.5}$, TSP) within the region. Dust and fine particulate emissions associated with mining operations include wind erosion from stockpiles, open mining pits, blasting, drilling, crushing and screening, material handling, ore processing operations, unpaved mine access roads and other exposed areas. Factors which influence the rate of wind erosion include surface compaction, moisture content, vegetation, shape of storage pile, particle size distribution, wind speed and rain.

Emissions from the mining activities are anticipated to be one of the dominant emissions influencing and impacting on the regional air quality.

6.1.6 Vehicle emissions

Air pollution generated from vehicle emissions may be grouped into primary and secondary pollutants. Primary pollutants are those emitted directly to the atmosphere as tail-pile emissions, whereas secondary pollutants are formed in the atmosphere as a result of atmospheric chemical reactions, such as hydrolysis, oxidation, or photochemical reactions. The primary pollutants emitted typically include carbon dioxide (CO_2), CO, hydrocarbons (including benzene, 1.2-butadiene, aldehydes and polycyclic aromatic hydrocarbons), SO_2, NO_x and particulates. Secondary pollutants formed in the atmosphere typically include NO_2, photochemical oxidants such as ozone, hydrocarbons, sulphur acid, sulphates, nitric acid, sulphates, nitric acid and nitrate aerosols.

The quantity of pollutants emitted by a vehicle depends on specific vehicle related factors such as vehicle weight, speed and age; fuel-related factors such as fuel type (petroleum or diesel), fuel formulation (oxygen, sulphur, benzene and lead replacement agents) and environmental factors such as altitude, humidity and temperature (Samaras and Sorensen, 1999).

Given the distribution of the mining activities, it is anticipated that vehicle exhaust emissions and their contribution to ambient air pollutant will be relatively significant.

6.1.6.1 Local ambient air quality monitoring

6.1.6.1.1 Dust fallout monitoring

Dust fallout monitoring at Gamsberg Mine is currently conducted at eleven monitoring locations, all equipped with single dust fallout units and in line with the NDCR and the ASTM D1739-70 methodology. The most current dust fallout monitoring results for the period January 2020 to May 2021 are presented in Table 23.

Results indicate that all dust fallout monitoring locations are compliant with the National Dust Control Regulations. To date a non-residential network average of 39 mg/m^2/day was recorded, below the non-residential dust fallout guideline of 1 200 mg/m^2/day.

Table 23: Dust fallout results from January 2020 to May 2021

Sample Location	Guidelines	Dust Fallout (mg/m^2/day)										Compliant
		Jan/Feb-20	Feb-May-20	Jun/Jul-20	Jul/Aug-20	Aug/Sept-20	Sep/Oct-20	Oct/Nov-20	Dec-Feb-21	Feb-Mar-21	Apr/May-21	
Kykgat 1	1 200	50	18	13	6	6	14	63	65	36	11	Yes
Kykgat 2	1 200	37	22	30	82	38	11	10	41	39	8	Yes
GAMS – SU1	1 200	150	35	67	85	76	92	75	154	143	106	Yes
GAMS – SU2	1 200	83	17	48	35	80	97	6	146	59	60	Yes
GAMS – SU3	1 200	20	4	17	10	22	12	20	25	15	19	Yes
GAMS – SU4	1 200	21	-	7	9	21	9	43	292	25	14	Yes
Achab (House)	1 200	48	14	16	-	4	9	6	50	-	14	Yes
Achab (Gams)	1 200	38	6	60	7	9	17	7	53	-	41	Yes
Gams Bloem	1 200	85	12	7	16	-	-	57	107	-	26	Yes
Achab House New	1 200	46	14	13	7	7	24	11	55	-	20	Yes
Achab Gams New	1 200	14	26	51	17	8	28	20	57	-	22	Yes

6.1.6.1.2 Particulate concentrations

Ambient PM_{10} sampling was undertaken at the site during 2018 and 2019. The monitoring locations are provided in Figure 9. The analysis of the data is detailed below (Table 24). Importantly, the GB NW site could be classified as a background site (representative of natural desert windblown dust).

Ambient daily PM_{10} concentrations were below the daily NAAQS of PM_{10} for all sampling points. However, sampling at GB Mining Offices, Aggeneys High school South village and GB Camp exceeded the NAAQS more than four times per annum and as such, results in non-compliance of the daily PM_{10} NAAQS. It should be noted that the data recovery was only 58% at GB NW, below the minimum data recovery of 90% (SANAS, 2012), for the dataset to be deemed representative of conditions during a specific reporting period. Results here should thus be viewed with caution.

Table 24: PM_{10} concentrations and exceedances recorded for the Gamsberg Mine during 2018 and 2019

Sampling ID	Data Recovery (%)	Daily P99 PM_{10} Concentrations ($\mu g/m^3$)	No. of Exceedances
GB Mining Offices (Jan-May-2018)	100	39	12
GB South Access (Jan-Jun 2018)	96	7	0
Aggeneys High School, South Village (Jan-Sept 2019)	97	23	5
GB Camp (Jan-Sept 2019)	98	28	7
GB NW (Jan-Sept 2019)	58	21	3

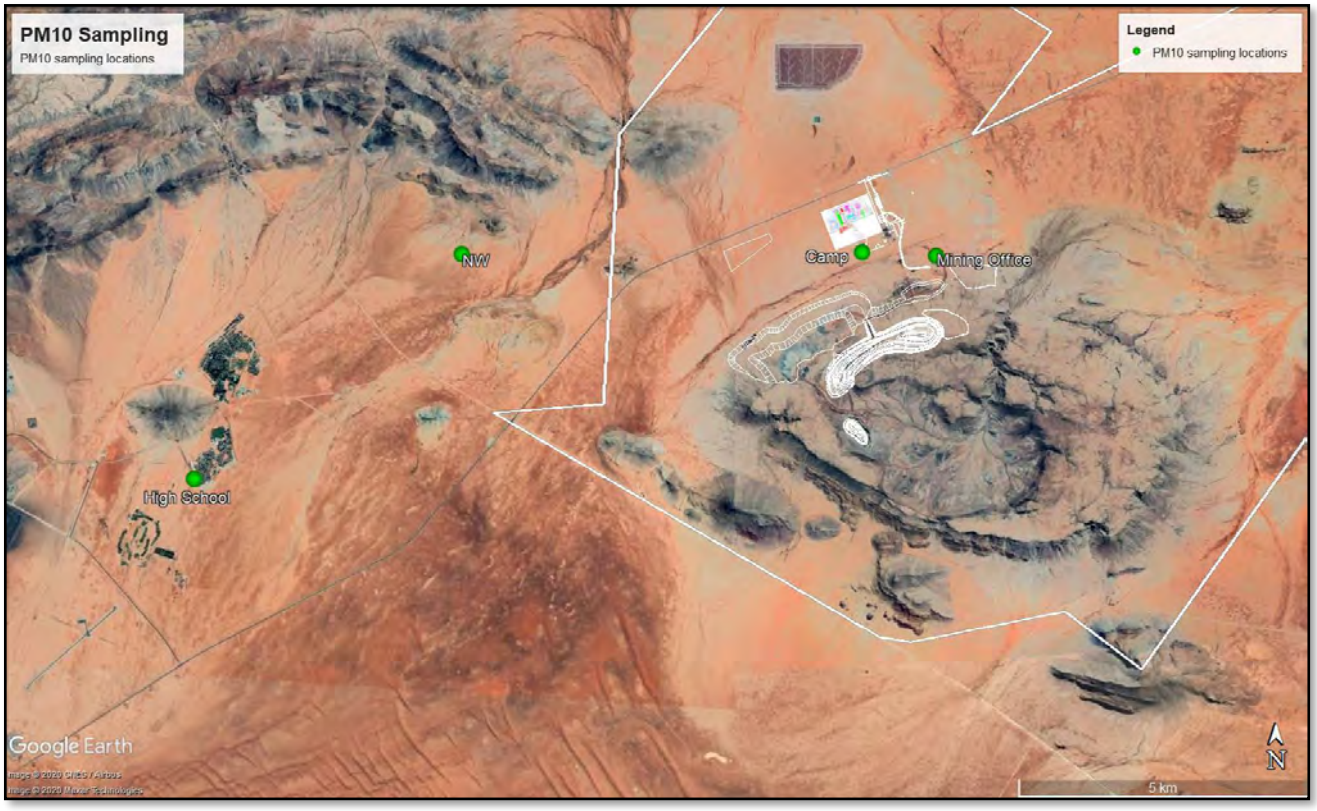


Figure 9: PM_{10} monitoring locations for the Gamsberg Mine during 2018 and 2019 (Airshed, 2020)

6.1.6.1.3 Gaseous concentrations

In 2009, NO_2 and SO_2 were sampled during the months of June and September at ten locations (SRK Consulting, 2010). These monitoring locations are provided in Figure 10. In the absence of a more recent data, this data was used for this assessment. The analysis of the data is detailed below (Table 25).

Ambient SO_2 concentrations for June and September 2009 were well below the daily NAAQS of 125 µg/m^3 for all sampling points. During September 2009, SO_2 concentrations increased when compared to June, but the measured levels remained below the daily SO_2 NAAQS (SRK Consulting, 2010).

NO_2 concentrations were below the hourly NAAQS of 200 µg/m^3 for both the June and September 2009 sampling periods. All sampled concentrations were recalculated from 24-hour to 1-hour values, for comparison to hourly NAAQS values.

Table 25: Gaseous concentrations recorded for the Gamsberg Mine during the 2009 survey

Sample ID	Daily SO_2 Concentrations (µg/m^3)		Hourly NO_2 Concentrations (µg/m^3)	
	Jun-09	Sep-09	Jun-09	Sep-09
GAM A1	BDL	3.64	BDL	0.32
GAM A2	BDL	0.60	BDL	BDL
GAM A3	BDL	0.32	BDL	0.32
GAM A4	BDL	6.78	BDL	BDL
GAM A5	BDL	0.10	BDL	BDL
GAM A6	BDL	0.10	BDL	0.19
GAM A7	BDL	BDL	BDL	BDL
GAM A8	BDL	0.48	0.09	0.12
GAM A9	0.47	0.62	0.33	BDL
GAM A10	0.36	0.10	0.001	0.42
NAAQS		**125**		**200**

Note: BDL = Below Detection Limit

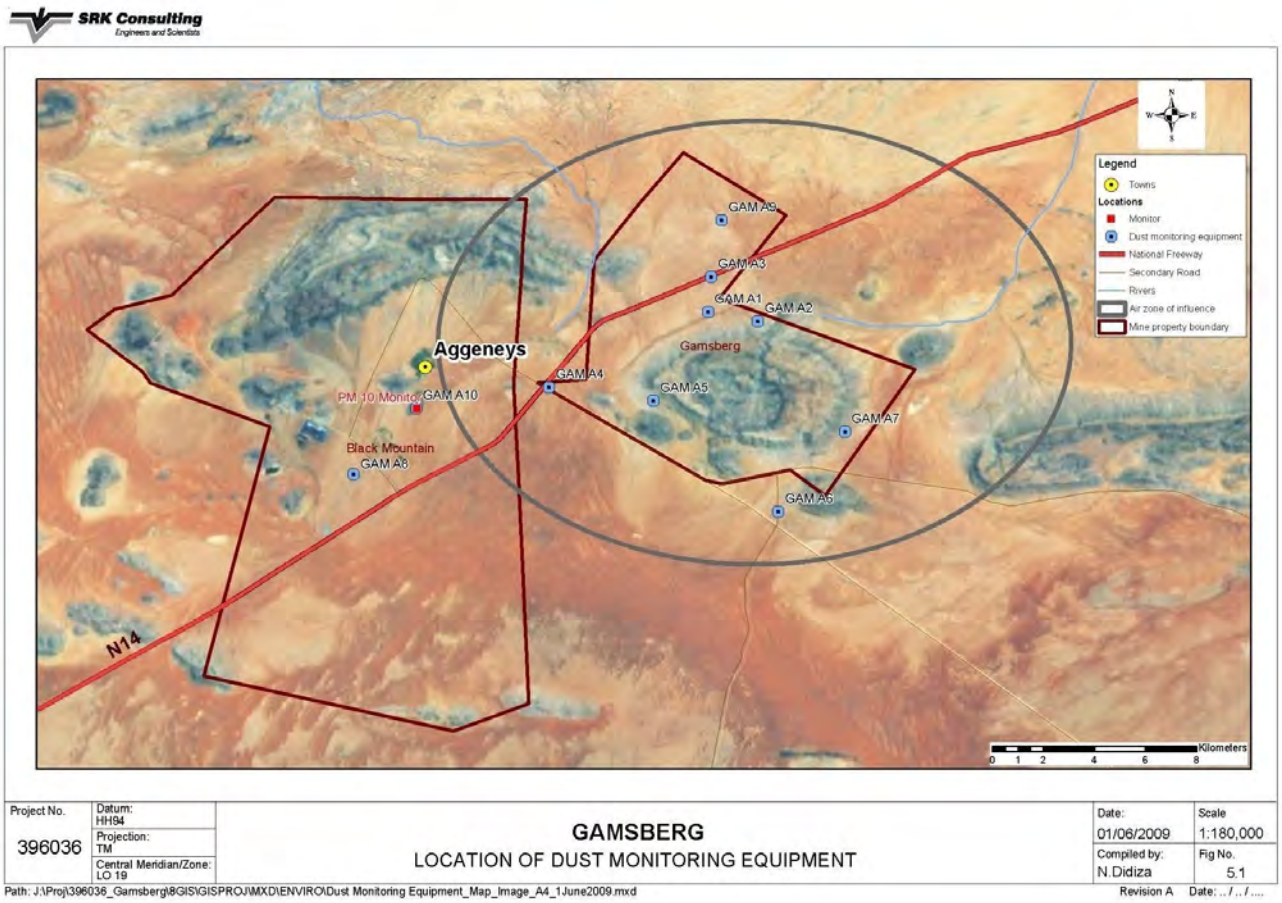


Figure 10: SO_2 and NO_2 monitoring locations for the Gamsberg Mine during the 2009 survey (SRK Consulting, 2009)

6.2 Dispersion modelling

6.2.1 Model type

Dispersion modelling is an effective tool for predicting the ambient air concentrations from pollutants emitted to the atmosphere from a variety of processes.

As per the Regulations Regarding Air Dispersion Modelling, this assessment is considered a Level 2 assessment as emissions are from sources where the greatest impacts are in the order of a few kilometres (less than 50 km), downwind. As such, the AERMOD modelling software was used to determine likely ambient air pollutant concentrations from the Gamsberg operations, for comparison against ambient air quality standards. The AERMET pre-processor was used to process MM5 modelled regional meteorological data for input into AERMOD. The AERMOD modelling software calculates likely changes in dispersion plume trajectory and concentrations in response to changes in local terrain, meteorology and source data. Model inputs are verified before the model is executed.

6.2.2 Model input

Data input into the model includes modelled MM5 surface and upper air meteorological data with wind speed, wind direction, temperature, pressure, precipitation, cloud cover and ceiling height for January 2019 to December 2021. Terrain data at a resolution of 30 m (SRTM1) was also input into the model. A modelling domain of 25 km × 25 km was used (Table 26), with multi-tier Cartesian grid receptor spacing's of 50 (1 km metre from source), 100 (5 km metre from source), 250 m (10 km metre from source) and 1000 (beyond 10 km from source). A receptor spacing of 50 m was also located along the boundary of the Gamsberg operations.

Table 26: Modelling domain coordinates

Domain Point	UTM East (mE)	UTM South (mS)
North-Eastern Point	327135.00	6790190.34
South-Western Point	277084.03	6740043.11

6.2.3 Model settings

A summary of the model settings into AERMOD used in this assessment is provided in Table 27.

Table 27: Summary of model settings

Parameter	Setting
Assessment Level	Level 2
Default Regulatory Settings Utilised	Yes
Dispersion Model	Aermod 10.2.1
Supporting Models	Aermet and Aermap
Pollutants modelled	PM_{10}, $PM_{2.5}$ and VOCs
Scenarios	Existing and Proposed Scenarios
Flag Pole Height	1.5 m
Building Downwash	N/A
Chemical Transformation	N/A
Exponential Decay	N/A
Terrain Settings (simple, flat, elevated)	Elevated
Terrain Data	SRTM1
Terrain Data Resolution (m)	30
Elevation Data	The WebGIS Shuttle Radar Topography Mission (STRM) Terrain data was used with a resolution of 30 m
Land Use Characterisation	Desert Shrubland (characterised based on aerial imagery and land use data)
Number of Sectors	1
Albedo Ratio	0.3275
Bowen Ratio	4.75
Surface Roughness	0.2625
Modelling Domain Centre	Latitude: -29.227428°S; Longitude: 18.964253°E
Modelling Domain (km)	25 x 25
Property Line Resolution (m)	50
Fine Grid Resolution (m)	50
Medium Grid Resolution (m)	100, 250 and 1000

6.2.4 Modelling scenarios

The following modelling scenarios have been considered for this assessment:

1) Proposed operating scenario for the expansion of the crusher and ore stockpile.

2) Existing operating scenario for the expansion of the fuel storage tanks on site.

3) Existing and proposed operating scenario of the fuel storage tanks on site.

Various statistical outputs that have been generated, are described below:

- Short-term averages: Refers to the predicted 99th percentile (P99) 1-hour and 24-hour average outputs. The P99 is required as per the ambient air quality guidelines and makes allowance for exceedances, eliminating outliers; and
- Annual average (long-term) outputs, which is calculated by averaging all hourly concentrations. The calculation is conducted for each grid point within the modelling domain.

It must be noted that, as defined in the Regulations Regarding Air Dispersion Modelling, ambient air quality objectives are applied to areas outside the facility fenceline (i.e. beyond the facility boundary). Within the facility boundary, environmental conditions are prescribed by occupational health and safety criteria.

6.2.5 Results and discussion

This section presents the results of the atmospheric dispersion modelling conducted for the Gamsberg Mine operations.

Furthermore, the National Framework for Air Quality Management in South Africa calls for air quality assessment in terms of cumulative impacts rather than the contributions from an individual facility. Compliance with the NAAQS is to be determined by taking into account all local and regional contributions to background concentrations. For the different facility locations and averaging times, the comparisons with NAAQS must be based on recommendations in Table 28.

Table 28: Summary of recommended procedures for assessing compliance with NAAQS

Facility Location	Annual NAAQS	Short-term NAAQS (24 hours or less)
Isolated facility not influenced by other sources, C_B insignificant*.	Highest C_P must be less than the NAAQS, no exceedances allowed.	99th percentile concentrations must be less than the NAAQS. Wherever one year is modelled, the highest concentrations shall be considered.
Facilities influenced by background sources e.g. in urban areas and priority areas.	Sum of the highest C_P and background concentrations must be less that the NAAQS, no exceedances allowed.	Sum of the 99th percentile concentrations and background CB must be less than the NAAQS. Wherever one year is modelled, the highest concentrations shall be considered.

*For an isolated facility influenced by regional background pollution C_B (background concentration) must be considered

** C_P is the predicted concentration

6.2.5.1 Predicted and cumulative concentrations

Modelling simulations to determine PM_{10}, $PM_{2.5}$, NO_2, SO_2, Zn, Pb concentrations and dust fallout from the Gamsberg project activities was undertaken in the Gamsberg Smelter AQIA in 2020. Two scenarios were simulated, namely baseline mining operations and cumulative baseline and proposed project operations, in order to understand the incremental increase in impacts due to the Gamsberg Smelter project. The following was deduced:

- The incremental increase in $PM_{2.5}$, PM_{10} concentrations and total dust deposition from baseline to proposed project operations was negligible.
- Cumulative $PM_{2.5}$ and PM_{10} concentrations were in compliance with the NAAQS at all sensitive receptors within the study area for all averaging periods.
- Cumulative dust fallout levels were within the dust control guidelines for residential areas at all sensitive receptors within the study area.
- Simulated Pb, NO_2 and SO_2 concentrations due to project activities, were within the NAAQS at all sensitive receptors within the study area for all averaging periods.
- The highest Zn concentrations were below the most stringent health effect screening levels.
- The highest concentrations for dioxins due to the project was 1.2 E-09 µg/m³ which was considered to be “very low”.
- No recent background concentrations were available for Pb, NO_2, SO_2 and dioxins. As such cumulative impacts for these pollutants could not be determined. However, given the type of existing sources within the project study it is likely that the cumulative impacts will be insignificant/minimal.

Dust fallout, $PM_{2.5}$, PM_{10} and VOCs will be emitted into the atmosphere as a result of the proposed Gamsberg Mine project changes associated with the operation of the crusher, ore stockpile and additional fuel storage on site. As such, only the dust fallout, $PM_{2.5}$, PM_{10} and VOCs were modelled in this assessment as the previous results, as per the Gamsberg Smelter AQIA in 2020, will still apply for all other pollutants associated with the facility.

Dust fallout, $PM_{2.5}$ and PM_{10} concentration results for the proposed expansion scenario at specified sensitive receptors are presented in tabular format, while concentration isopleths are presented graphically to indicate the dispersion of pollutants. The VOC concentration results for the existing (was modelled as this was not previously modelled) and existing plus proposed (cumulative) expansion scenarios at specified sensitive receptors are presented in tabular format, while concentration isopleths are presented graphically to indicate the dispersion of pollutants. It must be noted that in the absence of a VOC standard, VOCs, in the form of C_6H_6, being the most stringent standard, has been used for this assessment.

The following are noted from the proposed Gamsberg Mine additional infrastructure and activities:

- Dust fallout levels:
  - The highest predicted offsite dust fallout rate is well below the Residential Dust Control Regulations of 600 mg/m^2/day.
  - Predicted dust fallout rates are well below the Residential Dust Control Regulations at all sensitive receptors.
  - The background dust fallout rates from the Gamsberg Smelter AQIA undertaken in 2020 by Airshed (i.e. mining operations inclusive of the smelter operations) indicated dust fallout rates that were below the Residential Dust Control Regulations of 600 mg/m^2/day beyond the Gamsberg boundary. As such,

with the minimal increase of the expansion, cumulative impacts are also expected to be below the Residential Dust Control Regulations at all receptors.

- Particulate matter concentrations:
  - The highest predicted offsite P99 24-hour average and annual average PM_{10} and $PM_{2.5}$ concentrations are below their PM_{10} and $PM_{2.5}$ NAAQS.
  - Predicted PM_{10} and $PM_{2.5}$ concentrations are also below their NAAQS for PM_{10} and $PM_{2.5}$ at all sensitive receptors for all assessment periods.
  - The background PM_{10} and $PM_{2.5}$ concentrations from the Gamsberg Smelter AQIA undertaken in 2020 by Airshed (i.e., mining operations inclusive of the smelter operations) indicated PM_{10} and $PM_{2.5}$ concentrations that were below their relevant NAAQS beyond the Gamsberg Mine boundary. As such, with the low increase of the expansion, cumulative impacts are also expected to be below the NAAQS.
- VOC concentrations:
  - The highest predicted offsite annual average VOC concentrations for both scenarios are well below the annual average benzene NAAQS of 5 µg/m^3.
  - Predicted annual average VOC concentrations for both scenarios are below the annual average C_6H_6 NAAQS at all surrounding sensitive receptors.
  - VOC cumulative impacts will therefore be insignificant/minimal.

Table 29: Predicted dust fallout levels at sensitive receptors for the Gamsberg Mine operations

No.	Sensitive Receptor	Predicted Dust Fallout Rate (mg/m^2/day)
		Proposed
Dust Fallout Standard (mg/m^2/day)		**600**
1	Residential Area 1	0.76
2	Residential Area 2	1.05
3	Residential Area 3	1.29
4	Residential Area 4	2.42
5	Residential Area 5	1.73
6	Residential Area 6	1.43
7	Residential Area 7	1.36
8	Residential Area 8	2.85
9	Residential Area 9	0.54
10	Residential Area 10	0.61
11	Residential Area 11	0.52
12	Residential Area 12	0.96
13	Residential Area 13	2.21
14	Residential Area 14	1.47
15	Residential Area 15	0.86
Highest Offsite Concentration		104.24

Table 30: Predicted particulate matter concentrations at sensitive receptors for the Gamsberg Mine operations

No.	Sensitive Receptor	PM_{10} 24-Hour Concentration (µg/m³)	PM_{10} Annual Average Concentration (µg/m³)	$PM_{2.5}$ 24-Hour Concentration (µg/m³)	$PM_{2.5}$ Annual Average Concentration (µg/m³)
		Proposed	Proposed	Proposed	Proposed
NAAQS (µg/m³)		75	75	40	20
1	Residential Area 1	0.45	0.03	0.12	0.009
2	Residential Area 2	0.71	0.06	0.19	0.016
3	Residential Area 3	0.91	0.07	0.25	0.018
4	Residential Area 4	1.87	0.12	0.51	0.034
5	Residential Area 5	1.13	0.09	0.31	0.025
6	Residential Area 6	0.99	0.08	0.27	0.021
7	Residential Area 7	0.93	0.07	0.25	0.019
8	Residential Area 8	2.10	0.11	0.59	0.029
9	Residential Area 9	0.35	0.03	0.10	0.008
10	Residential Area 10	0.37	0.03	0.10	0.007
11	Residential Area 11	0.42	0.01	0.11	0.004
12	Residential Area 12	0.47	0.02	0.13	0.005
13	Residential Area 13	1.03	0.07	0.28	0.019
14	Residential Area 14	1.32	0.08	0.35	0.021
15	Residential Area 15	0.56	0.03	0.15	0.009
Highest Offsite Concentration		44.23	3.37	6.04	0.53

Table 31: Predicted VOC concentrations at sensitive receptors for the Gamsberg Mine operations

No.	Sensitive Receptor	Predicted Annual Average Concentration (µg/m³)	
		Existing	Existing plus Proposed
NAAQS (µg/m³)		5	5
1	Residential Area 1	7.00E-05	1.50E-04
2	Residential Area 2	1.30E-04	2.50E-04
3	Residential Area 3	1.50E-04	2.90E-04
4	Residential Area 4	2.50E-04	5.10E-04
5	Residential Area 5	1.90E-04	3.80E-04
6	Residential Area 6	1.70E-04	3.30E-04
7	Residential Area 7	1.50E-04	3.10E-04
8	Residential Area 8	2.10E-04	4.30E-04
9	Residential Area 9	7.00E-05	1.40E-04
10	Residential Area 10	6.00E-05	1.20E-04
11	Residential Area 11	4.00E-05	7.00E-05
12	Residential Area 12	6.00E-05	1.20E-04
13	Residential Area 13	2.30E-04	4.60E-04
14	Residential Area 14	2.60E-04	5.20E-04
15	Residential Area 15	8.00E-05	1.50E-04
Highest Offsite Concentration		2.35E-02	4.73E-02

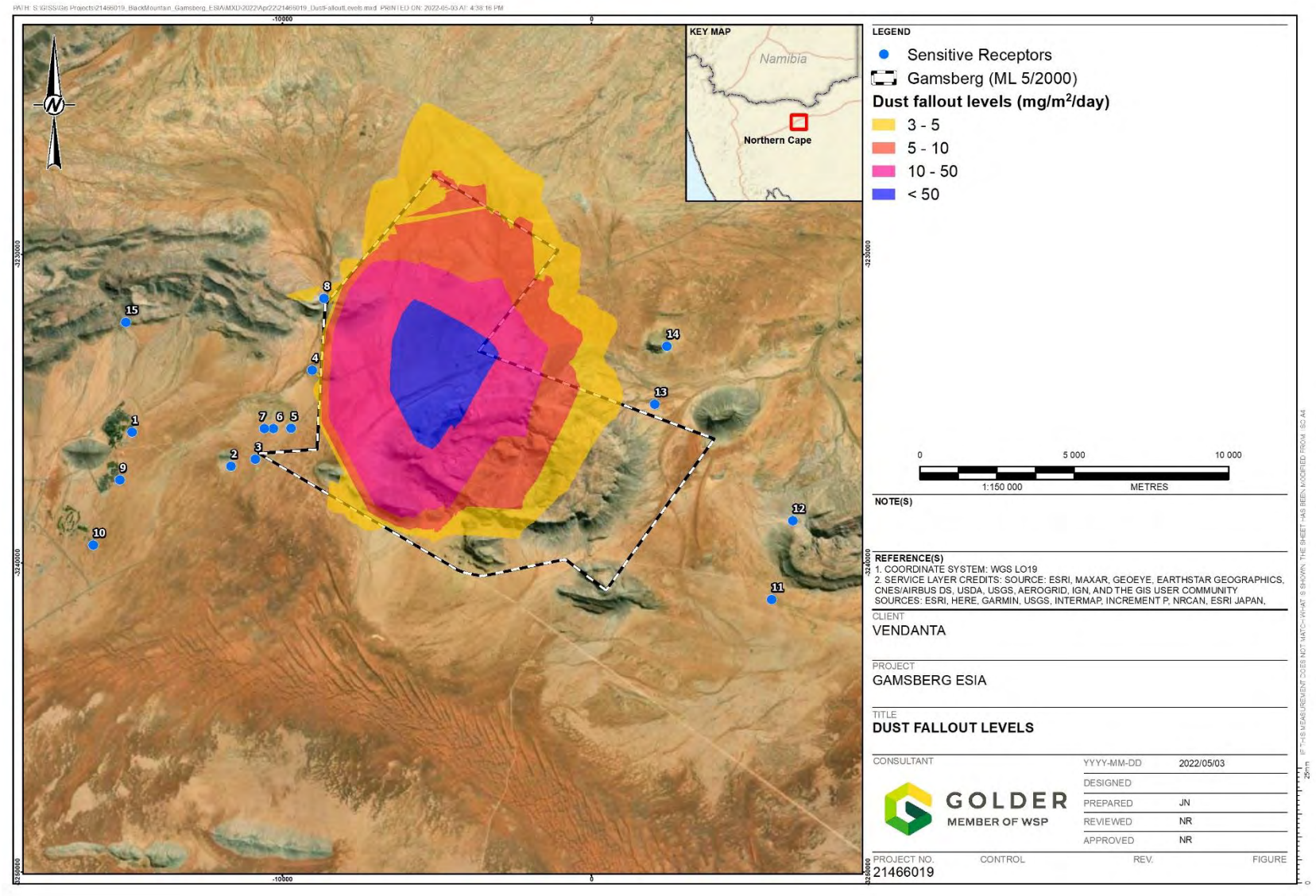


Figure 11: Predicted dust fallout levels for the additional Gamsberg Mine operations (mg/m²/day)

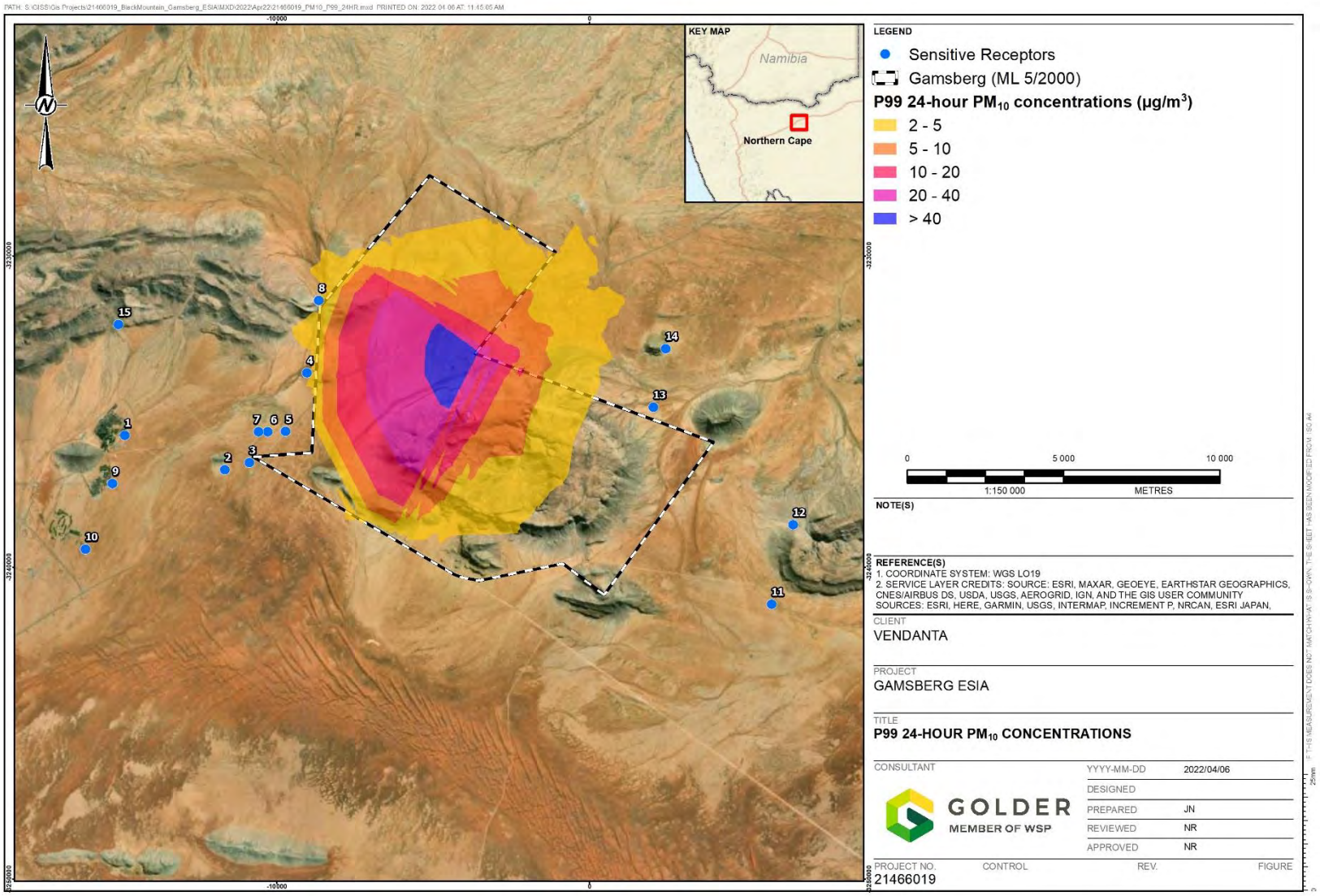


Figure 12: Predicted P99 24-hour PM_{10} concentrations for the additional Gamsberg Mine operations (µg/m³)

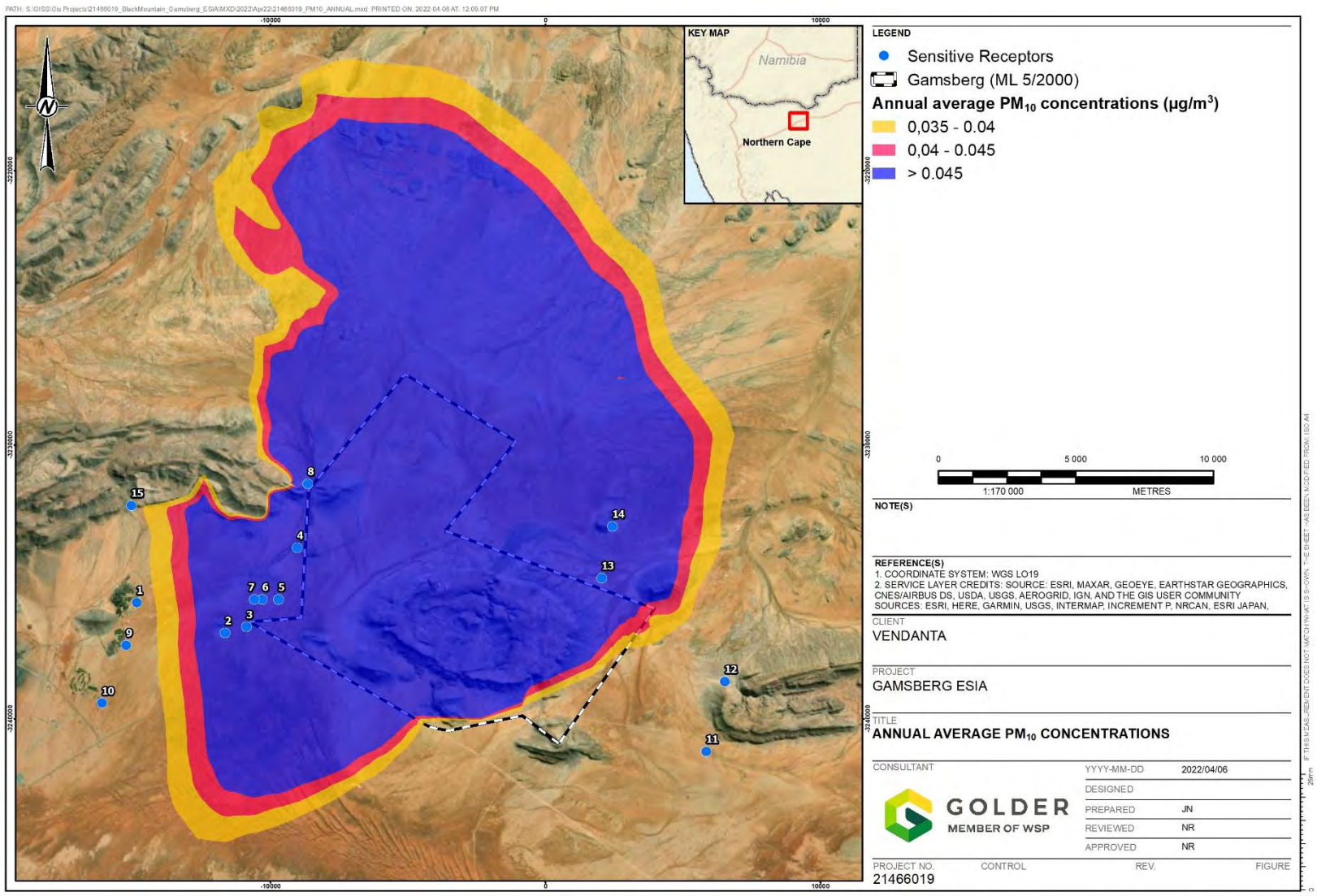


Figure 13: Predicted annual average PM_{10} concentrations for the additional Gamsberg Mine operations (µg/m³)

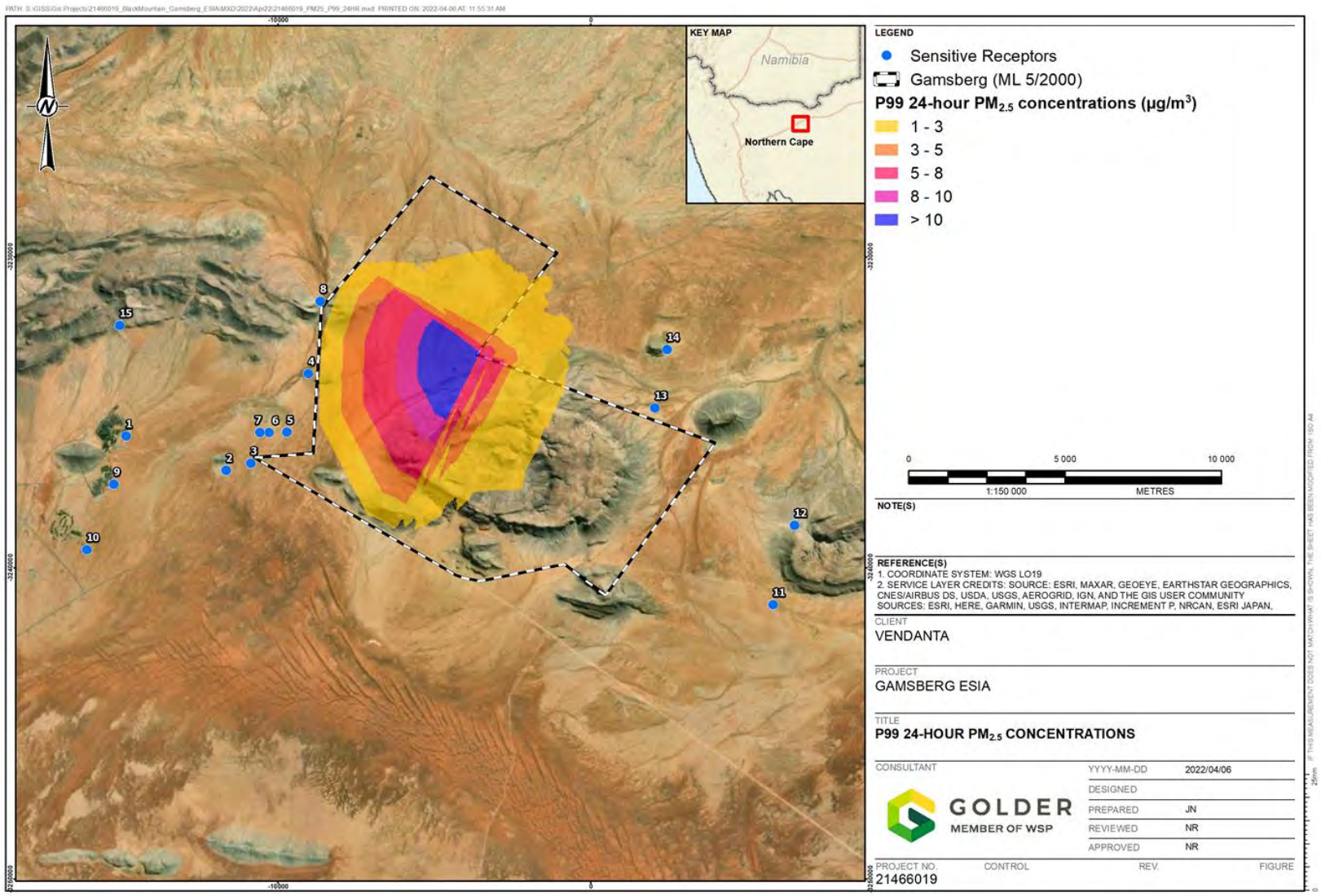


Figure 14: Predicted P99 24-hour $PM_{2.5}$ concentrations for the additional Gamsberg Mine operations (µg/m³)

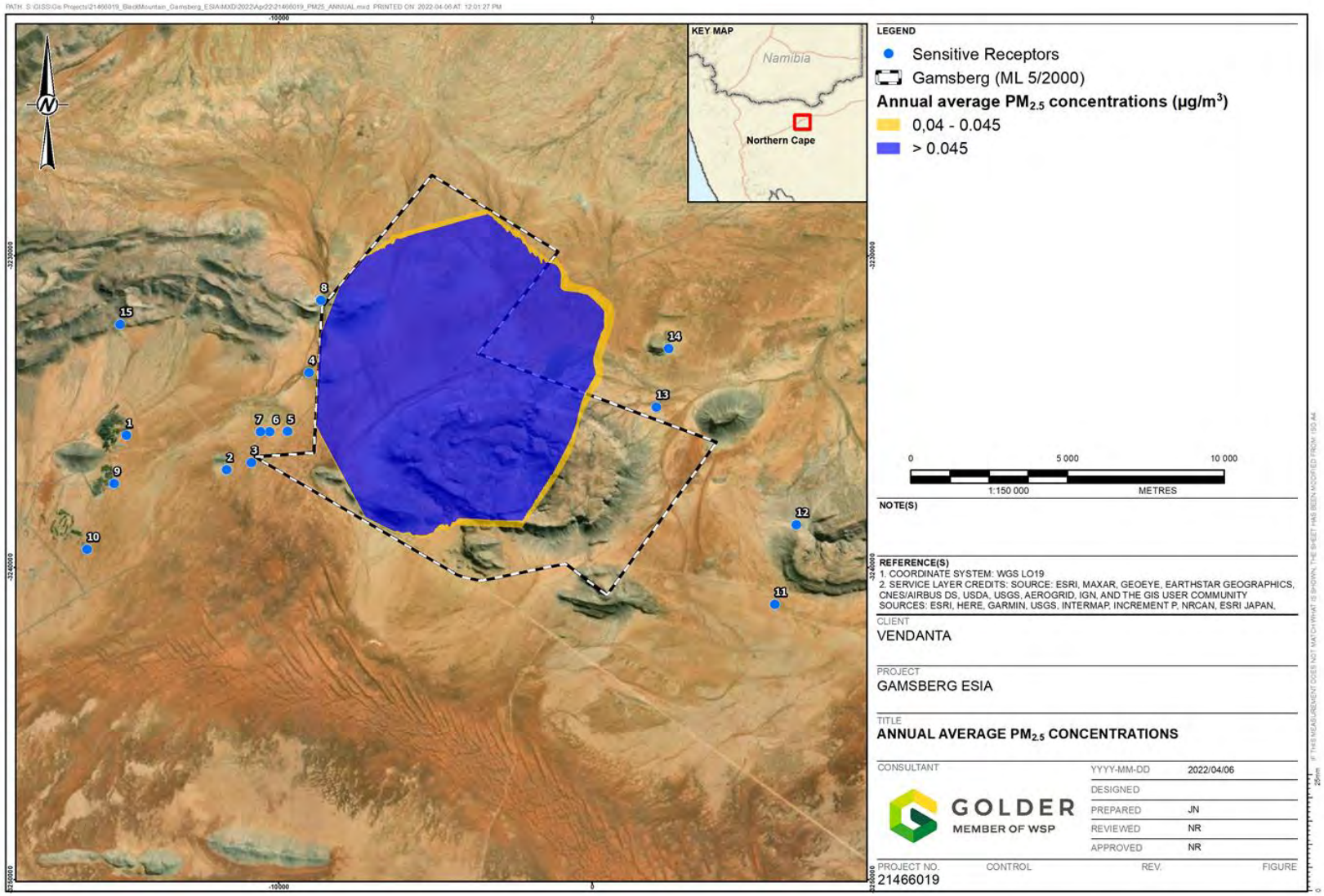


Figure 15: Predicted annual average $PM_{2.5}$ concentrations for the additional Gamsberg Mine operations (µg/m³)

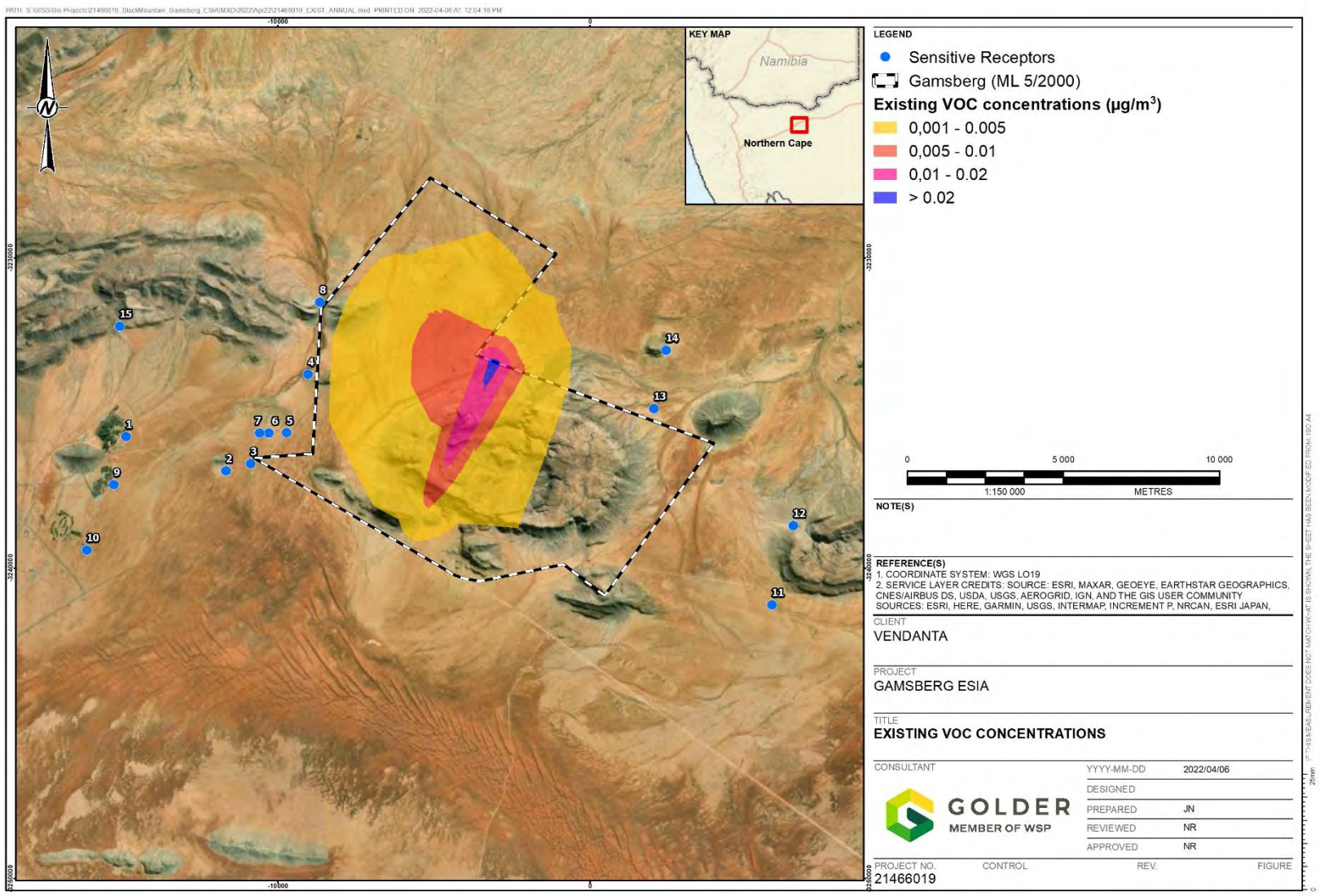


Figure 16: Predicted existing VOC concentrations for the Gamsberg Mine operations (µg/m³)

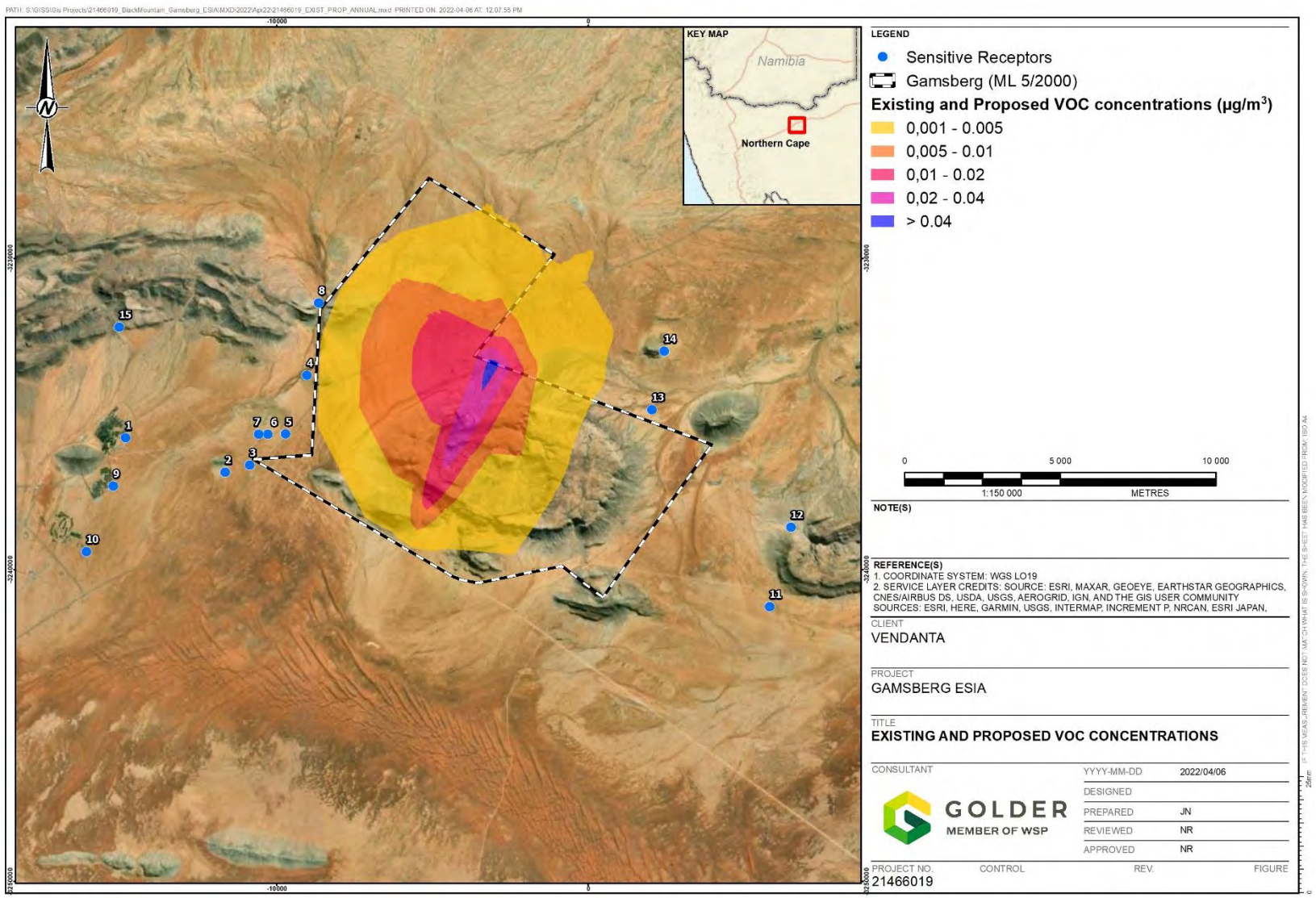


Figure 17: Predicted existing plus proposed VOC concentrations for the Gamsberg Mine operations (µg/m³)

6.3 Assumptions and Limitations

The following assumptions were made for the assessment:

- Data input into the model is based on the information provided by the Client. It is assumed that the information provided by the Client is accurate and complete at the time of modelling.
- The existing emissions inventory can be found in the Gamsberg Smelter AQIA undertaken in 2020 by Airshed.
- The new potable water pipeline will have no impact on air quality emissions and thus has been excluded in this assessment.
- Emulsion storage is proposed to be increased from 2 x 85t silos and 2 x 50t silos to 2 x 100t and 2 x 200t silos respectively, however emissions are considered to be negligible and within a confined enclosed space and has thus been excluded from this assessment.
- The river diversion will have no impact on air quality emissions and thus has been excluded in this assessment.
- A refined layout for the waste rock dump and quartzite rock dump/berm is proposed, however this will have no change in the air quality emissions and thus has been excluded in this assessment.
- The tank temperatures were modelled at ambient temperature for all storage tanks.
- The tanks were modelled using parameters that were set with a gas exit velocity of 0.001 m/s and a diameter of 0.001 m for all storage tanks.
- Horizontal tanks were modelled as a single point source.
- $PM_{2.5}$ emissions were assumed to equal 15% of TSP (USEPA, 2006) in the absence of a $PM_{2.5}$ emission factor for wind erosion. A 50% control efficiency for the use of wet suppression was applied as an environmentally conservative approach (NPI, 2012) for the stockpile that will be mitigated.
- $PM_{2.5}$ emissions were assumed to equal 30% of TSP (USEPA, 2006 particle size distribution for crushing) in the absence of a $PM_{2.5}$ emission factor for crushing. A 50% control efficiency was applied for the use of water sprays (NPI, 2012). Importantly, crushing emission factors include emissions from the screens, the crusher, feeder, and conveyor belt transfer points that are integral to the crusher (NPI, 2012).
- $PM_{2.5}$ emissions were assumed to equal 5.3% of TSP (USEPA, 2006) in the absence of a $PM_{2.5}$ emission factor for material handling activities. Various control measures are applied to the materials handling activities (NPI, 2012). Importantly, material handling from crushing activities (transfer of material) are excluded (to prevent double accounting of emissions) as the crushing emission factors include emissions from the screens, the crusher, feeder, and conveyor belt transfer points that are integral to the crusher (NPI, 2012).

7.0 MITIGATION MEASURES

It is recommended that the Gamsberg Mine maintain and ensure that the measures outlined in the Gamsberg Smelter AQIA, undertaken in 2020 are ongoing. Additionally, the following mitigation measures are recommended to be implemented and maintained for the proposed expansion, as discussed below:

7.1 Truck Loading, Unloading and Transfer Point Activities

The following techniques can be employed to assist with dust suppression (Katestone, 2011):

- Modifying or ceasing loading activities during dry and high wind conditions.

- Avoid double handling of material, where possible.
- Minimising the drop height of the material from truck loads/transfer points.
  - A drop height policy should be maintained on-site and all equipment operators should be trained in the policy such that drop height reduction is implemented during materials handling activities.
- Using water carts with boom sprayers or wet suppression systems.

7.2 Conveyor Belts

Wind erosion of material on conveyor belts can cause large quantities of dust to become airborne, particularly if they are not enclosed. Conveyors that are fully enclosed is the best method to be applied to mitigate dust.

Carryback material that sticks to the belt instead of falling off at the head pulley may also become airborne as the belt dries and passes over the return idlers. If a conveyor belt is not clean, dust can also be bumped from the belt as it passes over the idlers and pulleys, creating more potential for dust to become airborne and entrained in prevailing winds (Kissell, 2003). To prevent unnecessary airborne dust from the conveyors, it is recommended that the conveyor belts are cleaned on a regular basis through the use of belt scrapers, washers and or combinations of both. Implementing wet dust suppression sprays at conveyor tip points are also recommended.

7.3 Wind Erosion

Windbreaks in the form of shade cloth screens may be erected at exposed areas, and as such reduces the wind speed across the surface of the ground (higher wind speeds tend to scour the surface, leading to dust entrainment and subsequent transportation) and therefore reducing the impact of dust emissions on the surrounding environment.

Dust emissions from stockpiles can occur during the loading of the piles, when wind disturbs the stockpile surface, and during reclamation (USEPA, 2006a). To decrease the erosion potential of stockpiles, the following mitigation techniques are recommended:

- The height of existing berms at stockpiles be increased, reducing the impact of winds on the stockpile.
- Maintaining the stockpile moisture level to avoid further entrainment of particles.

7.4 Crushers

Mitigation methods in these areas that can be implemented to reduce dust emissions include:

- Tasking a team to be responsible for the removal of all deposited dust from machinery, enclosures and conveyors within the crushing plant and tip areas, resulting in less deposited dust available for wind entrainment.
- Deploy a dust sweeper in the plant, capable of collecting all deposited fines, reducing the amount of dust available for wind entrainment.
- Erecting porous wind breaks at the base of screens, crushers and transfer points, approximately 2 m high, completely enclosing the base of the structure. This method will ensure deposited fines from the activity are not entrained by winds. These areas can then be routinely cleaned.
- Wash down the plant areas on a periodic basis via water sprays.

7.5 Storage Tanks

Mitigation methods entail:

- Maintaining stable tank pressure and vapour space:

  - All tank lines should remain charged (i.e. liquid full), and only emptied for maintenance or product change.
  - Coordinating filling and withdrawal schedules, and implementing vapour balancing between tanks.
  - Thermal relief valves should be present to protect the pipes against overpressure due to solar heating.
- Use of bottom loading truck/rail car filling systems.
- Establishing a procedure for periodic monitoring of fugitive emissions from pipes, valves, seals, tanks and other infrastructure components with vapour detection equipment, and with subsequent maintenance or replacement of components as needed. The procedure should specify the monitoring frequency and locations, as well as the trigger levels for repairs.
- The quantity of vapour in an air-and-vapour mixture can be measured by means of a gas detector. Gas detector scales are graduated from 0 to 100, their graduation being based on the lower limit of flammability of 1 %. A reading of 50 indicates 50 % of the lower limit of flammability (i.e. the mixture contains 0,5 % of vapour), and a reading of 20 on that scale indicates 0,2 % of vapour (SANS 10089-1).
- The instrument used for recording the concentration of this vapour should be of an approved design and shall be regularly calibrated and tested for accuracy.
- During tank cleaning, the following should be observed:
  - Tank degassing vapours should be routed to an appropriate emissions control device. Other practices include restricting activities to a season when the potential for ozone formation is reduced or to a time of the day when the potential for ozone formation is less.
  - Tanks should be periodically inspected internally. An inspection frequency based on the condition of the tank at the previous internal inspection should be established (typically 10 years or less).
- During the operational phase passive monitoring campaign should be undertaken annually for a minimum of three months during the winter and summer seasons to determine the VOC concentrations liberated in the general vicinity of the operations. If concentrations levels are low, monitoring can stop.

8.0 IMPACT ASSESSMENT

All impacts of the proposed project were evaluated using a risk matrix, which is a semi-quantitative risk assessment methodology. This system derives an environmental impact level on the basis of the magnitude, duration, scale, probability and significance of the impacts, based on a clear understanding of the potential mitigatory measures that can be implemented and changes in risks as a result of implementation of these mitigatory measures. A full description of the risk rating methodology is presented in Appendix A.

Impacts from the proposed additional infrastructure at the Gamsberg Mine expansion operations are expected to be low (Table 32).

Table 32: Impact assessment summary

Phase	Activity	Impact	Aspect	Without Mitigation						With Mitigation					
				Magnitude	Duration	Scale	Probability	Significance Points	Significance	Magnitude	Duration	Scale	Probability	Significance Points	Significance
Construction of additional infrastructure	Emissions from the construction activities.	Impact on surrounding sensitive receptors due to increased dust and particulate matter	Ambient air quality	6	2	2	3	**30**	Moderate	4	2	1	2	**14**	Low
Operation of additional infrastructure	Emissions from the coarse ore stockpile, crusher, material handling and storage tanks.	Impact on surrounding sensitive receptors due to increased dust, particulate matter and VOC levels	Ambient air quality	4	3	2	3	**27**	Low	2	3	1	2	**12**	Low
Decommissioning of additional infrastructure	Emissions from the decommissioning activities.	Impact on surrounding sensitive receptors due to increased dust and particulate matter	Ambient air quality	6	2	2	3	**30**	Moderate	4	2	1	2	**14**	Low

8.1 Analysis of emissions' impact on the environment

The following sections analyse the potential impacts associated with air pollution on the surrounding environment.

8.1.1 Effect on vegetation

Air pollution can produce a wide variety of effects on the physiology of vegetation including the following:

- Deposition of the particulates on the vegetation can reduce light transmission to the chloroplasts thus reducing photosynthesis.
- The chemical composition of the particulates may indirectly change the soil chemistry from deposition and thus may influence the suitability of the habitat.
- Heavy metals and other toxic particles have been shown to cause damage and death of some species as a result of both the phytotoxicity and the abrasive action during deposition.
- Pollutants can influence the vegetation growth rates and lead to stunted growth and reduced crop yields.
- Gaseous pollutants can chemically burn the vegetation and/or lead to discolouration due to physiology damage from elevated concentrations.

8.1.2 Effects on animals

Air pollution effects animals in a similar manner to human sensitive receptors. Common negative health effects may include the following:

- Airway allergic inflammatory reactions and a wide range of respiratory problems.
- Adverse effects on the cardiovascular system.
- Increase in mortality.
- Heavy metals and other toxic particles have been shown to cause damage and death via bio-accumulation in the organs and/or bones.
- Effects on nervous system, kidney function, brain, gastrointestinal function, immune system, reproductive and developmental systems and the cardiovascular system.

8.1.3 Effects on physical structures

Air pollution commonly effects structures in the following manners:

- Soiling of structures.
- Increases corrosion of metals and/or concrete structures.
- Increased maintenance costs.

9.0 COMPLAINTS

No complaints pertaining to air quality or emissions have been received to date.

10.0 CURRENT OR PLANNED AIR QUALITY MANAGEMENT INTERVENTIONS

No other current or planned air quality management interventions are proposed.

11.0 COMPLIANCE AND ENFORCEMENT ACTIONS

There are no compliance or enforcement actions.

12.0 ADDITIONAL INFORMATION

No additional information is necessary.

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Reg. No. 2002/007104/07
Directors: RGM Heath, MQ Mokulubete, MC Mazibuko (Mondli Colbert), GYW Ngoma

https://golderassociates.sharepoint.com/sites/145886/project files/6 deliverables/final client deliverables/specialist studies/aqia/21466019-351699-2 gamsberg final aqia_25apr22.docx

APPENDIX A

Impact Assessment Criteria

The significance of each identified impact was determined using the approach outlined below (terminology from the Department of Environmental Affairs and Tourism Guideline document on EIA Regulations, April 1998). This approach incorporates two aspects for assessing the potential significance of impacts, namely occurrence and severity, which are further sub-divided as follows.

Impact assessment factors

Occurrence		Severity	
Probability of occurrence	Duration of occurrence	Scale/extent of impact	Magnitude of impact

To assess these factors for each impact, the following four ranking scales are used.

Impact assessment scoring methodology

Probability	Duration
5 - Definite	5 - Permanent
4 - Highly probable	4 - Long-term
3 - Medium probability	3 - Medium-term (8 - 15 years)
2 - Low probability	2 - Short-term (0 - 7 years) (impact ceases after the operational life of the activity)
1 – Improbable	1 – Immediate
0 – None	
Scale	**Magnitude**
5 – International	10 - Very high
4 – National	8 - High
3 – Regional	6 - Moderate
2 – Local	4 - Low
1 - Site only	2 - Minor
0 – None	

Once these factors are ranked for each impact, the significance of the two aspects, occurrence and severity, is assessed using the following formula:

SP (significance points) = (magnitude + duration + scale) x probability

The maximum value is 100 significance points (SP). The impact significance will then be rated as follows.

Significance of impact based on point allocation

SP >75	Indicates high environmental significance	An impact which could influence the decision about whether or not to proceed with the project regardless of any possible mitigation.
SP 30 – 75	Indicates moderate environmental significance	An impact or benefit which is sufficiently important to require management and which could have an influence on the decision unless it is mitigated.
SP <30	Indicates low environmental significance	Impacts with little real effect and which should not have an influence on or require modification of the project design.
+	Positive impact	An impact that constitutes an improvement over pre-project conditions,

For the methodology outlined above, the following definitions were used:

- ***Magnitude*** is a measure of the degree of change in a measurement or analysis (e.g. the area of pasture, or the concentration of a metal in water compared to the water quality guideline value for the metal), and is classified as none/negligible, low, moderate or high. The categorization of the impact magnitude may be based on a set of criteria (e.g. health risk levels, ecological concepts and/or professional judgment) pertinent to each of the discipline areas and key questions analysed. The specialist study must attempt to quantify the magnitude and outline the rationale used. Appropriate, widely recognised standards are to be used as a measure of the level of impact;
- ***Scale/Geographic extent*** refers to the area that could be affected by the impact and is classified as site, local, regional, national, or international;
- ***Duration*** refers to the length of time over which an environmental impact may occur: i.e. immediate/transient, short-term (0 to 7 years), medium term (8 to 15 years), long-term (greater than 15 years with impact ceasing after closure of the project), or permanent; and
- ***Probability*** of occurrence is a description of the probability of the impact actually occurring as improbable (less than 5% chance), low probability (5% to 40% chance), medium probability (40% to 60% chance), highly probable (most likely, 60% to 90% chance) or definite (impact will definitely occur).

APPENDIX B

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GOLDER ASSOCIATES AFRICA (PTY) LTD

APPENDIX C

Formal Declarations

Formal Declarations

Declaration of Accuracy of Information

DECLARATION OF ACCURACY OF INFORMATION - APPLICANT

Name of Enterprise: Black Mountain Mining (Pty) Ltd

Declaration of accuracy of information provided:

Atmospheric Impact Report in terms of section 30 of the Act.

I, Pieter D. Venter (duly authorised), declare that the information provided in this atmospheric impact report is, to the best of my knowledge, in all respects factually true and correct. I am aware that the supply of false or misleading information to an air quality officer is a criminal offence in terms of section 51(1)(g) of this Act.

Signed at Pretoria on this 6 day of May 2022.

SIGNATURE

Environmental Manager

CAPACITY OF SIGNATORY

Declaration of Independence of Practitioner

DECLARATION OF INDEPENDENCE - PRACTITIONER

Name of Practitioner: Novania Reddy

Declaration of independence and accuracy of information provided:

Atmospheric Impact Report in terms of Section 30 of the Act.

I, **Novania Reddy**, declare that I am independent of the applicant. I have the necessary expertise to conduct the assessments required for the report and will perform the work relating the application in an objective manner, even if this results in views and findings that are not favourable to the applicant. I will disclose to the applicant and the air quality officer all material information in my possession that reasonably has or may have the potential of influencing any decision to be taken with respect to the application by the air quality officer, The information provided in this atmospheric impact report is, to the best of my knowledge, in all respects factually true and correct. I am aware that the supply of false or misleading information to an air quality officer is a criminal offence in terms of section 51(1) (g) of this Act.

Signed at **Johannesburg** on this **04** day of **May 2022**.

SIGNATURE

Air Quality Consultant

CAPACITY OF SIGNATORY

golder.com

DETAILS OF THE SPECIALIST

Table 1: Details of specialist

Specialist Information	
Name:	Novania Reddy
Phone number:	+27 11 254 4917
Email:	Novania.reddy@wsp.com
Professional Registration Number	N/A
Curriculum vitae:	See Appended

Declaration of Independence by Specialist

I, Novania Reddy, declare that I –

- Act as the independent specialist for the undertaking of a specialist section for the proposed project.
- Do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed;
- Do not have nor will have a 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 information that have or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan, or document.

Novania Reddy

APPENDIX G

Surface Water Baseline Assessment Report

REPORT

Surface water baseline for Gamsberg Mine

Black Mountain Mining (Pty) Ltd

Submitted to:

Black Mountain Mining (Pty) Ltd.
1 Penge Road
Aggeneys
Northern Cape Province
South Africa

Submitted by:

Golder Associates Africa (Pty) Ltd.
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21466019-351776-4

May 2022

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Table of Contents

TABLES

FIGURES

APPENDICES

1.0 INTRODUCTION

Golder associates (Pty) Ltd (member of WSP) was appointed by Black Mountain Mining (Pty) Ltd to conduct a baseline assessment of the surface water in the Gamsberg Zinc Mine.

Black Mountain Mining (Pty) Ltd, part of Vedanta Zinc International, owns and operates the Gamsberg Zinc Mine. In 2010 Vedanta Resources Limited acquired Black Mountain Mining (Pty) Ltd from Anglo American as part of the acquisition of the zinc base metal mine take over. Following the acquisition of the Black Mountain Mining properties and rights, a feasibility and optimization of technology for the Gamsberg Zinc Mine was undertaken. Gamsberg Zinc Mine operates independently from The Black Mountain Complex (BMC), an existing base metals mining complex situated in Aggeneys.

Zinc deposits in the Gamsberg area were discovered in 1971 but have not been taken advantage of until recently. The Gamsberg Zinc Mine has been in operation since June 2016 and is currently mining up to 4 million tonnes per annum (mtpa) and producing up to 250 000 tonnes per annum (tpa) of zinc concentrate for export.

Mining activities commenced in June 2016 when overburden stripping for the open pit was started. The mining plan for Phase 1 consisted of three smaller open pits within the footprint of the 10 million ton per annum footprint. Development of the open pit mine and the concentrator plant was carried out in phases. The construction of the concentrator plant commenced in 2017 with the official opening in February 2019. Phase 2 will expand the mining capacity to 10 million tonnes per annum (mtpa).

2.0 BASELINE STUDY OBJECTIVES

The baseline describes the catchment and project area in respect of surface water resources and hydrological data for the current situation. It informs the stormwater management components that support the various legislative requirements.

3.0 PROJECT LOCATION AND EXTENT

Gamsberg is situated in Aggeneys, a small town in the Northern Cape Province, 60 km west of Pofadder and 110 km east of Springbok. Gamsberg, as part of the larger BMM, falls under the Namakwa District Municipality and the Springbok regional services council authority (see Figure 1 below). Gamsberg is located in the Lower Orange River Water Management Area (WMA), and specifically in the D82C Quaternary catchment.

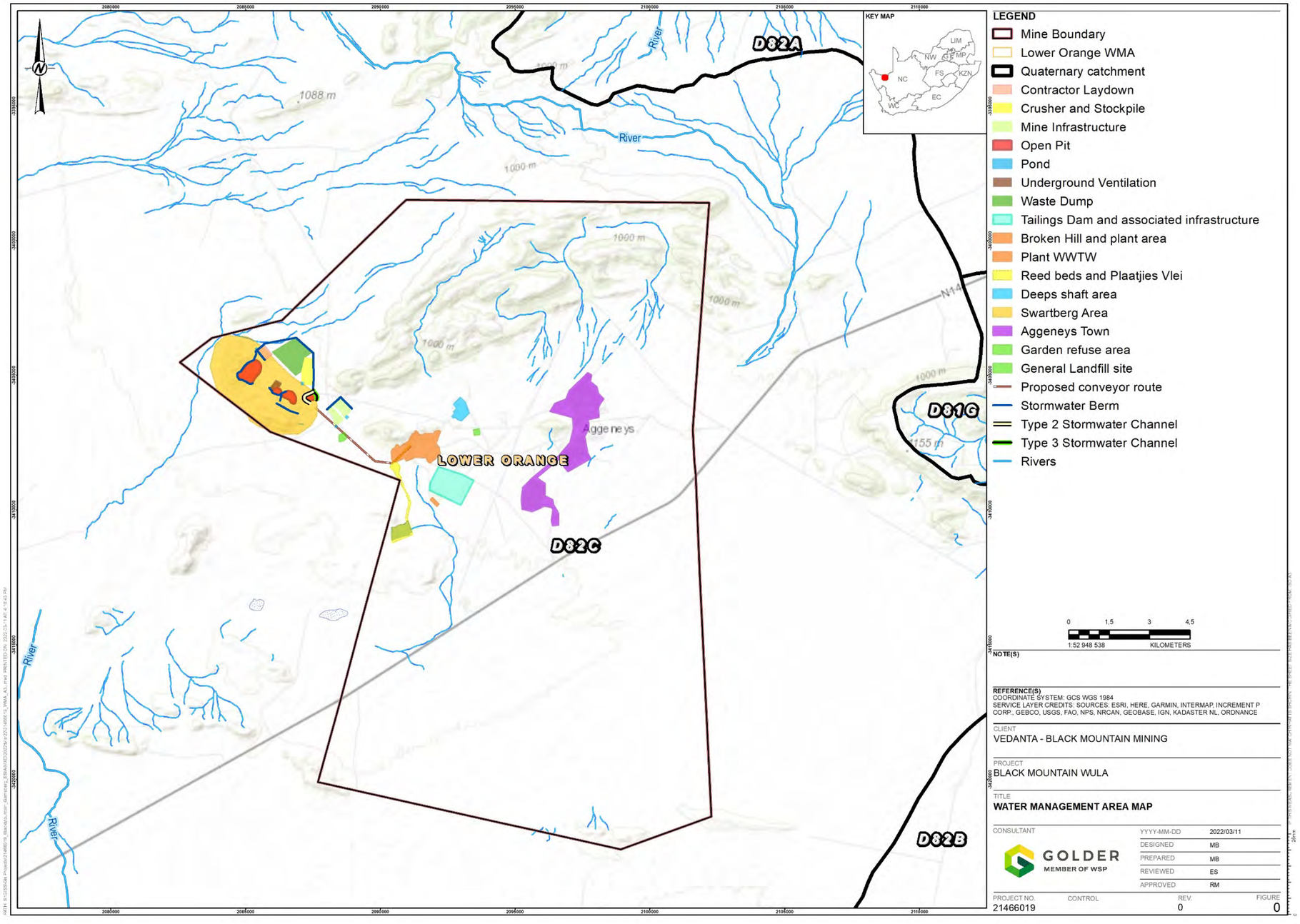


Figure 1: Water management area

3.1 Water supply

Water is currently supplied to the mine by Sedibeng Water via two existing pipelines from the Orange River. The existing water system has a common intake, low lift pump house and low lift pipeline. The low lift pumping system is feeding two circuits, namely the Black Mountain Mine circuit and the Gamsberg Zinc Mine circuit. Both the circuits consist of a flash mixer, clarifier, dosing system, sludge handling facility, balancing reservoir, high lift pump house, high lift pipelines and Horseshoe Reservoir with associated facilities. The current and future water demand, within the Black Mountain Mine operation, including Aggeneys, Pofadder and Pella towns is 43.45 ML/day, the existing intake water pumping system has been designed for 40.8 ML/day.

The existing bulk water pipeline infrastructure running from the Horseshoe Reservoir to the Gamsberg takeoff covers a distance of approximately 4 km and consists of one 400 mm diameter underground pipeline and one 400 mm aboveground pipeline. A 400mm HDPE diameter aboveground bulk water pipeline runs from the Gamsberg takeoff where the pipeline splits off from the Main Bulk Water Pipeline to the Gamsberg reservoir(25Ml) over a distance of 3km (SLR Consulting, 2020).

4.0 APPLICABLE LEGISLATION, GUIDELINES AND STANDARDS

4.1 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.

4.2 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:

- 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.
- 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 0.8 m above the full supply level.
- 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.

5.0 BASELINE OVERVIEW

5.1 Climate

The Gamsberg operation, similar to Black Mountain is situated in the north-west region of Bushmanland, an area that is marginal to the winter and summer rainfall zones in the North West Cape Province. Bushmanland, to the west, is considered a winter rainfall area, while Gordonia to the east, is a summer rainfall area. The climate in the Gamsberg regional areas can be described as arid to semi-arid in nature with very limited rainfall, primarily occurring during short periods (hours) as well as associated with short intense summer thunderstorm events.

5.1.1 Rainfall

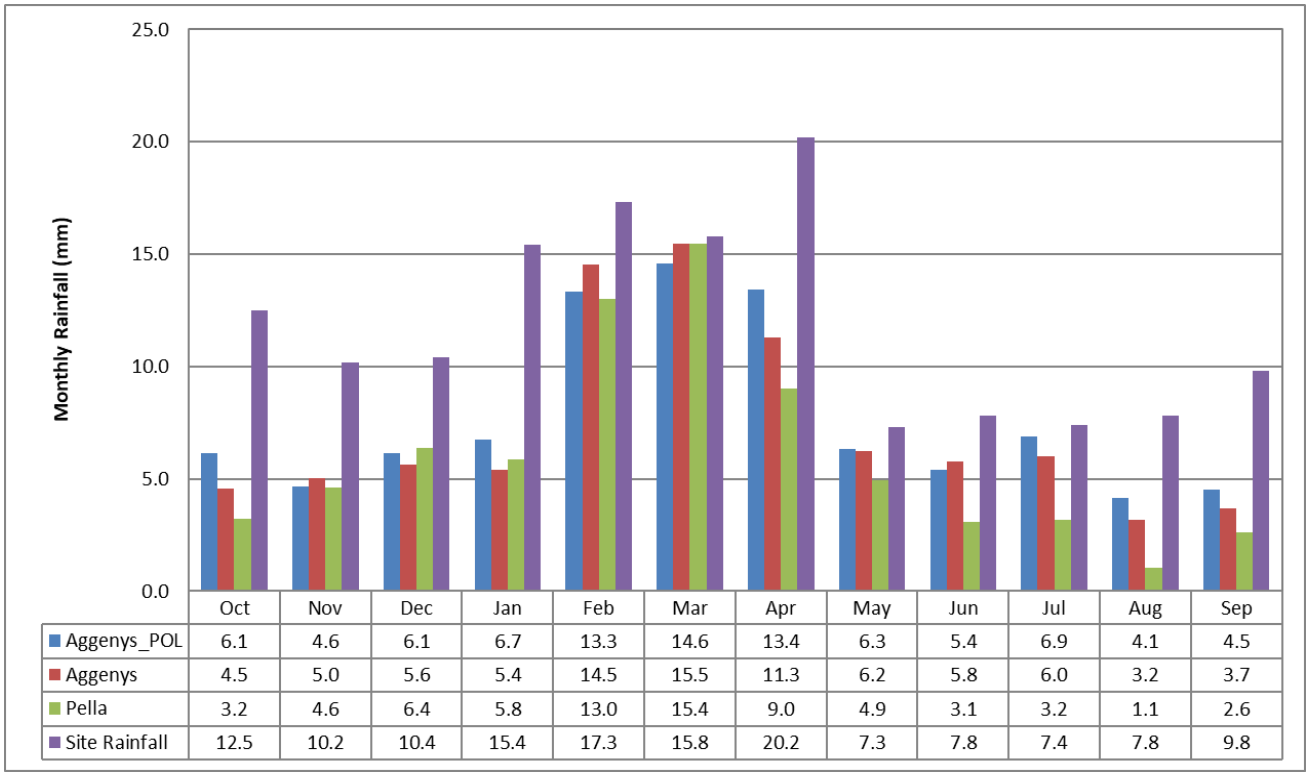
The rainfall data was generated using a rainfall simulator which was sourced through the Design Rainfall Estimation Program (Smithers & Schulze, 2002) and the Daily Rainfall Extraction Utility (Kunz, 2004). On-site rainfall data was provided by the client and used in the analysis. The rainfall stations presented in Table 1 summarize the rainfall data used in the analysis.

Table 1 : Rainfall station properties

Station number	Name	Distance (km)	Record period (years)	Period of records	Reliability (%)	MAP (mm)
0246555 W	Aggeneys (Pol)	1.6	50	1950 - 2000	100	92
0246613 W	Aggeneys	4.1	80	1920 - 2000	4.2	88
0247242W	Pella	39.1	79	1921 - 2000	75	72
-	-	On-site	34	1986 - 2019	100	96

5.1.1.1 Comparison of rainfall stations

The average monthly plot was used to compare the rainfall records as shown in Figure 2. On average, it is evident that slightly more rainfall was recorded on-site as compared to the other stations. On-site data also extends to a period that is more recent than the other stations. Though the rainfall records cover different time periods, the average monthly rainfall depths for the different stations have a similar pattern. During the wet season, the highest average rainfall was recorded in the month of March. The driest month on average was recorded in July.



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Aggenys_POL	6.1	4.6	6.1	6.7	13.3	14.6	13.4	6.3	5.4	6.9	4.1	4.5
Aggenys	4.5	5.0	5.6	5.4	14.5	15.5	11.3	6.2	5.8	6.0	3.2	3.7
Pella	3.2	4.6	6.4	5.8	13.0	15.4	9.0	4.9	3.1	3.2	1.1	2.6
Site Rainfall	12.5	10.2	10.4	15.4	17.3	15.8	20.2	7.3	7.8	7.4	7.8	9.8

Figure 2 : Average monthly rainfall for the stations

The station 024655 W Aggeneys (POL) was chosen as the station used in the study for the following reasons:

- The station is within proximity of the site.
- The station has a high reliability data set (having the lowest percentage of patched or missing data).
- The station has a longer duration of recorded data than what was recorded on-site

5.1.1.2 Aggeneys (Pol) rainfall station

Aggeneys (Pol) station is situated approximately 1.6 kilometres from the site with 50-years of recorded data. It has the highest reliability of the analysed stations. The maximum recorded 24-hour rainfall depth is 83 mm, recorded on the 19th of February 2000, as shown in Figure 3. Figure 4 shows the annual rainfall depths. The mean annual precipitation for the station is 92 mm.

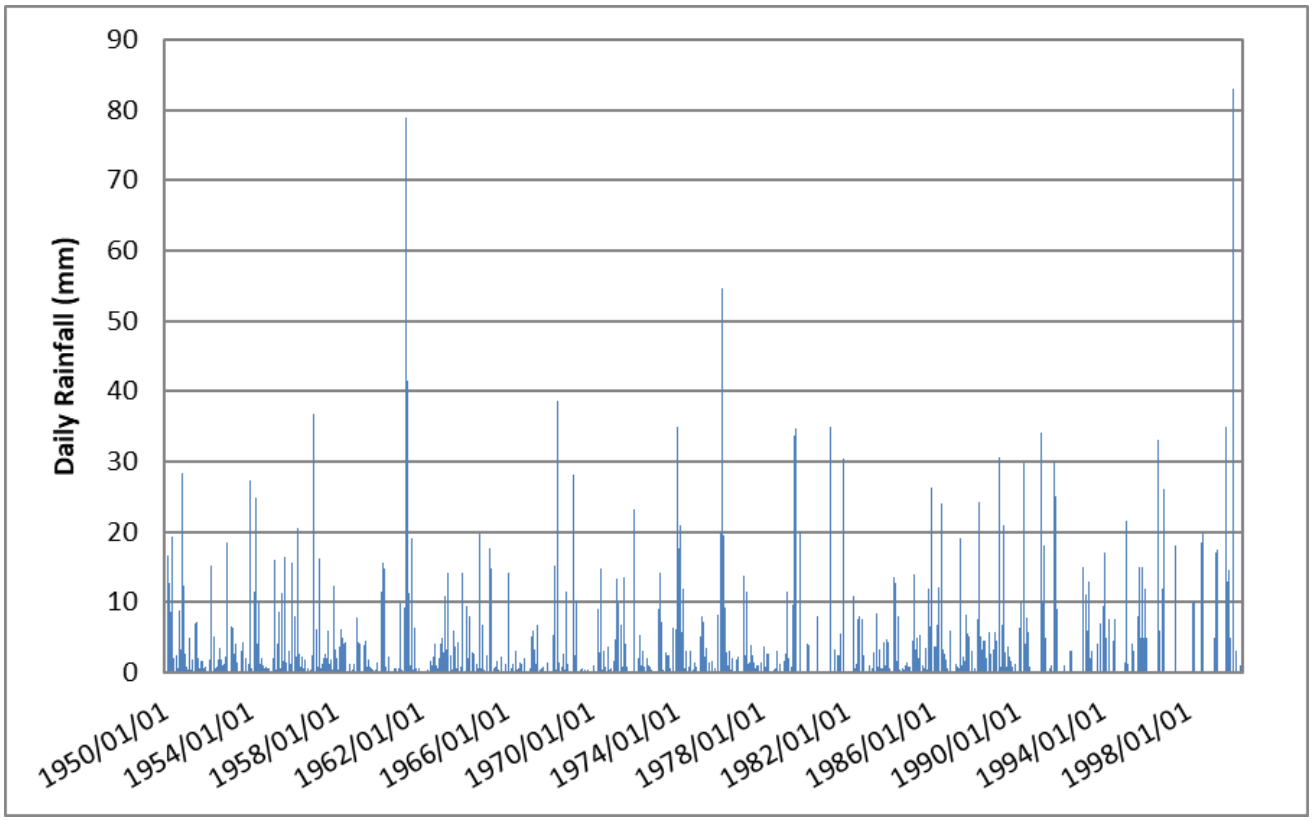


Figure 3 : Aggeneys (Pol) station daily rainfall

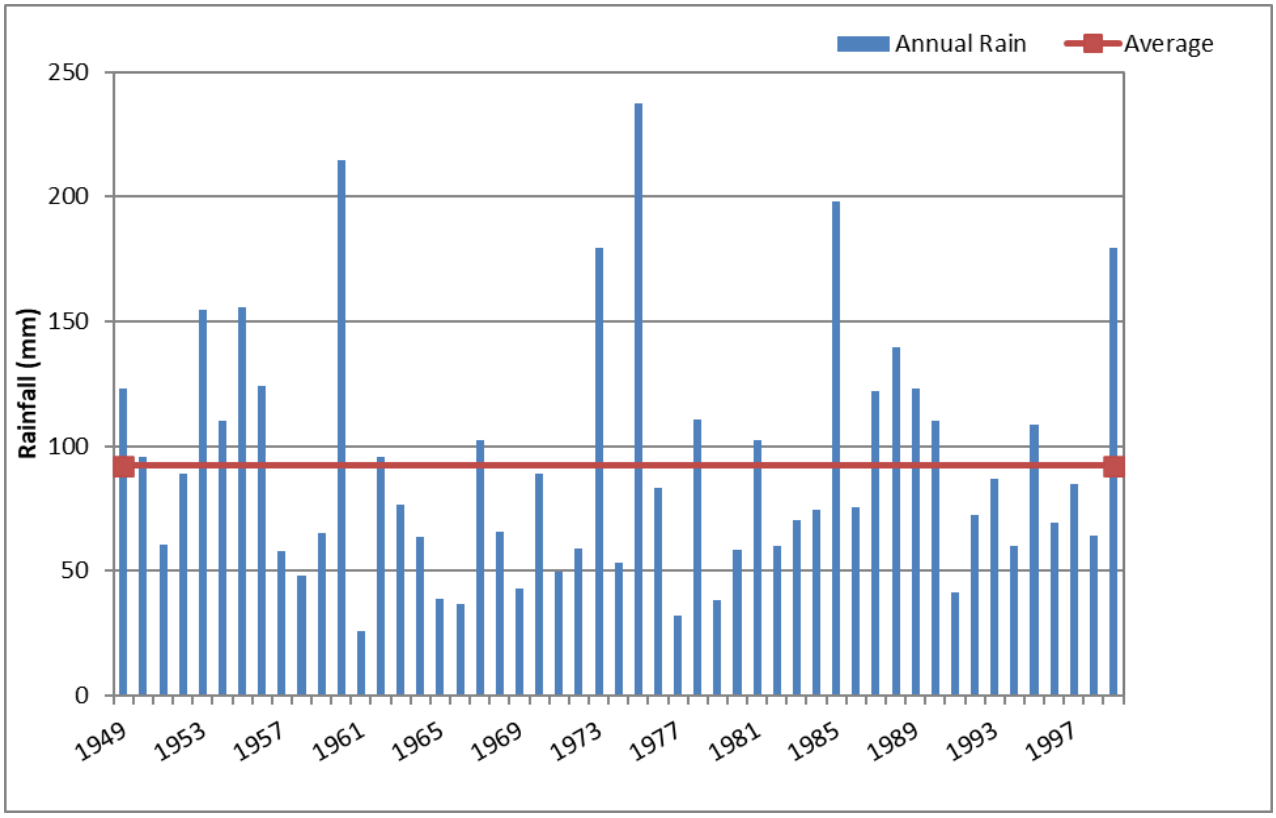


Figure 4 : Aggeneys (Pol) station annual rainfall depths

The boxplot of monthly rainfalls is presented in Figure 5. It provides the visual summary of every month's variations and the skewness of the data. The dry season occurs between May and September and receives less than 7 % of the annual rainfall. The wet season occurs between October and April and receives more than 83 % of the annual rainfall.

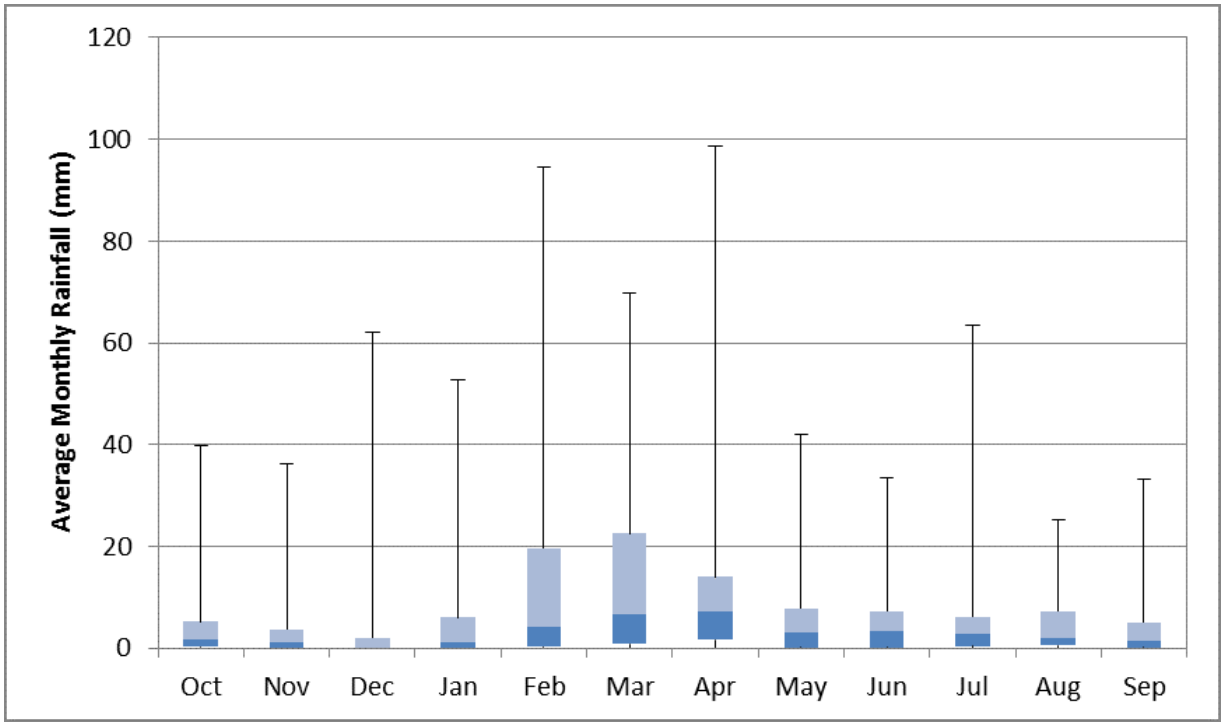


Figure 5: Box plot of monthly rainfall from Aggeneys (Pol) Station record from 1950 to 2000

5.1.1.3 Design rainfall estimation

The 24-hour rainfall depths for several recurrence intervals at the Aggeneys (Pol) station were calculated from the data available. To determine the likely magnitude of storm events, a statistical approach, using chi square statistics method (NIST/SEMATECH e-Handbook of Statistical Methods), was applied to the available recorded daily rainfall depths. This method statistically analyses the maximum daily rainfall depths for each year to determine the different recurrence intervals. The probability distribution with the best fit (R^2=0.936) was found to be the Log Normal distribution (see Figure 6), this was used to estimate the 24-hour storm rainfall depths associated with the various recurrence intervals as summarised in Table 2.

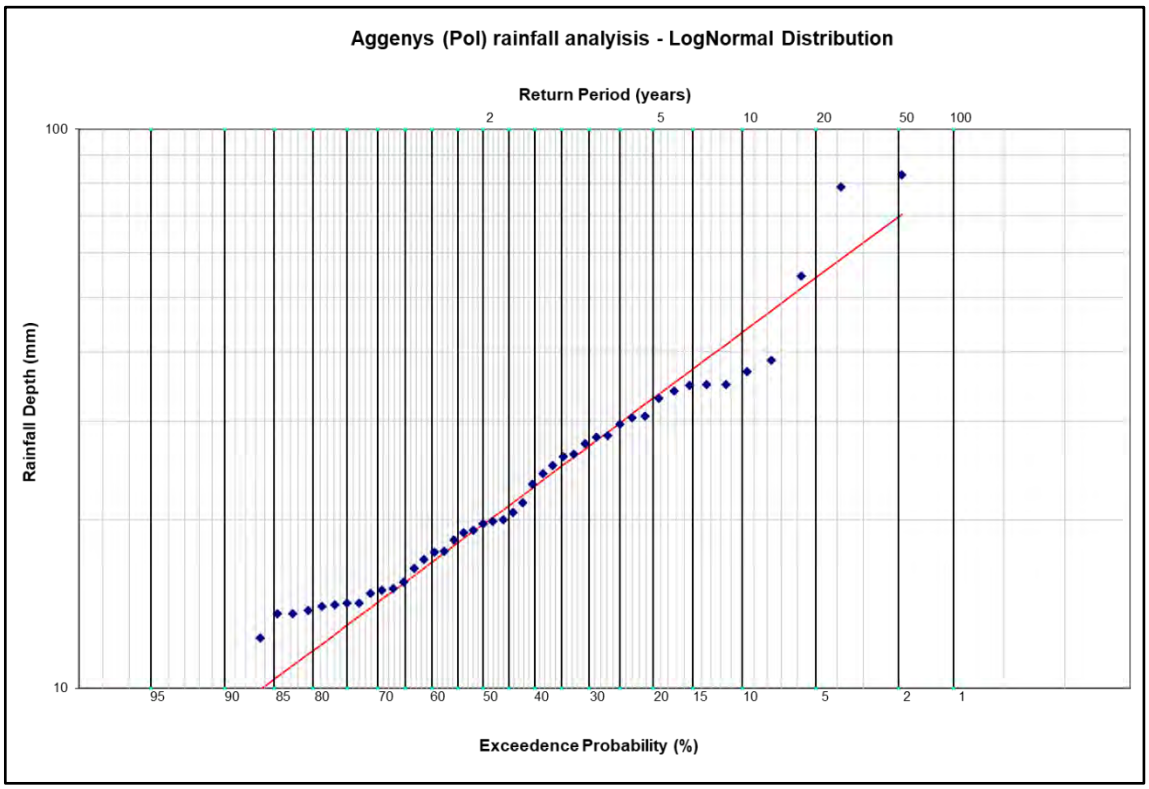


Figure 6: Aggeneys (Pol) Log Normal distribution

Table 2: Computed 24-hour rainfall depths for various annual reccurence intervals

Return period in years	5	10	20	25	50	100	200	500	100
24-hours Rainfall Depth (mm/d)	33	43	54	58	70	83	96	116	132

5.1.2 Evaporation

The average S-Class pan evaporation is 3115. mm/year measured at B8E004 station. The station is approximately 47 km away from the site area. The highest average monthly evaporation occurs in January.

Table 3: Average S-Pan evaporation

Month	S-pan evaporation (mm/month)
January	390
February	325

Month	S-pan evaporation (mm/month)
March	298
April	207
May	142
June	96
July	109
August	153
September	211
October	293
November	336
December	380
Total	3115

5.2 Temperature

Summers are hot with mean maximum temperatures in January, the hottest month, ranging between 30.7 °C and 35.4°C. During winter, the mean maximum temperatures range from 17.8 °C to 20 °C with significant temperature reductions at night.

5.3 Wind

The prevailing wind direction is southerly in summer and northerly in winter. The least common wind direction is north-westerly, which wind would seem to precede rain in the summer months. Wind velocities of up to 110 km/hour have been recorded. The average wind speeds recorded for day and night times are 3.25 m/s and 3.10 m/s respectively.

6.0 HYDROLOGICAL DESCRIPTION

6.1 Catchment description

The Gamsberg Zinc Mine Mining Right Area (MRA) is influenced by four quaternary catchments D81G, D82A, B82B, and B82C (see Figure 7). The D81G catchments drains into the Orange River and the D82C catchment is an interior drainage basin that does not drain into another catchment.

Most of the watercourses in the area are transient but the small catchment area on top of the Gamsberg Mine contains a spring and can experience seasonal flow.

6.2 Local hydrology

Natural drainage patterns are poorly defined in the area and watercourses are ephemeral (water only flows after heavy rainfall events). The drainage features of the area are characteristic of very dry areas where soil structures are relict and not favorable to the formation of riparian soils. However, during extreme rainfall events, these features become significant rivers and wetlands during a short period of time.

The most prominent watercourse is an ephemeral drainage line running parallel to the N14 at the base of the Gamsberg Inselberg. There is a spring within the Gamsberg Inselberg which can experience seasonal to perennial flows.

6.3 Mean Annual Runoff (MAR)

Given the arid and dry climate, characterised by low Mean Annual Precipitation (MAP), high evaporation and high infiltration rates, the watercourses are ephemeral in nature and completely dry for much of the year. Consequently, the quaternary catchments within which the study area are known to have very low Mean Annual Runoff (MAR) values.

These have been published in the 1990 WRC publication “Surface Water Resources of South Africa” and MAR values for the two sub-catchments under consideration were calculated by the weighted area method. Table 4 illustrates the baseline MAR in the context of the quaternary catchments, Table 5 presents the anticipated reduction in MAR as a consequence of the development. However, it should be noted that there are no known downstream users of surface water given the unreliable nature of this resource.

Table 4: Baseline MAR

Sub-Catchment	Quaternary Catchment	Quaternary Catchment Area (km^2)	Quaternary Catchment MAR ($X10^3$ m^3)	Baseline Sub-Catchment MAR ($X10^3$ m^3)	Sub-Catchment Contribution to MAR (%)
North	D82C	3,996	800	7.74	1.0%
South	D81G	2,007	900	5.87	0.7%

Table 5: Anticipated post development MAR reduction

Sub-Catchment	Quaternary Catchment	Quaternary Catchment Area (km^2)	Post-Development Sub-Catchment MAR ($X10^3$ m^3)	Reduction in Sub-Catchment MAR (%)	Sub-Catchment Contribution to MAR (%)
North	D82C	3,996	7.09	8%	0.2%
South	D81G	2,007	4.05	31%	0.2%

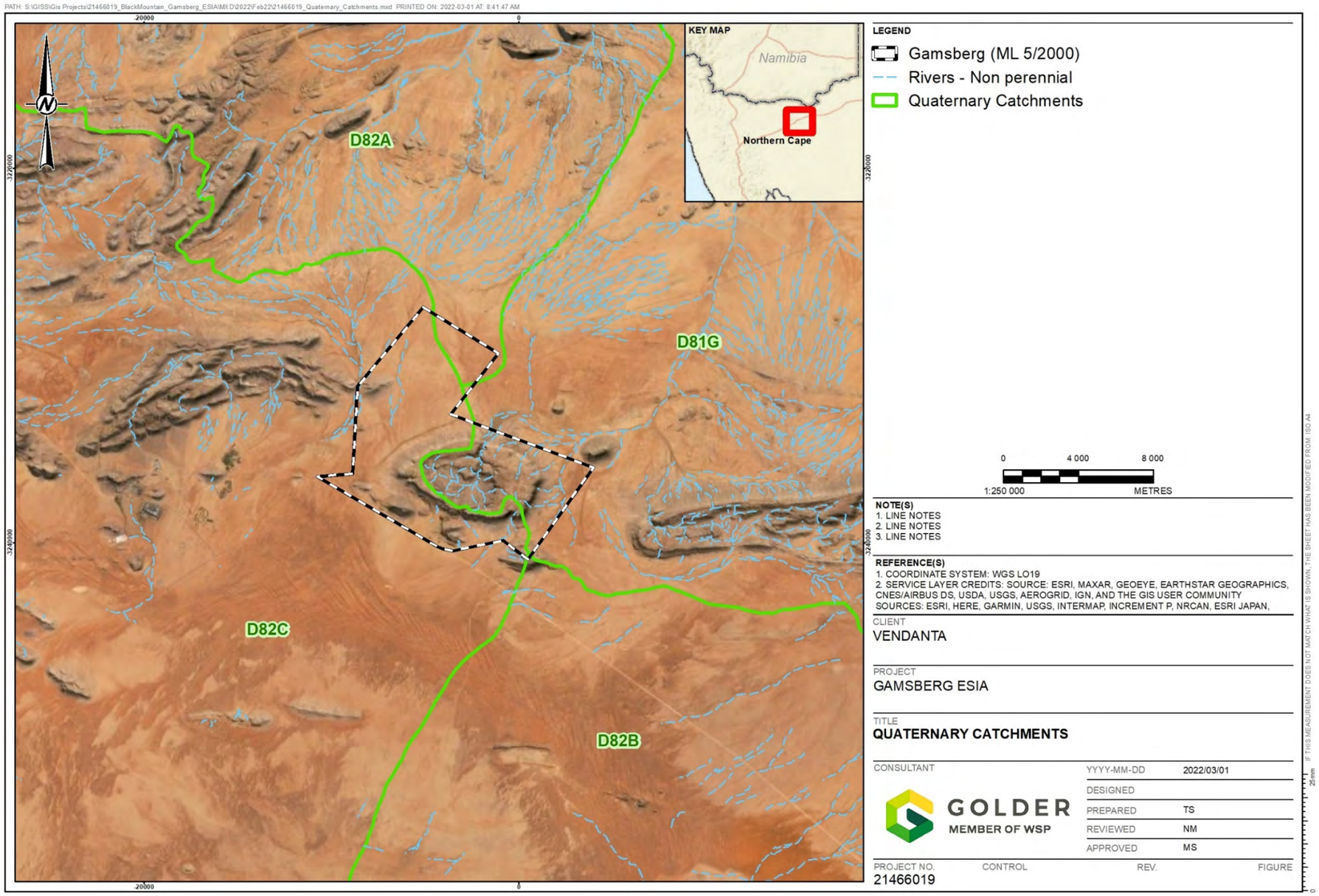


Figure 7: Quaternary Catchments

7.0 WATER QUALITY

The water quality assessment was previously limited as there was no database that existed of water quality data for surface runoff for the Gamsberg site. Only a review was undertaken of an existing one-year record of water quality data from the SRK Gamsberg Zinc Project Baseline study (SLR Consulting, 2010). Previously, ten surface water monitoring points were selected on the site and surveyed, however, only three monitoring points were sampled and analysed due to a lack of rainfall during the monitoring season (SLR Consulting, 2010).

The latest sampling was conducted on a monthly basis in the year 2021. The results have been compared to the South African National Standards (SANS) for drinking water (SANS 241: 2015). The 50th percentile values of Nitrate for the year were used the basis for comparison, and the 95th percentile values were used for all other parameters. All parameters were within the limits of the SANS 241: 2015.The results are presented in Table 6 below:

Table 6: South African National Standard Drinking water (SANS 241: 2015)

Variable	Limit
pH 6	5.0 - 9.7
Electrical Conductivity(mS/m)	170
Calcium as Ca in mg/l	150
Magnesium as Mg in mg/l	70
Sodium as Na in mg/l	200
Chloride as Cl in mg/l	300
Sulphate as $S0_4$ in mg/l	500
Nitrate as NO_x_ N in mg/l	11
Total Dissolved Salts in mg/l	1200

Table 7: Surface water quality

Parameter	Unit	South African National Standard for drinking water (SANS241: 2015)	S-GBM 10 (Mining Kitchen)	S-GBM 11 (Canteen Drinking Water)	S-GBM 16 (South Workshop)	S-GBM 19 (Camp Drinking Water)	S-GBM 22 (Moolmans Coucus DW)	S-GBM 23 (Moolmans Eng. W/Shop DW)	S-GBM 24 (Exploration)	S-GBM 25 (Mota - Enoil)	S-GBM 26 (Consulmet D W)
Calcium Ca	mg/l	< 150	113.9	103.7	101.1	109.8	106.9	108.7	103.6	108.6	99.3
Chloride Cl	mg/l	< 300	69.4	64.3	56.2	68.7	65.2	68.3	75.8	63.9	64.7
Total Dissolved Solids (TDS)	mg/l	< 1200	394.4	341.0	327.8	377.3	364.5	372.7	344.5	334.2	349.7
Electrical Conductivity EC	mS/m	< 170	71.6	63.1	60.6	68.6	66.1	68.2	69.8	65.2	64.6
Flouride F	mg/l	< 1.5	0.9	0.5	0.3	0.4	0.4	0.5	0.3	0.4	0.4
Potassium K	mg/l	< 70	6.9	6.9	3.5	6.4	3.6	3.8	3.5	3.2	3.6
Magnesium Mg	mg/l	< 200	37.8	39.7	27.6	37.9	23.5	24.0	23.3	22.2	23.0
Sodium Na	mg/l	< 200	55.7	49.0	48.4	55.8	54.0	54.4	49.2	45.0	52.9
Nitrate NO3-N	mg/l	< 11	10.2	11.6	15.1	0.7	0.4	0.5	0.4	0.4	0.4
pH	unitless	5.0 - 9.7	8.2	8.4	8.1	8.3	8.3	8.2	8.1	8.1	8.3
Sulphate SO4	mg/l	< 500	108.1	91.2	65.6	96.0	81.0	82.2	57.7	56.4	77.5

8.0 CONCLUSIONS AND RECOMMENDATIONS FROM THE BASELINE ASSESSMENT

The objective of this report was to describe the catchment and project area in respect of surface water resources and hydrological data for the current situation.

The available data has shown that the quality of water from Gamsberg is suitable quality for drinking. The water quality assessment was previously limited as there was no database that existed. Only data from 2021 was used for the analysis. It is therefore proposed that water quality measuring continue for further studies.

9.0 REFERENCES

SRK 2016- Gamsberg Mine Environmental Management Programme Amendment, Impact Assessment Report, SRK Report Number 507811/1, dated December 2016.

SRK. 2019. Integrated Water and Waste Management Plan for Gamsberg Mine, Aggeneys, Northern Cape. Report number: 525272/4. Dated: March 2019.

Golder. 2019. Integrated Water Management Plan for Black Mountain Mining. Report reference: 18108826-329577-1. Dated: December 2019. Golder Associates Africa (Pty0 Ltd. – Pretoria.

Signature Page

Golder Associates Africa (Pty) Ltd.

Tebatso Menziwa
Candidate Civil Engineer

Eugeshin Naidoo
Senior Civil Engineer

TA/EN/ck

Reg. No. 2002/007104/07
Directors: RGM Heath, MQ Mokulubete, MC Mazibuko (Mondli Colbert), GYW Ngoma

https://golderassociates.sharepoint.com/sites/145886/project files/5 technical work/river diversion/21466019-351776-4_gamsberg_baseline_final_04052022.docx

APPENDIX A

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GOLDER ASSOCIATES AFRICA (PTY) LTD

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DETAILS OF THE SPECIALIST

Table 1: Details of specialist

Specialist Information	
Name:	Eugeshin Naidoo
Phone number:	0828348037
Email:	Eugeshin.naidoo@wsp.com
Professional Registration Number	20190664
Curriculum vitae:	Appended

Declaration of Independence by Specialist

I, Eugeshin Naidoo, declare that I –

- Act as the independent specialist for the undertaking of a specialist section for the proposed project.
- Do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed;
- Do not have nor will have a 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 information that have or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan, or document.

_____

Eugeshin Naidoo

APPENDIX H

Hydrology and Conceptual Design of the Gamsberg Zinc Mine River Diversion

TECHNICAL MEMORANDUM

DATE 08 April 2022 **Project No.** 21466019_Mem003

TO Black Mountain Mining (Pty) Ltd

CC Eugeshin Naidoo

FROM Tebatso Menziwa **EMAIL** **Tebatso.menziwa@wsp.com**

HYDROLOGY AND CONCEPTUAL DESIGN OF THE GAMSBERG RIVER DIVERSION

1.0 INTRODUCTION

Golder Associate Pty Ltd (member of WSP) has been appointed by Black Mountain Mining (Pty) Ltd (BMM) to develop a conceptual design for a proposed river diversion for Gamsberg Zinc Mine. The design criteria for the river diversion will be established based on the regulatory requirements and best practice guidelines. The catchment area reporting to the proposed infrastructure will be delineated based on the site topography provided by the client, and the diversion will account for the current and proposed future site infrastructure. The study will ultimately form part of the WULA (Water Usage License Application).

2.0 BACKGROUND

Black Mountain Mining (Pty) Ltd, part of Vedanta Zinc International, owns and operates the Gamsberg Zinc Mine. In 2010 Vedanta Resources Limited acquired Black Mountain Mining (Pty) Ltd from Anglo American as part of the acquisition of the zinc base metal mine take over. Following the acquisition of the Black Mountain Mining properties and rights, a feasibility and optimization of technology for the Gamsberg Zinc Mine was undertaken. Gamsberg Zinc Mine operates independently from The Black Mountain Complex (BMC), an existing base metals mining complex situated in Aggeneys.

Zinc deposits in the Gamsberg area were discovered in 1971 but have not been taken advantage of until recently. The Gamsberg Zinc Mine has been in operation since June 2016 and is currently mining up to 4 million tonnes per annum (mtpa) and producing up to 250 000 tonnes per annum (tpa) of zinc concentrate for export.

3.0 OBJECTIVES

The objectives of this study are outlined below:

- Information sourcing/ literature review:
  - Review of existing information including reports and drawings.
- Hydrology:
  - Climate and rainfall analysis.
- Conceptual design of river diversion:

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P.O. Box 6001, Halfway House, 1685
Reg. No. 2002/007104/07
Directors: RGM Heath, MQ Mokulubete, SC Naidoo, GYW Ngoma

T: +27 11 254 4800 F: +27 0 86 582 1561

- The design criteria for the river diversion will be established based on the regulatory requirements and best practice guidelines.
- The catchment area reporting to the river will be delineated based on the site topography (contours) provided by BMM.
- The required flood peaks for the diversion will be determined based on the delineated catchment.
- The diversion will be sized and a route for the diversion determined accounting for the existing and proposed infrastructure developments on site.
- Conceptual level drawings will be produced for the diversion. The drawings will show the route, pipeline cross-section, and longitudinal profile.

- Environmental Risk, Potential Impact Identification and Proposed Mitigation Measures:
  - Identification of receptors downstream of the site using Water Authorisation Registration Management System (WARMS) data will be undertaken; and
  - Description of all potential, relevant surface water impacts and proposed mitigation measures will be undertaken. This will be undertaken for the construction, operational and closure phase of the proposed development.

4.0 PROJECT LOCATION AND EXTENT

Gamsberg is situated in Aggeneys, a small town in the Northern Cape Province, 60 km west of Pofadder and 110 km east of Springbok. Gamsberg, as part of the larger BMM, falls under the Namakwa District Municipality and the Springbok regional services council authority (see Figure 1 below). Gamsberg is located in the Lower Orange River Water Management Area (WMA), and specifically in the D82C Quaternary catchment.

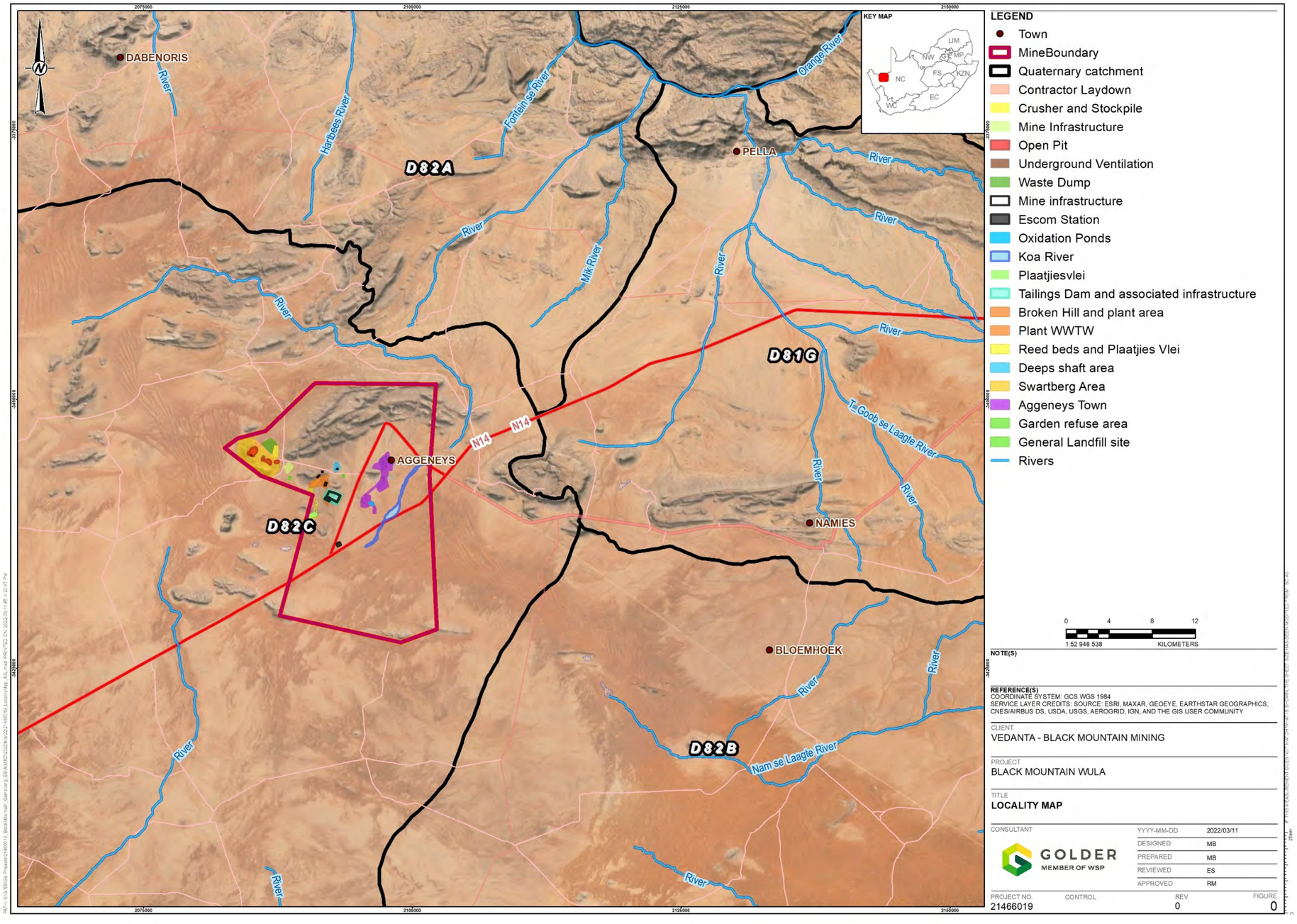


Figure 1 : Locality map

5.0 APPLICABLE LEGISLATION, GUIDELINES AND STANDARDS

5.1 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.

5.2 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:

- 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.
- 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 0.8 m above the full supply level.
- 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.

6.0 CLIMATE

The mine is situated in the north-west region of Bushmanland, an area that is marginal to the winter and summer rainfall zones in the North West Cape Province. Bushmanland to the west is considered a winter rainfall area while Gordonnia to the east is a summer rainfall area. The climate in the Gamsberg regional areas can be described as arid to semi-arid in nature with very limited rainfall, primarily occurring during short periods (hours) as well as short intense summer thunderstorm events.

6.1 Rainfall

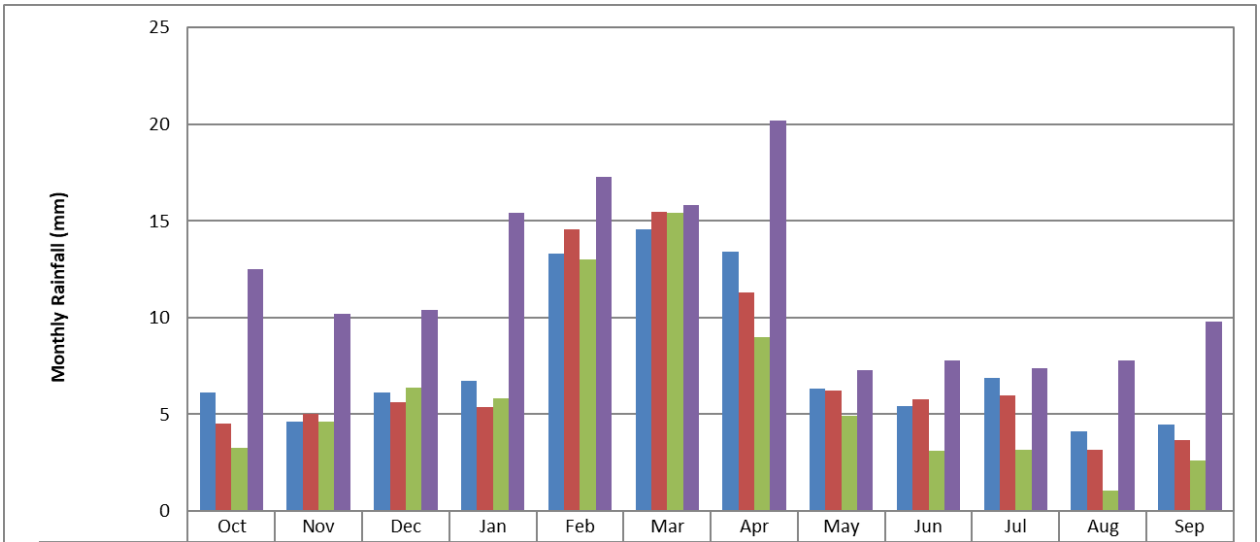
The rainfall data was generated using a rainfall simulator which was sourced through the Design Rainfall Estimation Program (Smithers & Schulze, 2002) and the Daily Rainfall Extraction Utility (Kunz, 2004). On-site rainfall data was provided by the client and used in the analysis. The rainfall stations presented in Table 1 summarize the rainfall data used in the analysis.

Table 1 : Rainfall station properties

Station number	Name	Distance (km)	Record period (years)	Period of records	Reliability (%)	MAP (mm)
0246555 W	Aggeneys (Pol)	1.6	50	1950 - 2000	100	92
0246613 W	Aggeneys	4.1	80	1920 - 2000	4	88
0247242W	Pella	39.1	79	1921 - 2000	75	72
-	-	On-site	34	1986 - 2019	100	96

6.1.1 Comparison of rainfall stations

The average monthly plot was used to compare the rainfall records as shown in Figure 2. On average, it is evident that slightly more rainfall was recorded on-site as compared to the other stations. On-site data also extends to a period that is more recent than the other stations. Though the rainfall records cover different time periods, the average monthly rainfall depths for the different stations have a similar pattern. During the wet season, the highest average rainfall was recorded in the month of March. The driest month on average was recorded in July.



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Aggeneys_POL	6	5	6	7	13	15	13	6	5	7	4	4
Aggeneys	5	5	6	5	15	15	11	6	6	6	3	4
Pella	3	5	6	6	13	15	9	5	3	3	1	3
Site rainfall	13	10	10	15	17	16	20	7	8	7	8	10

Figure 2 : Average monthly rainfall for the stations

The station 024655 W Aggeneys (POL) was chosen as the station used in the study for the following reasons:

- The station is within proximity of the site.
- The station has a high reliability data set (having the lowest percentage of patched or missing data).
- The station has a longer duration of recorded data than what was recorded on-site.
- Under normal circumstances, on-site rainfall data is preferred for such studies, however, only monthly , on-site rainfall data was available, making it difficult to determine 24-hour design rainfall depths required for the study.

6.1.1.1 Aggeneys (Pol) rainfall station

Aggeneys (Pol) station is situated approximately 1.6 kilometres from the site with 50 years of recorded data. It has the highest reliability of the analyzed stations. The maximum recorded 24-hour rainfall depth is 83 mm, recorded on the 19th of February 2000, as shown in Figure 3. Figure 4 shows the annual rainfall depths. The mean annual precipitation (MAP) for the station is 92 mm.

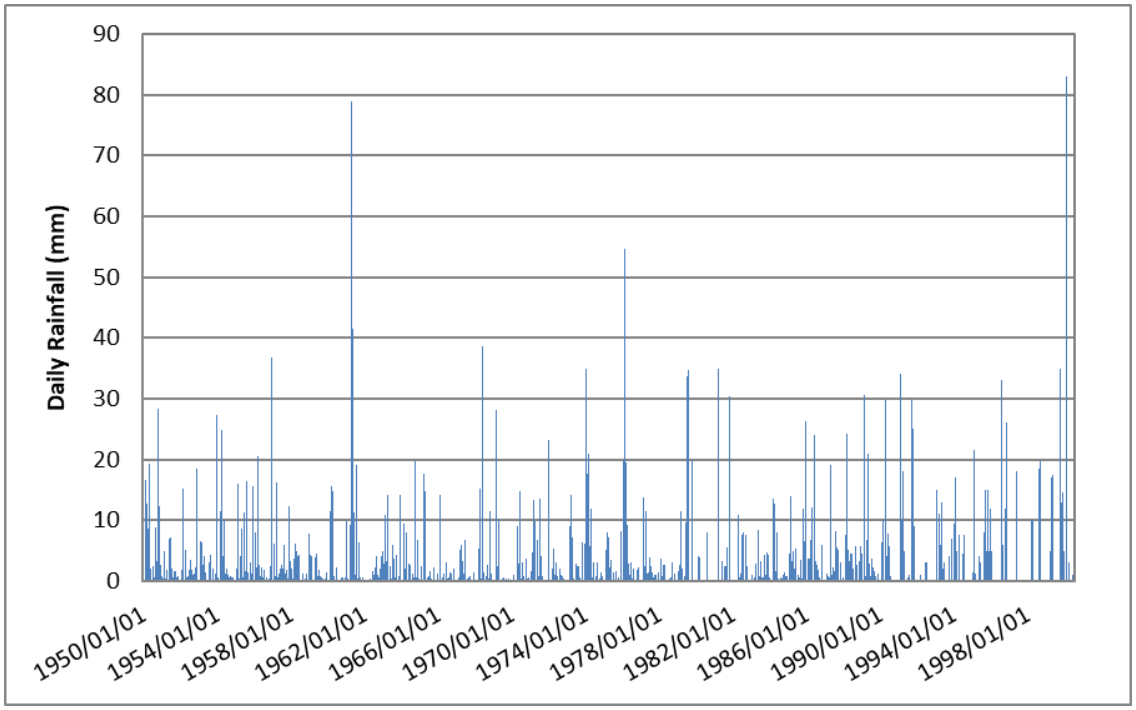


Figure 3 : Aggeneys (Pol) station daily rainfall

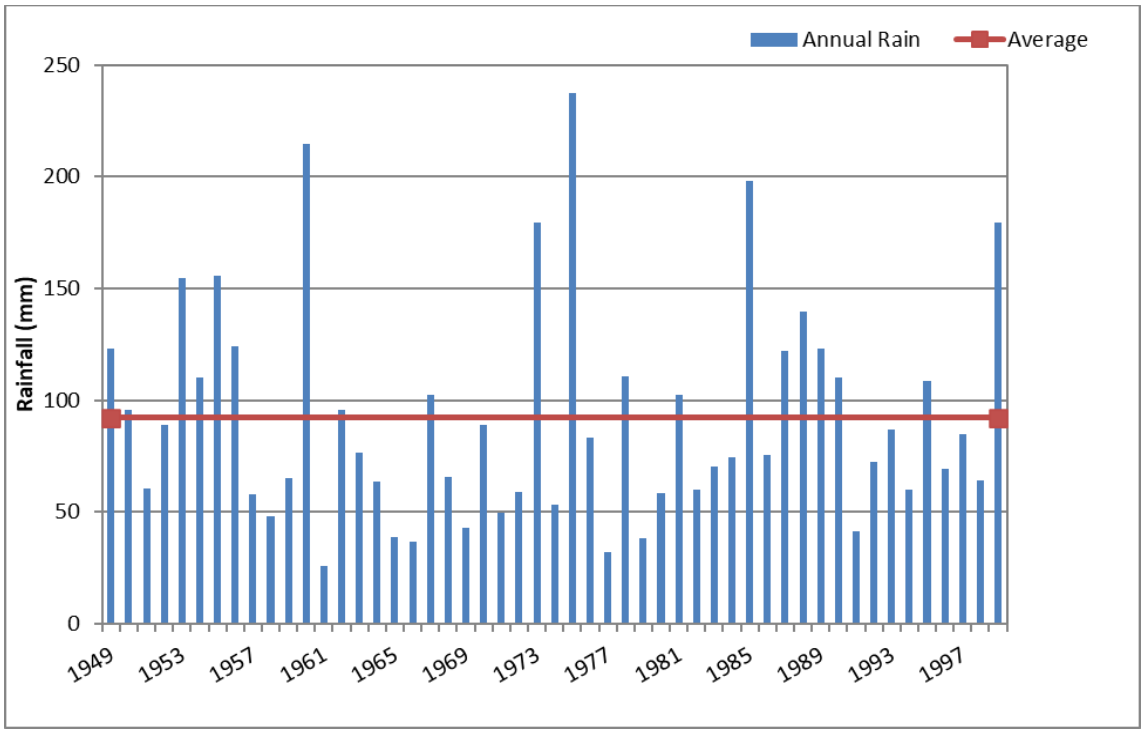


Figure 4 : Aggeneys (Pol) station annual rainfall depths

6.1.1.2 Design rainfall estimation

The 24-hour rainfall depths for several recurrence intervals at the Aggeneys (POL) station were calculated from the data available. To determine the likely magnitude of storm events, a statistical approach, using the chi-square statistics method (NIST/SEMATECH e-Handbook of Statistical Methods), was applied to the available recorded daily rainfall depths. This method statistically analyses the maximum daily rainfall depths

for each year to determine the different recurrence intervals. The probability distribution with the best fit (R^2=0.936) was found to be the Log-Normal distribution (see Figure 5), this was used to estimate the 24-hour storm rainfall depths associated with the various recurrence intervals as summarized in Table 2.

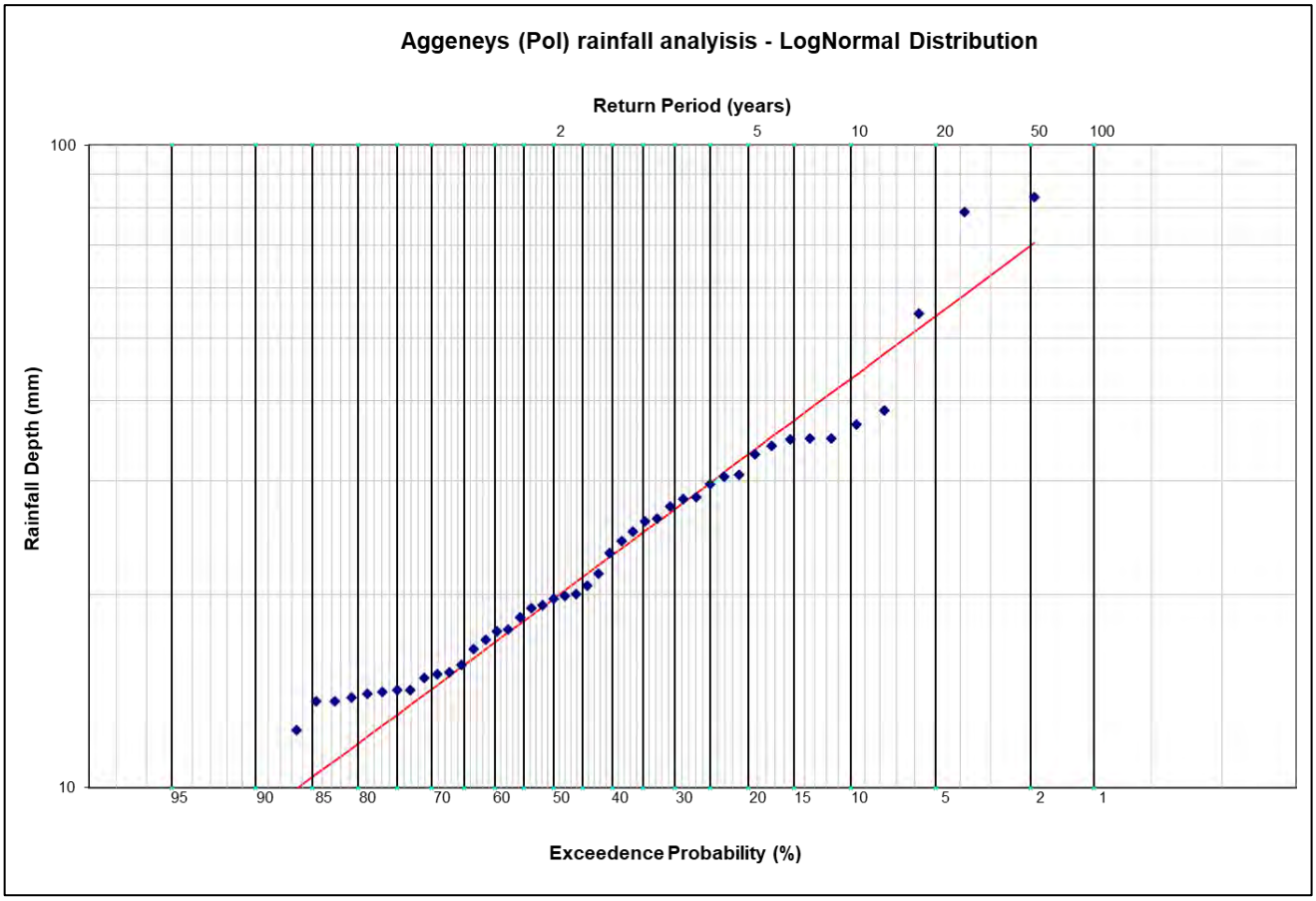


Figure 5 : Aggeneys (Pol) Log-Normal distribution

Table 2 : Computed 24-hour rainfall depths for various annual recurrence intervals

Return period in years	5	10	20	25	50	100	200	500	100
24-hours Rainfall Depth (mm/d)	33	43	54	58	70	83	96	116	132

6.2 Evaporation

The average S-Class pan evaporation is 3116 mm/year measured at B8E004 station. The station is approximately 47 km away from the site area. The highest average monthly evaporation occurs in January.

Table 3: Average S-Pan evaporation

Month	S-pan evaporation (mm/month)
January	390
February	325
March	298

Month	S-pan evaporation (mm/month)
April	207
May	142
June	96
July	109
August	153
September	211
October	293
November	336
December	380
Total	3116

7.0 DESIGN RAINFALL INTENSITY

Four general types of time distribution curves of rainfall intensity have been determined for Southern Africa from recorded rain gauge data. These synthetic time distribution curves are termed Type 1, 2, 3 and 4 (The South African National Roads Agency SOC Limited (SANRAL), 2013). Figure 6 illustrates the spatial variation of the four synthetic time distribution curves over Southern Africa. Gamsberg lies in SCS South African Type 3 region. The resulting hyetograph from SCS South African type 3 based on the 1 in 50-year 24-hour rainfall depth of 70 mm used in modeling is shown in Figure 7.

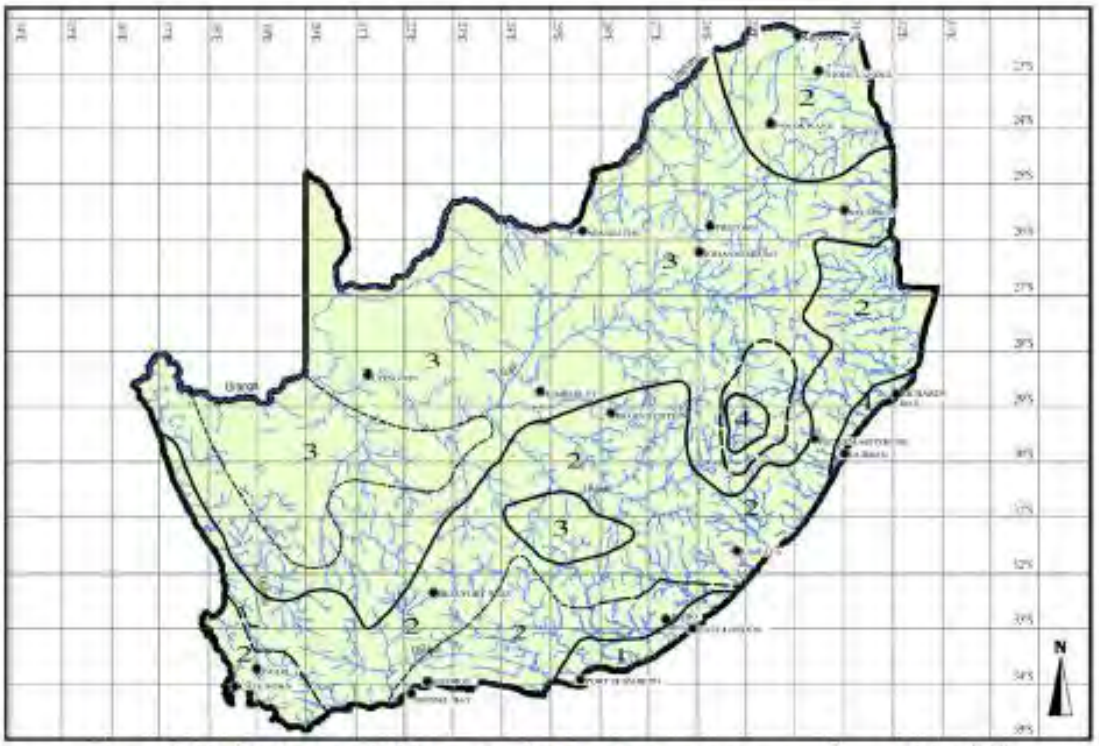


Figure 6 : Spatial variation of four synthetic time distribution curves over southern Africa (The South African National Roads Agency SOC Limited (SANRAL), 2013)

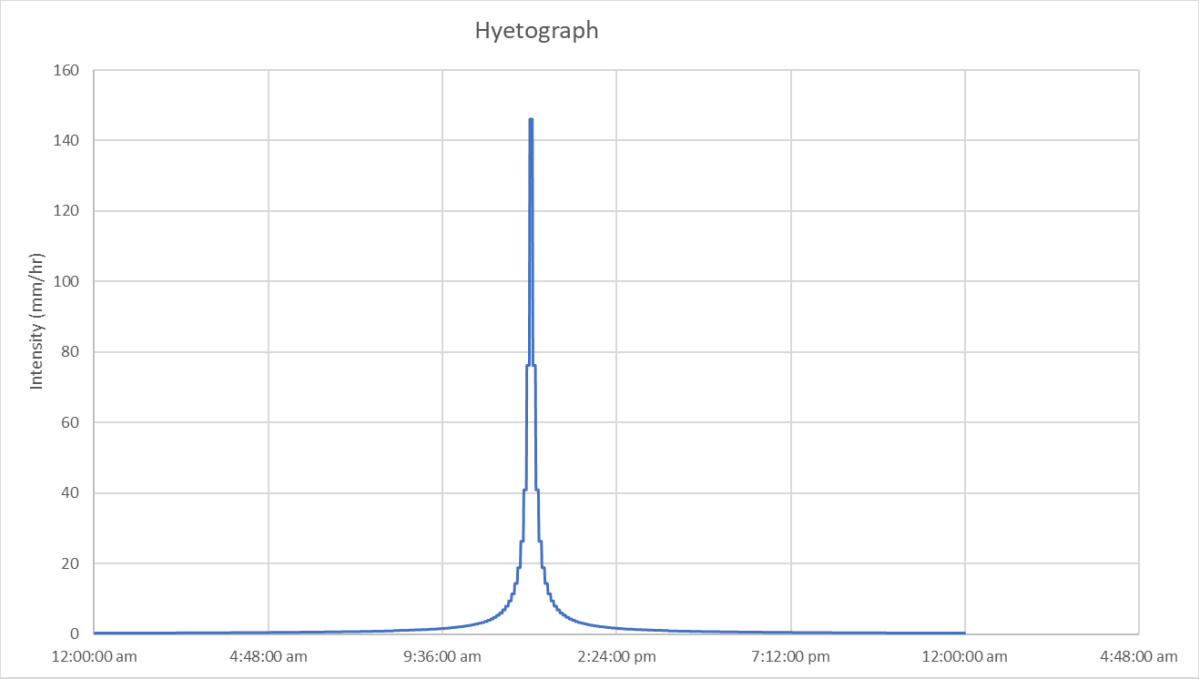


Figure 7 : 1 in 50-year 24-hour hyetograph

8.0 STORM WATER MODELLING

The US EPA Storm Water Management Model (SWMM) was used to develop a rainfall-runoff model for the study areas. The PCSWMM® (refer www.chiwater.com) commercial software package, developed by Computational Hydraulics International (CHI) was used as the analysis tool. PCSWMM® is a dynamic rainfall-runoff simulation model used for single event or long-term simulation of runoff quantity.

The runoff component of SWMM operates on a collection of sub-catchment areas that receive precipitation and simulate runoff overland and underground through a system of pipes, channels, storage and treatment devices, pumps, and regulators.

PCSWMM tracks the quantity of runoff generated within each sub-catchment, and the flow rate, flow depth, and quality of water in each pipe and channel during a simulation period comprised of multiple time steps.

8.1 Rainfall and runoff parameters

The topography and natural condition of the site were obtained from existing reports to understand the soil and vegetation conditions from which the runoff parameters are estimated. The following parameters were used for the hydrologic and hydraulic input parameters based on the information available.

- **Impervious catchment percentage** is the percentage of artificial structures such as pavements, roads, sidewalks, and parking lots in a catchment area.
  - Estimated Impervious natural catchment percentage = 5 % of the total catchment.
- **Cross-sectional profile of pipelines** = HDPE circular.
- **Infiltration model** used in PCSWMM: Greens-Ampt.
  - Based on the geological study completed by SRK (2009), in which the geomorphology of the area was described as predominantly sandy, the following Infiltration parameters were used for modeling of the runoff from the clean catchments.

  - Average Capillary Suction: 49.5 mm
  - Saturated hydraulic conductivity: 235.6 mm/hr
  - Initial Moisture Deficit for Soil: 0.404
- Manning's n is a coefficient that represents the roughness or friction applied to overland flow in the sub-catchments. The assumed value is based on soil conditions on-site (see Figure 8).

The following table was compiled by Crawford and Linsley by calibration using the Stanford Watershed Model.

Ground Cover	Manning's n*
Smooth Asphalt	0.01
Asphalt or concrete paving	0.014
Packed clay	0.03
Light turf	0.20
Dense turf	0.35
Dense shrubbery and forest litter	0.4

The next table was compiled by Engman (1986) by kinematic wave and storage analysis of measured rainfall-runoff data.

Ground Cover	Manning's n*	Range
Concrete or asphalt	0.011	0.01 - 0.013
Bare sand	0.01	0.01 - 0.016
Gravelled surface	0.02	0.012 - 0.033
Bare clay-loam (eroded)	0.02	0.012 - 0.033
Range (natural)	0.13	0.01 - 0.32
Bluegrass sod	0.45	0.39 - 0.63
Short grass prairie	0.15	0.10 - 0.20
Bermuda grass	0.41	0.30 - 0.48

Figure 8 : Manning's n for overland flow

- Assumed Manning's n for Impervious area = 0.035.
- Assumed Manning's n for Pervious area = 0.15.

9.0 PROPOSED STORM WATER MANAGEMENT PLAN

The general arrangement for the layout of the site, including the proposed layout of the pipeline and berms around the facility is shown in Figure 11. The basis of the proposed system is based on the following principles:

- Effective drainage of surface water into the attenuation weir.
- Discharge and conveyance of water from attenuation weir to natural stream.

9.1 Attenuation Weir and River Diversion System

An attenuation weir will collect the runoff emanating from sub-catchment (S1_2.). The attenuation weir will then release the flow into HDPE pipelines via a decant system. Water will thereafter be discharged downstream directly into the natural river (environment). The river will also collect runoff generated from sub-catchment (S1_1). The stage-storage curve of the attenuation weir is shown in Figure 9.

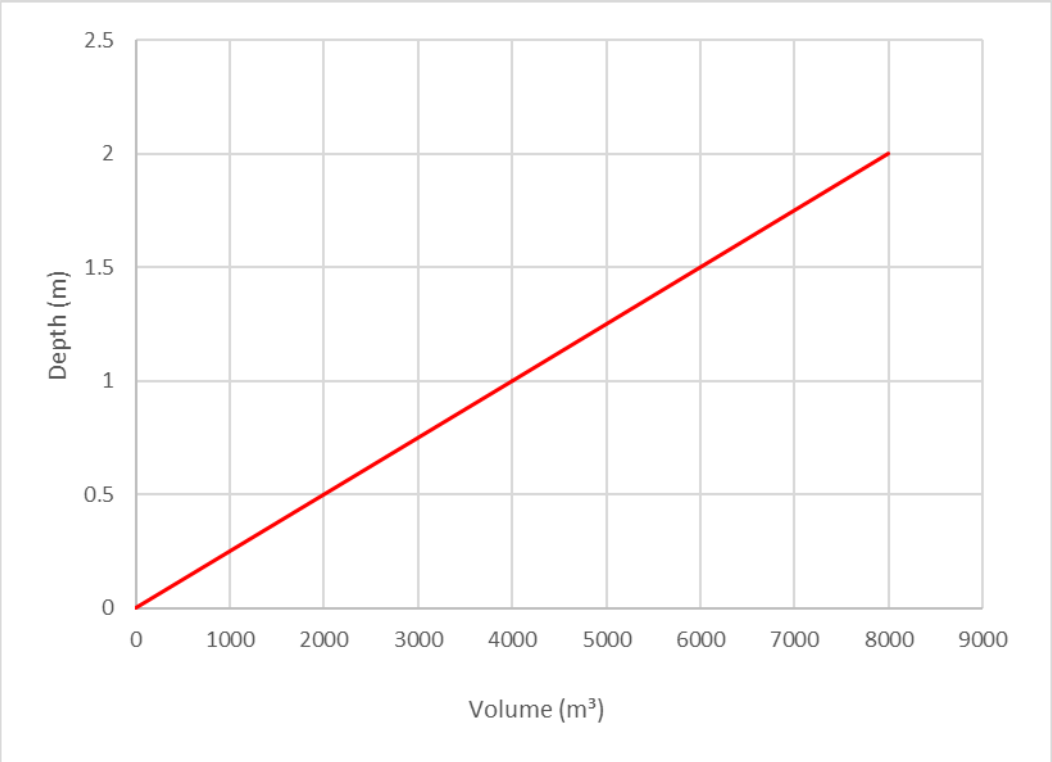


Figure 9 : Attenuation weir stage-storage relationship

9.2 Rainfall-runoff model results

9.2.1 Sub-catchments characteristics

The hydrological sub-catchments were delineated using the topographical contours for the site provided by the client (see Figure 10). The sub-catchment characteristics and simulation outputs of each sub-catchment for the 1:50-year recurrence interval 24-hour storm are shown in Table 4 below. It is assumed that the natural catchments have a 5% impervious area. PCSWMM model uses the Green-Ampt Method to calculate the flood peaks and the runoff volumes.

Table 4: Sub-catchment characteristics

Name	Tag	Area (ha)	Slope (%)	Impervious (%)	Runoff Volume (ML)	Peak Runoff (m^3/s)	Runoff Coefficient
S1_1	Clean	1987	1	5	68	17.1	0.05
S1_2	Clean	429	1	5	15	5.6	0.05

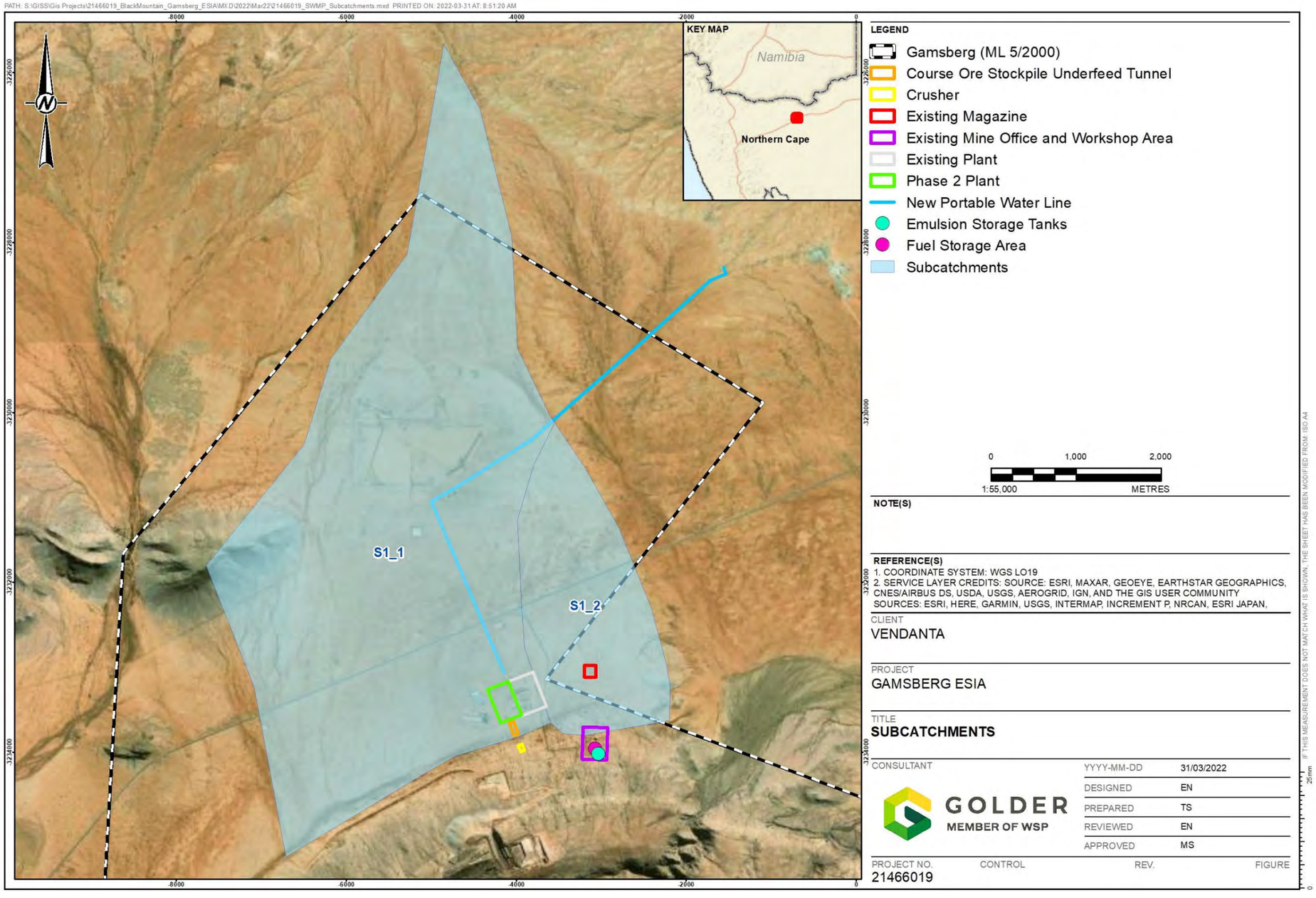


Figure 10 : Delineated sub-catchments

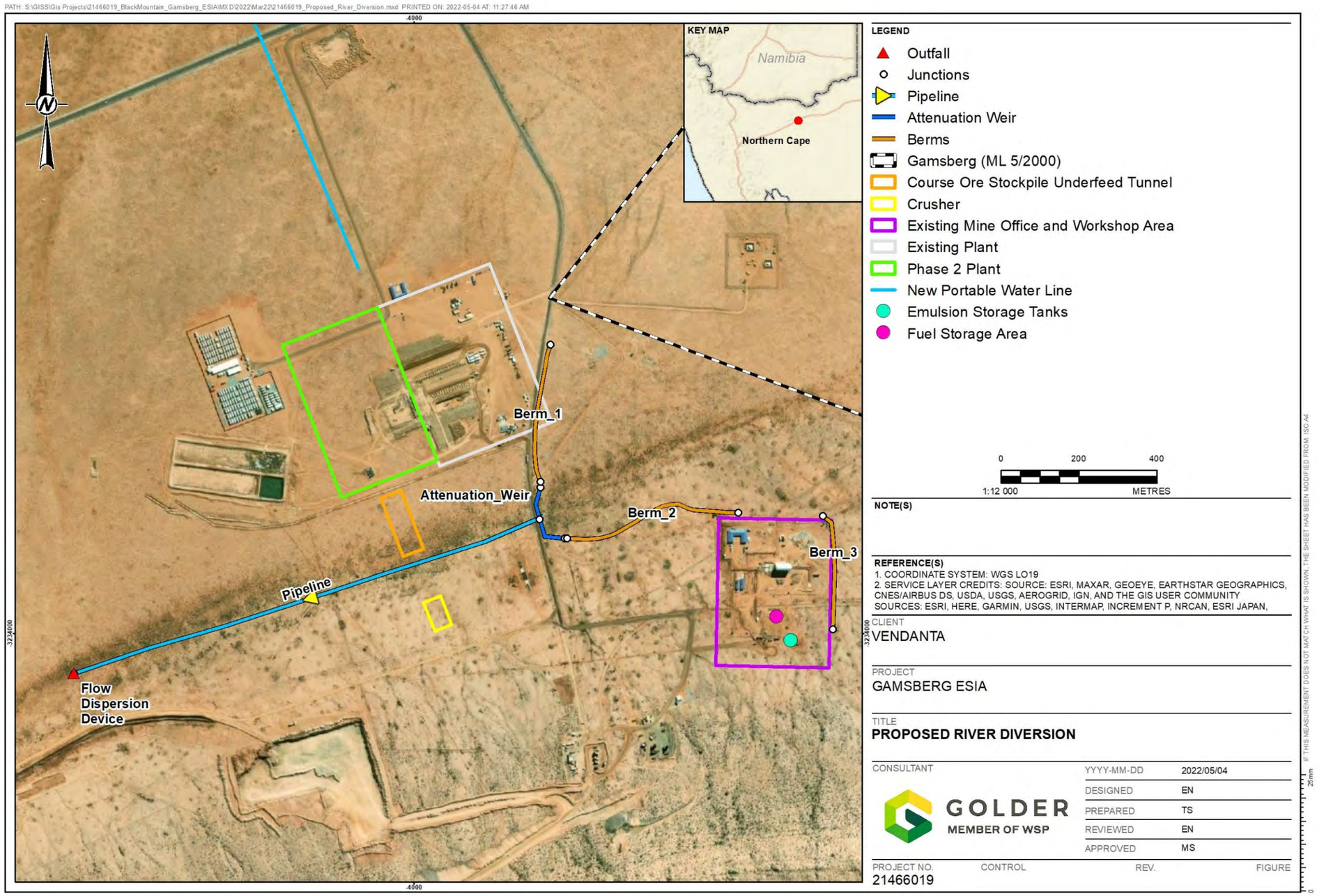


Figure 11 : Proposed river diversion

9.3 Conveyance structures

9.3.1 HDPE pipelines

Two circular HDPE (High Density Polyethylene) pipes are proposed to convey water from the attenuation weir to the natural river stream. The pipelines will both be operational and will be laid above ground, within the existing river channel. Due to the high temperatures in the Gamsberg area, it is recommended that pipes are covered with soil to avoid ultraviolet (UV) exposure and reduce any snaking effects caused by expansion and contraction. An energy dissipator is recommended at the end of the discharge point of the pipeline. This will be implemented to disperse the flow and to counter the erosion that may be caused by high flow velocities at the outfall. The details of the pipelines are shown in Table 5.

Table 5 : Pipeline characteristics

Name	Length (km)	Roughness	Entry loss coefficient	Exit loss coefficient	Max flow (m^3/s)	Max velocity (m/s)	Inside diameter (m)
Pipeline	1.2	0.012	0.5	0.3	1.7	2.6	0.75

9.3.2 Berms

Three berms are proposed to route stormwater runoff into the attenuation weir. The first berm will be located on the northern side of the attenuation facility and will extend along the road (see Figure 11) to assist in diverting surface water runoff to the attenuation weir. A second berm is proposed north of the plant area, ultimately preventing water from flowing into the plant area facility, and directing water into the attenuation weir. A third berm is proposed east of the plant area, this berm will ensure runoff is diverted into the attenuation weir. It is also recommended that excavated material from the attenuation weir be used to construct the berms.

9.3.3 Pipeline decant system

It is proposed that a pipeline be used as an outlet to the attenuation weir. The pipelines connect the attenuation weir to the natural river stream. As the water level in the attenuation weir rises, the outlet initially behaves as a weir until the whole opening is submerged, then the behaviour switches to orifice flow. The discharges for the first stages of the orifice flow area are computed using the weir equation:

$$Q = CLH^{\frac{3}{2}}$$

Where:

C = Constant. ($C = C_d\sqrt{g}$)

L = perimeter length of the weir opening.

H = height of water above the opening.

After the orifice opening is fully submerged, the discharges can be computed using the orifice equation:

$$Q = C_d A_o \sqrt{2gH}$$

Where:

C_d = Coefficient of discharge (typically 0.67)

A_o = Area of orifice opening.

H = height of water above the opening.

A discharge curve was developed using the two equations, where the maximum flow through the orifice and pipelines were determined. The discharge curve generated is shown in Figure 12. A head height of 1.5 m was selected, giving a maximum design flow of 1.6 m^3/s. Figure 13 shows the results of the analysis (peak values are shown). The proposed orifice properties are shown in Table 6.

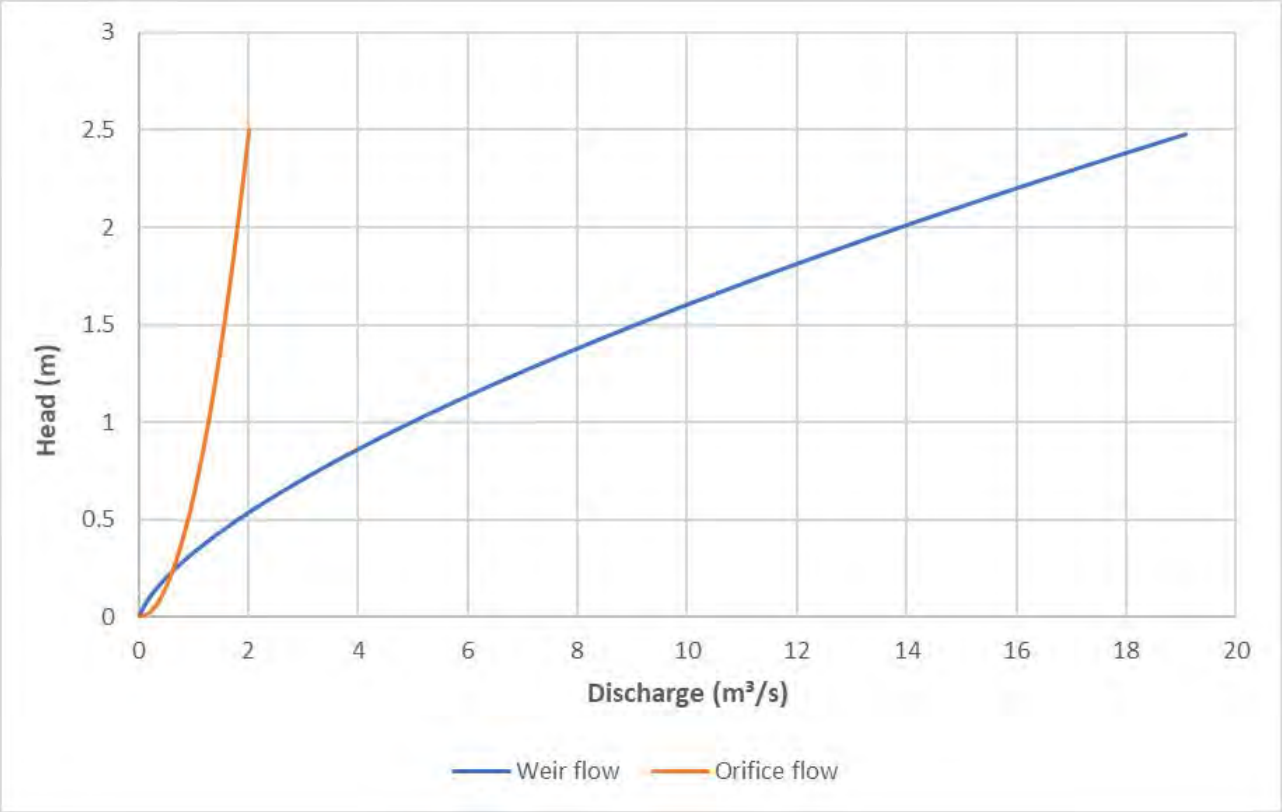


Figure 12 : Discharge curve

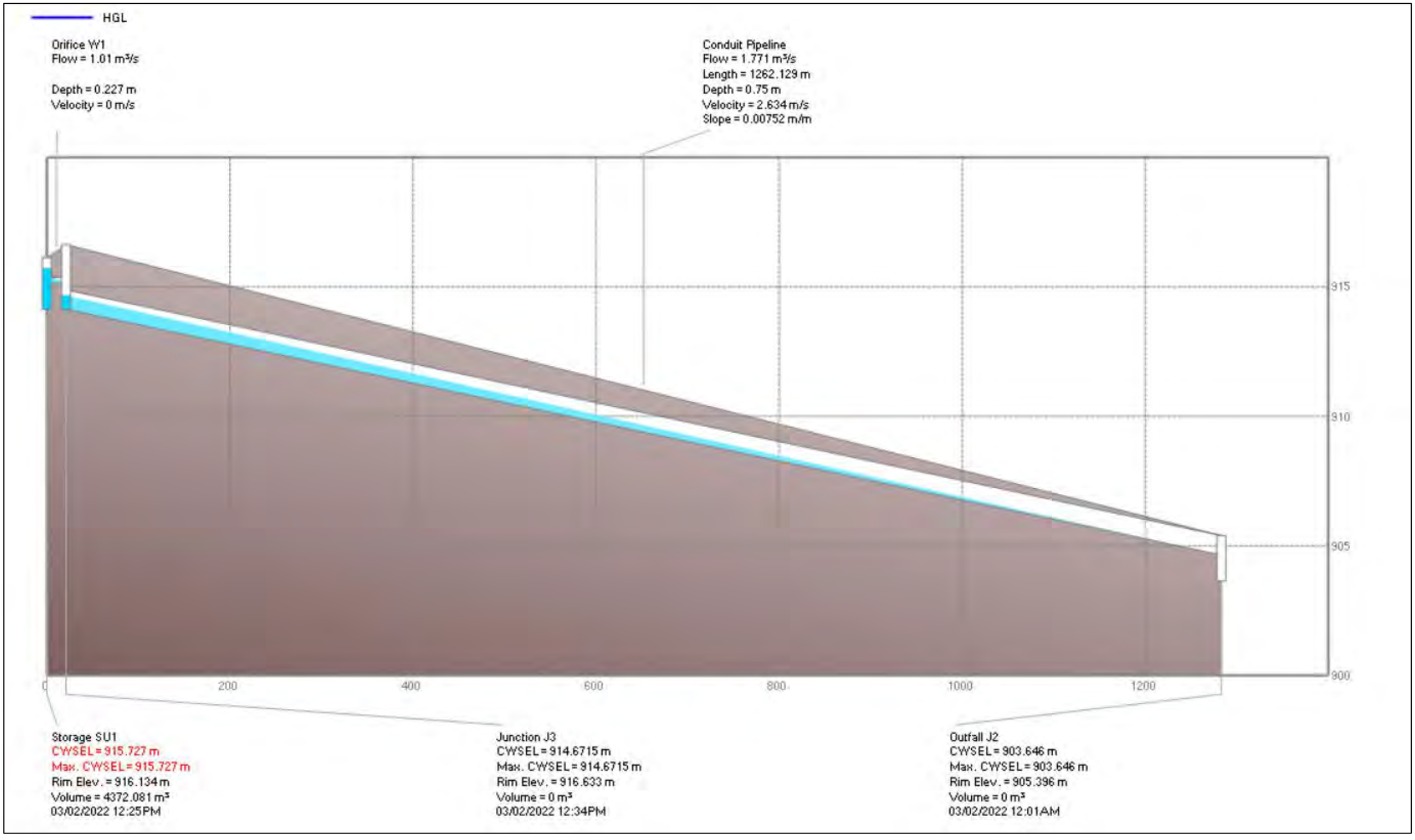


Figure 13 : PCSWMM long-section profile results

Table 6 : Orifice characteristics

Orifice type	Discharge Coefficient	Cross-section	Inlet opening diameter (m)	Inlet offset (m)	Slope (m/m)	Max flow (m^3/s)
Bottom	0.67	Circular	0.75	1	0.004	1.6

10.0 ATTENUATION RESULTS

The peak runoff generated from the surface water catchment (S1_2) that reports to the attenuation weir is 5.6 m^3/s (see Table 4). Based on the findings of the pipeline decant system, an attenuation weir capacity of 8000 m^3 was determined using PCSWMM. The inflow hydrograph is shown in Figure 14.

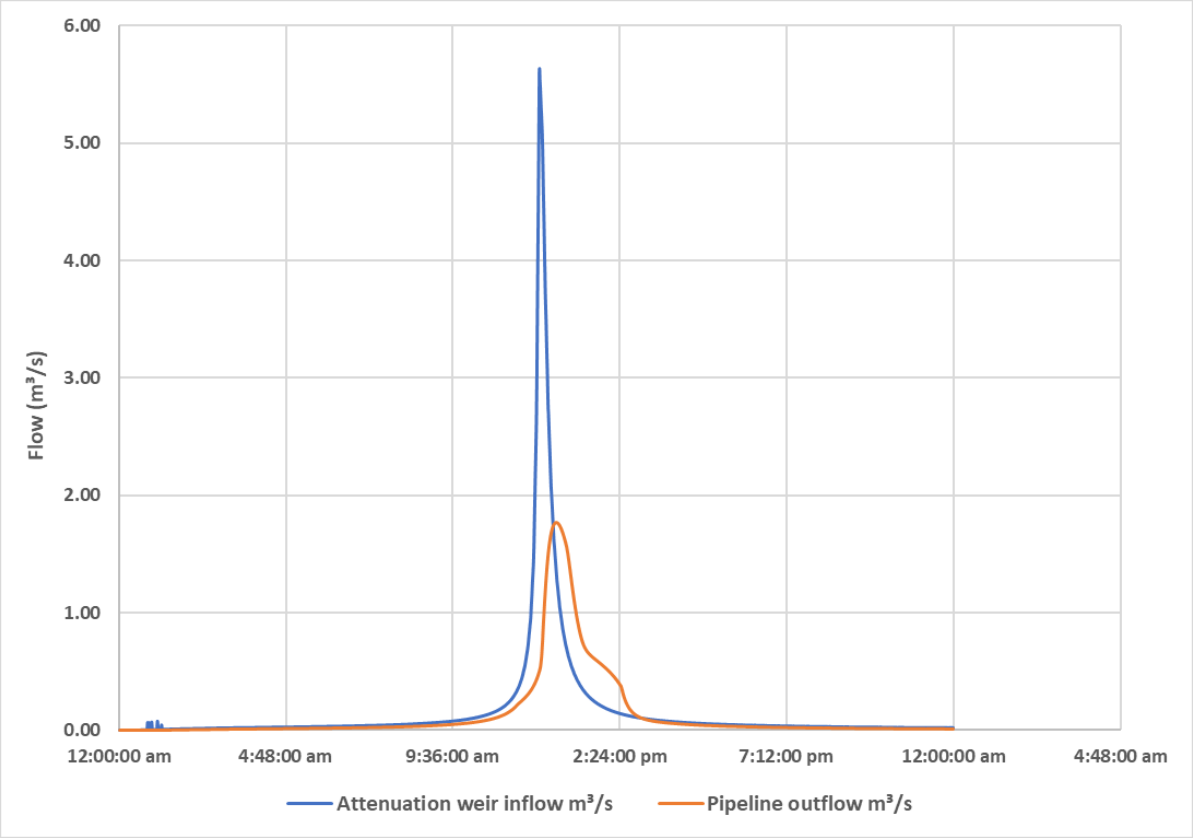


Figure 14 : Attenuation weir inflow hydrograph

The simulation of the attenuation weir volume indicates that it has sufficient capacity, indicating there will be no overflow in the weir for a the 1:50 year storm event with the freeboard maintained. The inflow volume of the weir is shown in Figure 15.

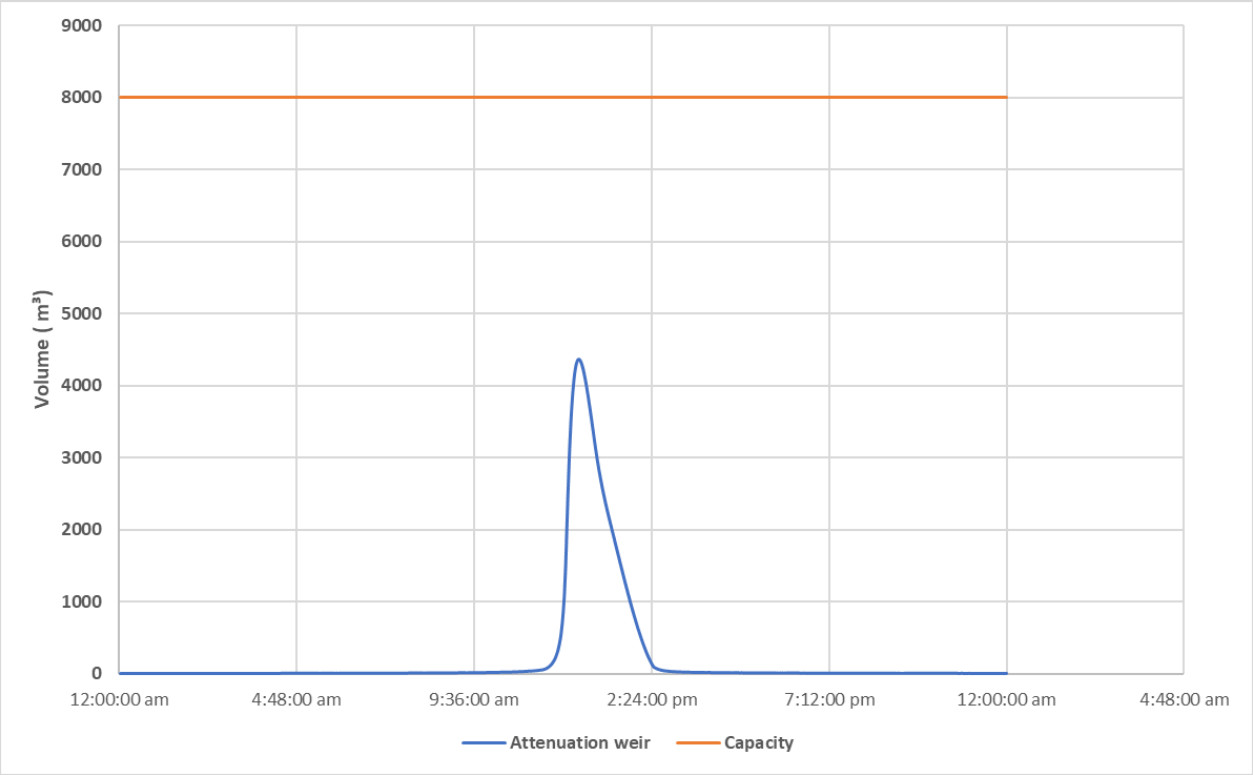


Figure 15 : Attenuation weir inflow volume

11.0 IMPACT ASSESSMENT

11.1 Major areas of concern for surface water impact

The following section describes those activities that would have an impact on the surface water resources in the area in which the attenuation weir and associated activities are proposed. For the purposes of this impact assessment, the proposed project has been subdivided into the construction, operational and closure phases.

The major activities of concern relating to the surface water resources are:

Construction phase

- Construction of the attenuation weir.
- Installation of pipelines.
- Construction of berms.
- Activities related to construction equipment.

Operational phase

- Maintenance of pipeline system.
- Operation of the attenuation weir.

Closure/decommissioning phase

- Removal of redundant infrastructure and contaminated soils.
- Grading of the project site to ensure long-term drainage conditions; and

- Soil placement and revegetation of project site.

11.2 Impact Assessment Methodology

The significance of the identified impacts on the various environmental components were determined using the approach outlined below. This incorporates two aspects for assessing the potential significance of impacts (terminology from the Department of Environmental Affairs and Tourism Guideline document on EIA Regulations, April 1998), namely occurrence and severity, which are further sub-divided as follows:

Occurrence		Severity	
Probability of Occurrence	Duration of Occurrence	Magnitude (Severity) of Impact	Scale / Extent of Impact

To assess each of these factors for each impact, the following ranking scales will be used (Table 7).

Table 7: Impact ranking scales

Probability (P)		Duration (D)		Scale (S)		Magnitude (M)	
5	Definite / Don't know	5	Permanent	5	International	10	Very High / Don't know
4	Highly Probable	4	Long-term (impact Cease after the operational life of the activity)	4	National	8	High
3	Medium Probability	3	Medium-term (5-15 years)	3	Regional	6	Moderate
2	Local Probability	2	Short-term (0-5 years)	2	Local	4	Low
1	Improbable	1	Immediate	1	Site only	2	Minor
0	None			0	None		

Definitions

Magnitude is a measure of the degree of change in a measurement or analysis (e.g. the area of pasture, or the concentration of a metal in water compared to the water quality guideline value for the metal), and is classified as none/negligible, low, moderate or high. The categorization of the impact magnitude may be based on a set of criteria (e.g. health risk levels, ecological concepts and/or professional judgment) pertinent to each of the discipline areas and key questions analyzed. The specialist study must attempt to quantify the magnitude and outline the rationale used. Appropriate, widely-recognized standards are to be used as a measure of the level of impact;

Scale/ Geographic extent refers to the area that could be affected by the impact and is classified as site, local, regional, national, or international;

Duration refers to the length of time over which an environmental impact may occur: i.e. immediate/transient, short-term (0 to 7 years), medium-term (8 to 15 years), long-term (greater than 15 years with impact ceasing after the closure of the project), or permanent; and

Probability of occurrence is a description of the probability of the impact occurring as improbable (less than 5% chance), low probability (5% to 40% chance), medium probability (40% to 60% chance), highly probable (most likely, 60% to 90% chance) or definite (impact will definitely occur).

Once these factors have been ranked for each impact, the significance of the two aspects, occurrence and severity, will be assessed using the following formula:

SP (significance points) = (magnitude + duration + scale) x probability

The maximum value is 100 significance points (SP). The environmental effects are then rated as of **High**(>75 SP), **Moderate** (50 - 75 SP) or **Low** (<50 SP) significance, both with and without mitigation measures and for both occurrence and severity, on the following basis:

Table 8 : Significance of impact based on point allocation

Points	Significance	Description
SP >75	Indicates high environmental significance	Where it would influence the decision regardless of any possible mitigation. An impact that could influence the decision about whether to proceed with the project.
SP 50 - 75	Indicates moderate environmental significance	Where it could have an influence on the decision unless it is mitigated. An impact or benefit which is sufficiently important to require management. Of moderate significance - could influence the decisions about the project if left unmanaged
SP <50	Indicates low environmental significance	Where it will not have an influence on the decision. Impacts with little real effect and which should not have an influence on or require modification of the project design or alternative mitigation

11.3 Construction phase impacts

11.3.1 Erosion during construction

Soil stripping, stockpiling, excavations of the attenuation weir and pipeline trenches, and construction of berms may result in loss of soils through erosion, particularly for topsoil stockpiles with unvegetated steep slopes, resulting in increased sedimentation to water resources.

Contaminants from areas in which contractor vehicles and equipment are housed, as well as from the areas in which the construction vehicles and equipment are being used, will include hydrocarbons that are spilled or leaked during use.

During construction, it is expected that the magnitude of the impact will be moderate due to the topography of the area and potential hydrocarbon contamination from equipment and trucks. The impact significance is **moderate**, and will require mitigation to reduce the risk.

11.3.1.1 Mitigation

In summary, the following mitigation measures are proposed:

- Avoid clearing during the wet season when short heavy downpours can be expected. This should help to limit erosion.
- Re-use stockpiled soil within as short a period as possible.

- Ensure adequately designed berms and stormwater collection facilities to capture sediment before water is released into the environment. All stormwater management systems should be compliant with Regulation GN 704; and
- Ensure clean-up of hydrocarbon spills from machinery is done immediately, and contaminated soils disposed of to a permitted site.
- After construction, the land must be cleared of debris, surplus materials, and equipment. All parts of the land must be left in a condition as close as possible to that prior to construction.

Should the measures described above be implemented during construction, then the impact significance will reduce to **moderate – low**.

11.4 Operational phase impacts

11.4.1 Maintenance of the pipeline and the attenuation weir

The stormwater design will be such that clean water will be diverted around the site to the tributaries, and it is likely that there will be increased flows because of the hardened surface. Furthermore, erosion may occur at the end of the pipeline over time due to the high discharge velocities.

The risk of sedimentation is directly linked to the risk of erosion, as eroded soil particles will end up in nearby watercourses as sedimentation.

The impact significance in the operational phase is expected be **low**.

11.4.1.1 Mitigation

The following mitigation measures are proposed:

- Design stormwater management facilities to comply with regulation GN 704.
- Regularly schedule inspection and maintenance of water management facilities, to include inspection of drainage structures. Pipelines should be maintained according to the manufacturer's specifications.

A well-designed stormwater management system will ensure that the clean water to the environment is maximized. Should the measures described above be implemented during the operation phase, the impact significance will be kept to **low**.

11.4.2 Overflow from the Attenuation weir

As described in Section 5.0, the stormwater management system including the attenuation weir will be designed to comply with GN 704, which will include the operation of the weir with a freeboard of 0.8m by discharging and evaporating the water. The likelihood of overflow from the attenuation weir is therefore low. Should an incident occur, the magnitude is likely to be low to moderate, depending on the quantity of the water at the time, the duration would be short-term or immediate and the scale would be local, or limited to the site only. With a medium probability, the impact significance is **low**.

11.4.2.1 Mitigation

The following mitigation measures are proposed:

- Implement the proposed attenuation weir to comply with regulation GN 704 so that it can contain a 1: 50 flood event.
- Maintain a 0.8m freeboard

11.5 Closure/decommissioning during rehabilitation

11.5.1 Contaminated runoff during rehabilitation

Similarly, to the construction phase, the runoff during the rehabilitation (decommissioning/ closure) phase may contain contaminants. In addition, soil compaction to reshape the landform may cause increased runoff which may still contain higher concentrations of contaminants and sediment.

Spillage of chemical solutions during the dismantling of plant equipment and pipelines which were in contact with chemicals solution may contaminate the soils; Spillage of diesel, oils, and greases from the dismantled plant equipment, resulting in hydrocarbon contamination of exposed soils.

Furthermore, erosion and sedimentation of downstream resources is possible in this phase. This will be due to areas around the weir that will not be adequately revegetated.

The magnitude is therefore rated as moderate, with a medium-term duration, on a local scale. The probability is medium with the resultant impact significance of the runoff during rehabilitation expected to be **moderate.**

11.5.1.1 Mitigation

The following mitigation measures are proposed:

- All pollution control mechanisms are to be in accordance with GN 704, and all necessary pollution control mechanisms must be protected and repaired or established when stockpiles or residue deposits are reclaimed, removed, or rehabilitated so that water pollution is minimized and abated.

Should the measures described above be implemented then the impact significance should be reduced to **low**.

11.6 Impact assessment summary

The predicted environmental impacts resulting from the proposed project activities are listed in Table 9 along with their significance ratings before and after mitigation.

Table 9 : Summary of activities and associated surface water impacts

ACTIVITY	POTENTIAL IMPACT	ASPECT AFFECTED	Magnitude	Duration	Scale	Probability	Significance	Significance without Mitigation	Magnitude	Duration	Scale	Probability	Significance	Significance with Mitigation
Construction Phase														
Soil stripping and stockpiling	Loss of soils through erosion, particularly for topsoil stockpiles with unvegetated steep slopes, resulting in increased sedimentation to water resources.	Downstream water resources	8	3	2	4	52	Moderate	4	3	1	3	24	Low
Construction of attenuation weir	Increased runoff and erosion in compacted areas and modification of natural infiltration. Soil contamination from chemical spills including sterilisation by cement pollutants.	Downstream water resources	8	3	2	4	52	Moderate	4	3	1	5	24	Low
Layout of pipeline system	Loss of soils through erosion, particularly when excavating pipeline trenches.	Downstream water resources	8	3	2	4	52	Moderate	4	3	1	5	24	Low

ACTIVITY	POTENTIAL IMPACT	ASPECT AFFECTED	Magnitude	Duration	Scale	Probability	Significance	Significance without Mitigation	Magnitude	Duration	Scale	Probability	Significance	Significance with Mitigation
Vehicles and use of equipment/ machinery	Contamination of soils and downstream water resources by chemical pollutants. Increased soil compaction and runoff at equipment and machinery laydown areas. Potential spills/ leakage of chemicals.	Downstream water resources	8	3	2	4	52	Moderate	4	3	1	3	24	Low
Operational phase														
Vehicles and use of equipment/ machinery	Contamination of soils and downstream water resources from chemical spills/ leaks.	Downstream water resources	6	2	2	3	30	Moderate	4	2	1	3	21	Low
Pipeline system operations	Sediment depositions causing blockages and deterioration of pipelines. Energy dissipaters must be provided to slowdown surface water runoff and prevent erosion.	Downstream water resources	6	2	2	3	30	Moderate	4	2	1	3	21	Low
Attenuation weir operations	Potential overflow from the attenuation weir.	Downstream water resources	6	2	2	3	30	Moderate	4	2	1	3	21	Low
Decommissioning & Closure Phase														

ACTIVITY	POTENTIAL IMPACT	ASPECT AFFECTED	Magnitude	Duration	Scale	Probability	Significance	Significance without Mitigation	Magnitude	Duration	Scale	Probability	Significance	Significance with Mitigation
Removal of redundant infrastructure	Spillage of chemical solutions during the dismantling of plant equipment, pipelines and which were in contact with chemicals solution may contaminate the soils; Spillage of diesel, oils, and greases from the dismantled plant equipment, resulting in hydrocarbon contamination of exposed soils.	Downstream water resources	6	4	3	3	39	Moderate	4	2	1	2	14	Low
Grading of the project site to ensure long-term drainage conditions on site	Contamination of soils by hydrocarbons, and downstream areas during compaction in areas where active heavy machinery will be mobilised for the shaping of the final landform.	Downstream water resources	6	3	2	3	33	Moderate	4	3	2	2	18	Low
Soil placement and revegetation of project site	Erosion and sedimentation of downstream resources from areas not adequately revegetated.	Downstream water resources	6	3	2	3	33	Moderate	4	3	2	2	18	Low

12.0 CONCLUSION AND RECOMMENDATION

- It is recommended that regular maintenance be carried out on the pipeline system to ensure there are no obstructions that would limit the efficacy of the system.
- Energy dissipators are recommended at the discharge point downstream of the pipeline.

Overall, the surface water impact assessment has indicated the following potential surface water impacts that will require mitigation.

The biggest concern relates to polluted runoff reaching the water resources during all the phases of the project. During the construction phase the concerns relate to the potential for erosion and sedimentation to water resources from the excavation of the weir, soil stripping and stockpiling, as well as potential hydrocarbon contamination from spills or leaks from heavy vehicle and equipment use.

During the operational phase, the areas of concern also relate to maintenance of the pipeline system, including the attenuation weir.

The concerns at closure/ decommissioning relate to contamination of soils by hydrocarbons, and downstream areas during compaction in areas where active heavy machinery will be mobilised for the shaping of the final landform, erosion and sedimentation of downstream resources from areas not adequately revegetated.

Prior to mitigation the impact significance for all impacts identified, are rated as moderate due mostly to the potential impacts to the downstream water users, however, should mitigation be implemented as proposed, then the impact significance should be reduced to low.

Golder Associates Africa (Pty) Ltd.

Tebatso Menziwa
Candidate Civil Engineer

Eugeshin Naidoo
Senior Civil Engineer

TA/EN/ck

https://golderassociates.sharepoint.com/sites/145886/project files/5 technical work/river diversion/21466019_mem004_gamsberg_river_diversion_final_04052022.docx

DETAILS OF THE SPECIALIST

Table 1: Details of specialist

Specialist Information	
Name:	Eugeshin Naidoo
Phone number:	0828348037
Email:	Eugeshin.naidoo@wsp.com
Professional Registration Number	20190664
Curriculum vitae:	Appended

Declaration of Independence by Specialist

I, Eugeshin Naidoo, declare that I –

- Act as the independent specialist for the undertaking of a specialist section for the proposed project.
- Do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed;
- Do not have nor will have a 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 information that have or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan, or document.

_____

Eugeshin Naidoo

APPENDIX I

Desktop Soil Assessment Report

REPORT

Gamsberg Mine Additional Infrastructure Project - Desktop Soil Assessment

Black Mountain Mining (Pty) Ltd

Submitted to:

Black Mountain Mining (Pty) Ltd

1 Penge Road
Aggeneys
8893

Submitted by:

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April 2022

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Table of Contents

TABLES

FIGURES

APPENDICES

APPENDIX A
Soils Map (SRK, 2009)

1.0 INTRODUCTION

Black Mountain Mining (Pty) Ltd. (BMM), a subsidiary of Vedanta Zinc International (VZI), operates the Black Mountain Complex consisting of the underground Black Mountain Mine operations, Deeps and Swartberg, and the opencast Gamsberg Zinc Mine. The Black Mountain Mine complex mines zinc, lead, silver and copper and hoists 1.7 million tonnes (mt) of ore a year with a current production capacity of 90 000 tonnes per annum (tpa) metal-in-concentrate.

The Gamsberg Zinc Mine came into operation in June 2016 and mines approximately 4 million tonnes per annum (Mtpa) and produces 250-300 tpa of zinc concentrate.

The mine is situated in the Namakwa District, Northern Cape and is approximately 120 km east of Springbok and approximately 270 km from Upington, between the towns of Aggeneys and Pofadder. The Gamsberg Zinc Mine is located over three properties namely, Portion 1 of the farm Bloemhoek 61, Portion 1 of the farm Gams 60 and Portion 0 of farm Aroams 57.

Gamsberg Mine currently requires further environmental related applications to authorise additional infrastructure and activities that are required for ongoing operations and which were not included in the previous authorisations, and to authorise changes required in infrastructure layout as a result of optimised planning. As part of the Basic Assessment process, a specialist soil, land capability and land use assessment are required.

WSP in Africa (WSP), a wholly owned affiliate of WSP Global Inc., was commissioned to undertake a desktop soils assessment for the proposed project. The objective of this study is to identify and assess the potential impacts of the proposed infrastructure and associated activities on the soils and to provide recommended mitigation measures, monitoring requirements and rehabilitation guidelines for the identified impacts.

2.0 PROPOSED INFRASTRUCTURE DEVELOPMENT AND CHANGES

Gamsberg Mine is applying for environmental authorisation for the proposed infrastructure and activities described in the sections below and illustrated in Figure 1.

2.1 New potable water pipeline

A new above-ground potable water pipeline is proposed to run from the Horseshoe dam to the processing plant. This pipeline will be developed in an existing servitude already use for pipelines transporting water from Sedibeng Water to the mine. The location where the pipeline is proposed to be developed has already been cleared of vegetation as it is within a road reserve. The proposed pipeline will be installed above-ground and will have an inside diameter of 400 mm, an outside diameter of 460 mm, a throughput of 460 m3/hour and will be approximately 7 km in length. The entire pipeline will belong to Gamsberg Mine.

2.2 Expansion of dangerous goods storage facilities

To support the ongoing operations at Gamsberg Mine, an increase in storage capacity will be required for the following dangerous goods storage facilities:

- Fuel storage capacity which is proposed to increase from 600 m3 to 1 200 m3.
- Emulsion storage is proposed to be increased from 2 x 85t silos and 2 x 50t silos to 2 x 100t and 2 x 200t silos respectively.

The proposed expansion of the above-mentioned facilities will be adjacent to the existing storage facilities, located at the existing mine office and workshop area.

2.3 River diversion

To minimise pollution from the waste rock dump, ROM pad and crushers and conveyer infrastructure associated with the phase 1 and 2 plant infrastructure, it is proposed that the ephemeral riverbed that passes between the processing plant and the mining operations, be altered.

The diversion will include the construction of an attenuation weir, diversion berms, two above-ground pipelines for conveying any upstream runoff past the impacted area (processing plant and the mining operations) and an energy dispersion outlet structure. The altered section will be approximately 2.5 km in length.

The alteration will be in place for the duration of the operational phase of the mine and will be rehabilitated during the decommissioning and closure phase.

2.4 Refined layout of the waste rock dump and quartzite rock dump/berm

A waste rock dump facility, with a capacity to store 1.5 billion tons of waste rock on an area of 490 ha, is approved in the Environmental and Social Impact Assessment Report for the Gamsberg Zinc Mine and Associated Infrastructure in the Northern Cape (June 2013).

In addition to the main waste rock dump facility and in order to mitigate the impacts on biodiversity as a result of the basin/crater mining activities, it was recommended that a rock dump / berm, comprising only quartzite rock, be designed and constructed to shield the remainder of the basin / crater from mining activities. It is detailed in the Environmental Management Programme for the Gamsberg Zinc Mine and Associated Infrastructure in the Northern Cape (May 2013), that the berm should be constructed to the same elevation as the plateau comprising a non-acid leaching rock core and a quartzite rock outer layer. It is further stated that the placement of the barrier must be defined with input from a qualified botanist and the engineering team prior to the placement of the rock.

The Gamsberg Mine engineering team has refined the layout of the current waste rock to optimise the placement of waste rock and to avoid current mine infrastructure and to ensure safe operation of the facility. The updated waste rock dump layout is based on the storage capacity and footprint as approved in the 2013 EIA and EMPr.

The 2013 EMPr does not include a final position and layout of the biodiversity protection rock dump / berm. The engineering team, in consultation with the biodiversity specialist has defined the final layout and position.

The updated waste rock dump layout and layout and position of the biodiversity rock dump / berm will be included in the Basic Assessment Report.

2.5 Defined layout for the crusher and coarse ore stockpile for the 2nd phase of the plant

The 2013 EIA states that the full production capacity of the mine will be 10 Mtpa ore. This capacity will be reached in a modular approach following the mine ramp up plan as described in the report. It is stated that the current concentrator plant will be ramped up in three modules to full capacity. It is indicated that the three phases of the concentrator plant will each consist of a concentrator stream with supporting utility and supporting infrastructure.

An amended concentrator plant boundary and shortened conveyor route was approved in the Gamsberg Mine Environmental Management Programme Amendment (December 2016). The information was presented at a high level and did not differentiate between the infrastructure components required for the three plant modules.

The Gamsberg Mine engineering team has defined the phase 2 plant components in preparation for construction. The updated conveyor and phase 2 concentrator plant layout will be included in the Basic Assessment Report.

3.0 SPECIALIST STUDY INTRODUCTION

The report provides, at a desktop level, the soil characteristics, land capability and land use of the project area. The study provides an input into the Basic Assessment Report as required in terms of the Mineral and Petroleum Resources Development Act (MPRDA), Act 28 of 2002 and the National Environmental Management Act (NEMA), Act 107 of 1998. These Acts require the avoidance of pollution and/or degradation of the environment or where neither can be avoided, it is required that the pollution or degradation thereof be minimised or remediated.

3.1 Study Objectives

The objectives of the study were therefore to do the following:

- Conduct a desktop soil assessment based on the available literature and specialist studies and reports conducted for the Gamsberg Mine and surrounding areas.
- Determine the impacts on soil, land use and land capability associated with the project.
- Propose environmental management actions required for the preservation of local soils (mitigation measures and monitoring requirements).

3.2 Study Limitations

The content of this report is based on existing specialist studies and reports available for the Gamsberg Mine and surrounding area. The author of this report did not visit the study site.

The assessment rating of impacts is not an absolute measure. It is based on the subjective considerations and experience of the specialist but is done with due regard and as accurately as possible within these constraints.

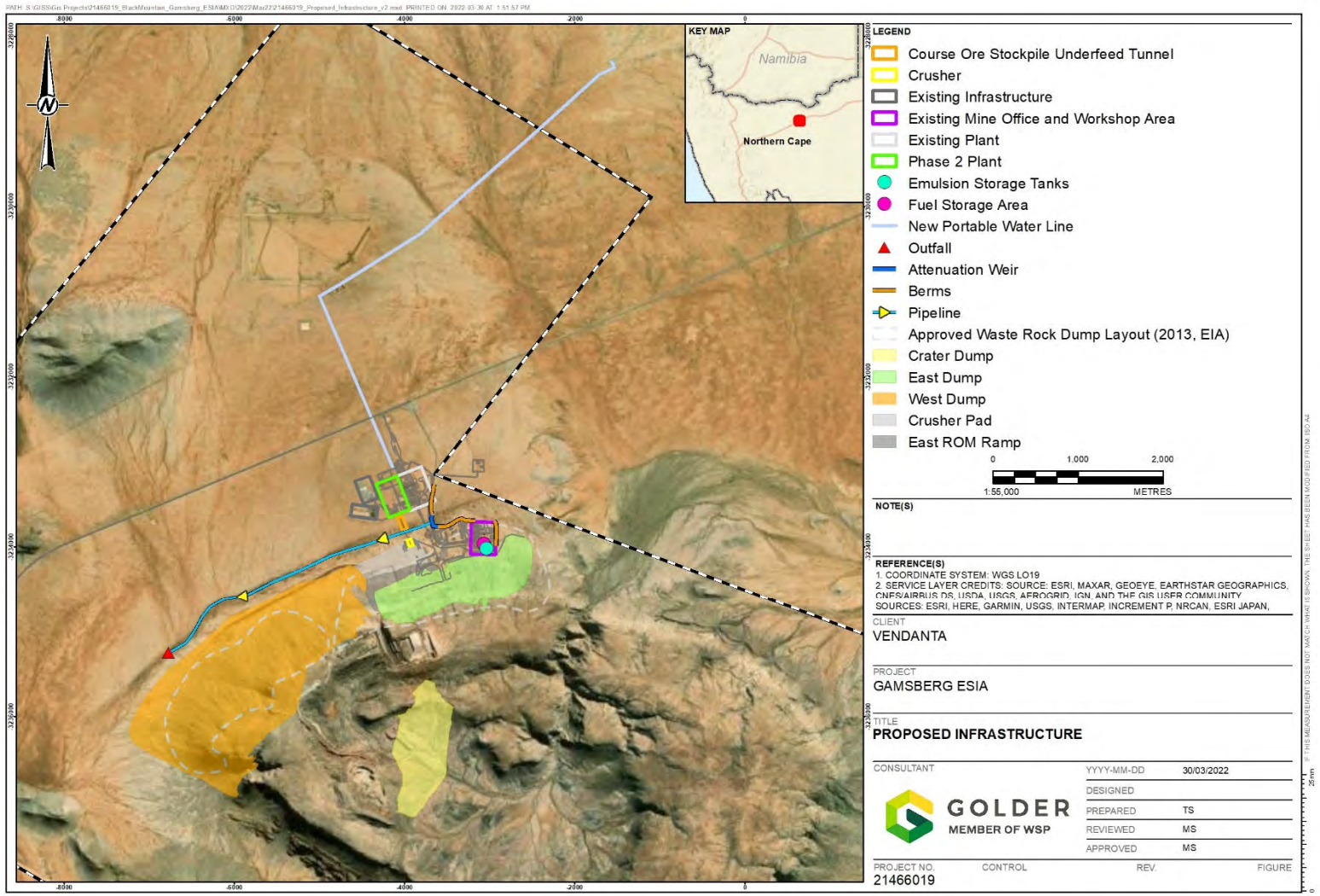


Figure 1: Gamsberg Mine study site and proposed infrastructure

4.0 POLICY AND LEGAL AND ADMINISTRATIVE FRAMEWORK

The following section outlines a summary of South African Environmental Legislation that needs to be considered for the proposed Gamsberg Mine infrastructure project with regards to management of soil:

- The law on Conservation of Agricultural Resources (Act 43 of 1983) states that the degradation of the agricultural potential of soil is illegal.
- The Bill of Rights states that environmental rights exist primarily to ensure good health and well-being, and secondarily to protect the environment through reasonable legislation, ensuring the prevention of the degradation of resources.
- The Environmental right is furthered in the National Environmental Management Act (No. 107 of 1998), which prescribes three principles, namely the precautionary principle, the “polluter pays” principle and the preventive principle.
- It is stated in the above-mentioned Act that the individual/group responsible for the degradation/pollution of natural resources is required to rehabilitate the polluted source; Soils and land capability are protected under the National Environmental Management Act 107 of 1998, the Environment Conservation Act 73 of 1989, and the Conservation of Agricultural Resources Act 43 of 1983.
- The National Veld and Forest Fire Bill of 10 July 1998 and the Fertiliser, Farm Feeds, Agricultural Remedies and Stock Remedies Act 36 of 1947 can also be applicable in some cases.
- The National Environmental Management Act 107 of 1998 requires that pollution and degradation of the environment be avoided or, where it cannot be avoided, be minimized and remedied.
- The Conservation of Agriculture Resources Act 43 of 1983 requires the protection of land against soil erosion and the prevention of water logging and salinisation of soils by means of suitable soil conservation works to be constructed and maintained.

5.0 METHODOLOGY

5.1 Data Gathering

A desktop soil assessment was undertaken for the Gamsberg Mine site. This included accessing the ISRIC World Soils Database, based on the World Reference Base Classification System (WRB, 2014), the Soil and Terrain Database for South Africa (ISRIC, 2008) and a previous soils report undertaken in the area by SRK Consulting (Pty) Ltd (SRK, 2009). These sources, most notably the previous SRK study, cover the majority of the proposed infrastructure study area. The soils underlying the 1.2km long northern-most section of the proposed potable water line, located outside the Gamsberg Mine mining right area (MRA) have not previously been classified (refer to Figure 1). The proposed potable water line will be located within an existing servitude already used for pipelines transporting water from Sedibeng Water to the mine.

5.2 Available literature and studies

Documents appraised as part of the desktop study included the following:

- SRK Consulting (2009). Gamsberg Zinc Project Soils and Land Capability Baseline Report. Report No. 396036/Soils.

- ERM (2013). Environmental and Social Impact Assessment Report for the Gamsberg Zinc Mine and Associated Infrastructure in the Northern Cape. Final Report. June 2013.
- SLR. (2020). Gamsberg Smelter Project: Environmental Impact Assessment and Environmental Management Programme.
- International Soil Reference and Information Centre (2008). The Soil and Terrain Database for South Africa.
- World Resource Base (previous FAO system) (2014). The World Reference Base Classification System 2008.

6.0 ENVIRONMENTAL CONTEXT

6.1 Climate

The Gamsberg Mine is located in an area that is classified as a desert region with very low rainfall and very high evaporation rates. The mean annual precipitation is estimated at 92.4 mm and rainfall can occur in both summer and winter as the area lies in a transition zone between winter and rainfall areas and average summer temperatures range between 30°C and 35°C while in winter the maximum temperatures range between 17°C and 20°C.

6.2 Geology

6.2.1 Regional Geology

ERM (2013) states that the Gamsberg zinc deposit is developed in a medium to high grade metamorphic volcano-sedimentary succession belonging to the Aggeneys Sub-Group of the Bushmanland Group. This group is bordered to the east by the Hartbees River Thrust, to the north by the Groothoek Thrust and Wortel Belt, and it is overlain by Karoo-age rocks to the south. Together these Groups occur within the Namaqualand Metamorphic Complex, which, as stated by ERM (2013), consist of Precambrian metamorphic rocks and intrusives formed or metamorphosed during the Namaqua Orogeny.

The Bushmanland Group is composed of basement granitic rocks (1 700 to 2 050 mega annum (Ma)), supra-crustal sequences of sedimentary and volcanic origin (1 200, 1 600 and 1 900 Ma) and intrusive charnockite to granitic rocks (950, 1 030 to 1 060, and 1 200 Ma) (ERM, 2013).

6.2.2 Local Geology

ERM (2013) describes the local geology of the Gamsberg Mine area as a succession of basal quartzo-feldspathic gneiss overlain progressively upwards by sillimanite-bearing pelitic schist and metaquartzites of up to 450 m thickness; the Gams Iron Formation (GIF) of 0 to 80 m thickness; and Koeris Formation rocks consisting of quartz-muscovite schist, lenses of conglomerate and amphibolite to a thickness of 400 to 500 m.

6.3 Topography

The local topography is characterized with undulating plains, containing low growing shrubby vegetation and grasses. The surrounding plains are approximately 750 – 900 meters above mean sea level (mamsl), with the highest areas of the Gamsberg inselberg varying between 1 100 – 1 150 mamsl. The Gamsberg inselberg measures approximately 7.5 km east-west and approximately 4.6 km north-south. A basin, varying between 60 to 70 m below the rim, has developed at the top of the inselberg as a result of erosion (SLR, 2020).

6.4 Regional Soils and Land Use

The Gamsberg Mine area is described by ERM (2013) as being characterised by extensive peneplain[1]. It is explained that the soils present in the peneplain are predominantly shallow and stony. However, soils found within the inselberg are characterised with boulder and stony scree slope soils (SRK Consulting, 2010 as cited by SRK, 2013). The scarps and crest of the inselberg are characterised with bare rocks, while the Gamsberg Basin itself is characterised with shallow gravelly soils.

It is further stated by ERM (2013) that the soils present on the peneplain are generally characterised with reddish sandy topsoil that is shallow in nature. It is however noted that this layer of red sandy soils varies between being 10 cm to up to 60 cm across the Gamsberg Mine area.

The area is unsuitable for crop production due to the dry climate and low rainfall and therefore livestock farming is the dominant form of land use in the region.

The proposed project area falls within the existing Gamsberg MRA except for a short section of the proposed potable water pipeline that will be constructed within an existing pipeline servitude. Therefore, no agricultural land will be transformed for this project.

7.0 SOILS IDENTIFIED

The soils identified at the site that coincide with the abovementioned proposed new infrastructure areas are described in the previous SRK soils study of the site (SRK, 2009) and are listed in Table 1 below (refer to APPENDIX A for the soil type distribution map compiled by SRK).

The area closest to the previously unclassified northern-most section of the proposed water line has been classified as Knersvlakte soil (SRK, 2009), and because there are no significant differences between this area and the unclassified area, it has been assumed that that the unclassified area is also underlain by Knersvlakte soil.

7.1 Knersvlakte Soil Form

Knersvlakte consists of red sand that forms an Orthic topsoil underlain by a Dorbank. The Dorbank can be several centimetres to several metres deep, underlain by hard carbonate and then soft carbonate. In other areas the carbonate sequence is reversed, where soft carbonate is above hard carbonate. During the SRK study site visit, the topsoil was moist in most areas due to rain earlier in the week of sampling, and was described as red in colour, friable to slightly firm, clay sand and wind deposited. Given the arid climate of the region, the moisture observed is likely to be associated with conditions that prevail after rainfall. The Dorbank is a hard to very hard red layer, comprising of sand, gravel and in some places fines stones cemented together. There was visual evidence of precipitated salts in the Dorbank.

7.2 Coega Soil Form

Coega is composed of an Orthic A horizon, underlain by hard carbonate. The thin topsoil cover of red sand was absent in places, exposing the underlying hard carbonate on the surface. The thickness of the hard carbonate varied (0.4 – 1.5 m) across the site.

[1] A more or less level land surface produced by erosion over a long period, undisturbed by crustal movement.

7.3 Prieska Soil Form

Prieska is composed of a thin topsoil overlying a red sand soil with carbonate. This soil layer is underlain by hard carbonate starting from a depth of about 40 cm in places.

7.4 Glenrosa Soil Form

The Glenrosa soils identified at the site were composed of red sandy topsoil overlying weathered rock. The weathered rock was about 40 cm thick and merged into a hard rock.

7.5 Mispah Soil Form

Mispah is comprised of a very thin topsoil horizon directly on hard rock. These shallow, sandy, stony and /or rocky soils do not have a clear profile, overlying hard rock.

7.6 Oakleaf Soil Form

The Oakleaf soils identified comprised moderately shallow red sand over rock or gravelly material. Most of these soils had an effective soil depth about 60 cm, but the water holding capacity was reduced by the low clay and fairly high gravel contents.

Table 1: Soil forms identified in proposed development areas

	Soil Forms Identified						
Proposed Development Areas	**Shallow Oakleaf**	**Deep Oakleaf**	**Knersvlakte**	**Mispah**	**Glenrosa**	**Prieska**	**Coega**
Potable water pipeline			X			X	X
Potable water pipeline area outside mining rights area			X				
Expansion of dangerous goods storage areas		X	X				
River diversion/alteration		X					
Waste rock dump area	X	X	X	X	X		
Crusher and coarse ore stockpile for plant phase 2	X	X	X				X

8.0 ENVIRONMENTAL IMPACT ASSESSMENT

8.1 Methodology for assessing impact significance

The significance of identified impacts was determined using the approach outlined below (terminology from the Department of Environmental Affairs and Tourism Guideline document on EIA Regulations, April 1998).

This approach incorporates two aspects for assessing the potential significance of impacts, namely occurrence and severity, which are further sub-divided as follows:

Table 2: Impact assessment factors

Occurrence		Severity	
Probability of occurrence	Duration of occurrence	Scale/extent of impact	Magnitude of impact

To assess these factors for each impact, the following four ranking scales were used:

Table 3: Impact assessment scoring methodology

Magnitude	Duration
10- Very high/unknown	5- Permanent (>10 years)
8- High	4- Long term (7 - 10 years, impact ceases after site closure has been obtained)
6- Moderate	3- Medium-term (3 months- 7 years, impact ceases after the operational life of the activity)
4- Low	2- Short-term (0 - 3 months, impact ceases after the construction phase)
2- Minor	1- Immediate
Scale	**Probability**
5- International	5- Definite/Unknown
4- National	4- Highly Probable
3- Regional	3- Medium Probability
2- Local	2- Low Probability
1- Site Only	1- Improbable
0- None	0- None

Significance Points= (Magnitude + Duration + Scale) x Probability.

Table 4: Significance of impact based on point allocation

Points	Significance	Description
SP>60	High environmental significance	An impact which could influence the decision about whether or not to proceed with the project regardless of any possible mitigation.
SP 30 - 60	Moderate environmental significance	An impact or benefit which is sufficiently important to require management and which could have an influence on the decision unless it is mitigated.
SP<30	Low environmental significance	Impacts with little real effect and which will not have an influence on or require modification of the project design.
+	Positive impact	An impact that is likely to result in positive consequences/effects.

For the methodology outlined above, the following definitions were used:

- Magnitude is a measure of the degree of change in a measurement or analysis (e.g., the area of pasture, or the concentration of a metal in water compared to the water quality guideline value for the metal), and is classified as none/negligible, low, moderate or high. The categorization of the impact magnitude may be based on a set of criteria (e.g. health risk levels, ecological concepts and/or professional judgment) pertinent to each of the discipline areas and key questions analysed. The specialist study must attempt to quantify the magnitude and outline the rationale used. Appropriate, widely recognised standards are to be used as a measure of the level of impact;
- Scale/Geographic extent refers to the area that could be affected by the impact and is classified as site, local, regional, national, or international;
- Duration refers to the length of time over which an environmental impact may occur: i.e. immediate/transient, short-term (0 to 7 years), medium term (8 to 15 years), long-term (greater than 15 years with impact ceasing after closure of the project), or permanent; and
- Probability of occurrence is a description of the probability of the impact actually occurring as improbable (less than 5% chance), low probability (5% to 40% chance), medium probability (40% to 60% chance), highly probable (most likely, 60% to 90% chance) or definite (impact will definitely occur).

8.2 Project Phases

The environmental impacts were considered with respect to the Project Description detailed in Section 2.0 with the understanding that the following project activities are anticipated:

- Constructing and operating of the above ground potable water pipeline within the existing pipeline servitude.

- Constructing and operating the infrastructure required for the diversion / alteration of the ephemeral riverbed. These will include berms, an attenuation weir, above-ground pipelines and an energy dispersion outlet structure
- Constructing and operating the additional fuel and emulsion storage infrastructure adjacent to the existing storage facilities.
- Continued deposition of waste rock dump on the refined layout footprint and construction of the approved quartzite crater dump/berm (biodiversity mitigation measure).
- Construction and operation of the crusher and coarse ore stockpile (associated infrastructure of the approved 2nd phase of the concentrator plant).
- Removal of all infrastructure during the closure and rehabilitation phase and rehabilitation of the areas to a state of physical and chemical stability to ensure safety and to prevent further degradation of the ecological environment.

9.0 POTENTIAL SOIL IMPACTS

The following impacts are potentially significant across the site in respect of soil, land use and land capability.

9.1 Erosion and Sedimentation

POTENTIAL ENVIRONMENTAL IMPACT	ENVIRONMENTAL SIGNIFICANCE						MITIGATION AND MANAGEMENT MEASURES	ENVIRONMENTAL SIGNIFICANCE					
	Before mitigation							After mitigation					
	M	D	S	P	SP	R		M	D	S	P	SP	R
Construction, Operational and Decommissioning Phases													
Development of the proposed infrastructure will lead to some erosion during the construction and decommissioning phases of development, and potentially the operational phase of the development as measures will need to be put in place to prevent eroded areas from spreading. The sandy soils identified in the study area are less resilient to wind erosion than the coarse rocky soils. Furthermore, as the hydraulic characteristics of the area are likely to be significantly altered as a result of channelling of runoff or increased water velocity from artificial slopes, there is the potential that the soils may be subjected to increased water erosion. The risk of sedimentation is directly linked to the risk of erosion, as eroded soil particles will end up in the very	2	2	1	3	15	Low	■ Implement an effective system of run-off control, where it is required, that collects and safely disseminates run-off water from all hardened surfaces and prevents potential down slope erosion. ■ Periodic erosion monitoring to be undertaken in cleared areas. ■ Any occurrence of erosion must be attended to immediately and the integrity of the erosion control system at that point must be amended to prevent further erosion form occurring there.	2	2	1	2	10	Low

POTENTIAL ENVIRONMENTAL IMPACT	ENVIRONMENTAL SIGNIFICANCE						MITIGATION AND MANAGEMENT MEASURES	ENVIRONMENTAL SIGNIFICANCE					
	Before mitigation							After mitigation					
	M	D	S	P	SP	R		M	D	S	P	SP	R
nearby surrounding watercourses as sedimentation.							■ Retain as much vegetation cover over as much of the site as possible to protect soil from water and wind erosion. ■ Work should be stopped in land clearance areas during heavy rainfall periods.						

9.2 Loss of Topsoil

POTENTIAL ENVIRONMENTAL IMPACT	ENVIRONMENTAL SIGNIFICANCE Before mitigation						MITIGATION AND MANAGEMENT MEASURES	ENVIRONMENTAL SIGNIFICANCE After mitigation					
	M	D	S	P	SP	R		M	D	S	P	SP	R
Construction, Operational and Decommissioning Phases													
Loss of topsoil from site during the construction phase. Although topsoil will be lost from the site during the construction phase, it can potentially be transferred to an alternative area for cultivation or stockpiled and reused in accordance with a site-specific soil management plan, where possible.	4	4	1	3	27	**Low**	• Any available topsoil should first be stripped from the entire surface to be disturbed and stockpiled for re-spreading during rehabilitation. The depth of topsoil stripping will be dependent on the specific field conditions. • It is only in areas where topsoil cannot be retained on the surface during the operational phase, and where the area will be rehabilitated back to veld after decommissioning, that it should be stripped and stockpiled for the duration of the operational phase for re-spreading during de-commissioning. • Topsoil stockpiles must be conserved against losses through erosion by establishing vegetation cover on them. • During rehabilitation, the stockpiled topsoil must be	2	4	1	2	14	**Low**

POTENTIAL ENVIRONMENTAL IMPACT	ENVIRONMENTAL SIGNIFICANCE Before mitigation						MITIGATION AND MANAGEMENT MEASURES	ENVIRONMENTAL SIGNIFICANCE After mitigation					
	M	D	S	P	SP	R		M	D	S	P	SP	R
							evenly spread over the entire disturbed surface. • If there is compaction, either in re-spread topsoil or in areas where topsoil was retained during the operational phase, it must be loosened using appropriate decompaction (ripping) equipment. • If topsoil has been stockpiled for the duration of the operational phase, re-vegetation is likely to require seeding and / or planting. • Erosion must be carefully controlled where necessary on topsoiled areas.						

9.3 Soil compaction

POTENTIAL ENVIRONMENTAL IMPACT	ENVIRONMENTAL SIGNIFICANCE Before mitigation						MITIGATION AND MANAGEMENT MEASURES	ENVIRONMENTAL SIGNIFICANCE After mitigation					
	M	D	S	P	SP	R		M	D	S	P	SP	R
Construction, Construction and Decommissioning Phases													
Soil compaction is likely to occur in some areas of the site during the construction phase. Compaction of a proportion of the site will occur during the operational phase. Although soils could be ripped after decommissioning of the site, the soils will not regain their original structure so this cannot be fully mitigated against. Having said this, the low clay content and sandy nature of the soils found throughout most of the study area is beneficial as sandy soils are less likely to be compacted than soils with a higher clay content.	6	5	1	3	36	**Moderate**	• Soil compaction during construction and decommissioning phases cannot be avoided as heavy machinery will be operational in all areas where disturbance is anticipated. • Contractors (in particular heavy machinery) will be restricted to designated areas as defined by the Environmental Department. • Tracked vehicles will be utilised in soil clearance activities as per soil stripping and handling procedures. • Limit traffic to designated roads.	4	5	1	3	30	**Moderate**

9.4 Change in surface profile

POTENTIAL ENVIRONMENTAL IMPACT	ENVIRONMENTAL SIGNIFICANCE Before mitigation						MITIGATION AND MANAGEMENT MEASURES	ENVIRONMENTAL SIGNIFICANCE After mitigation					
	M	D	S	P	SP	R		M	D	S	P	SP	R
Construction Phase													
In order to create platforms/foundations for development of the proposed infrastructure, the surface profile of the sites will be changed during the construction phase. This will affect water flow, sedimentation and erosion patterns.	6	5	1	3	36	**Moderate**	• No mitigation possible.	6	5	1	3	36	**Moderate**

9.5 Change in land use

POTENTIAL ENVIRONMENTAL IMPACT	ENVIRONMENTAL SIGNIFICANCE Before mitigation						MITIGATION AND MANAGEMENT MEASURE	ENVIRONMENTAL SIGNIFICANCE After mitigation					
	M	D	S	P	SP	R		M	D	S	P	SP	R
Construction and Operational Phase													
The proposed development activities will result in a temporary change of land use during the construction and operational phases. The areas will be rehabilitated during the closure and rehabilitation phase.	6	4	1	5	55	**Moderate**	• Minimise the infrastructure footprint and therefore disturbance to the minimum area necessary by forward planning (clearing land during the dry season rather than wet season) and clear demarcation of the areas to be disturbed. • Avoid permanently impacting topsoil and subsoil, but salvaging the maximum depth of these when clearing areas for infrastructure. • Avoid mixing topsoil (A-horizon) with subsoil (B-horizon) during stripping and storing of soil (where applicable). • Ensuring that the overall thickness of the soils utilised for rehabilitation is consistent with surrounding undisturbed areas and future land use (at least gazing land use).	4	4	1	5	45	**Moderate**

9.6 Change in Land Capability

POTENTIAL ENVIRONMENTAL IMPACT	ENVIRONMENTAL SIGNIFICANCE Before mitigation						MITIGATION AND MANAGEMENT MEASURES	ENVIRONMENTAL SIGNIFICANCE After mitigation					
	M	D	S	P	SP	R		M	D	S	P	SP	R
Construction, Operational Phases													
The proposed development activities will result in a temporary loss of land capability under surface infrastructure during the construction and operational phases. At closure, when the infrastructure is demolished and the area is rehabilitated, there will be a return of land capability in the infrastructure areas.	6	5	1	3	36	**Moderate**	• No mitigation possible.	6	5	1	3	36	**Moderate**

9.7 Soil Contamination

POTENTIAL ENVIRONMENTAL IMPACT	ENVIRONMENTAL SIGNIFICANCE Before mitigation						MITIGATION AND MANAGEMENT MEASURES	ENVIRONMENTAL SIGNIFICANCE After mitigation					
	M	D	S	P	SP	R		M	D	S	P	SP	R
Construction, Operational and Decommissioning Phases													
Soil is likely to be contaminated during the construction and decommissioning phases of the development as large vehicles will be on site, thus on-site pollutants' contact with the soils will need to be limited. There is also a risk of soil contamination during the operational phase, although these will largely be different kinds of pollutants. In all phases soil contamination can and should be prevented, especially as these contaminants will likely quickly enter the surrounding watercourses. The rocky soils on the slopes are very thin, thus it is unlikely that they will be resilient to salt and metal contamination. However, the thinness of the soils would result in the contaminants being rapidly leached from the soil profile, taking cognisance of the fact that there is	4	4	1	3	27	**Low**	• All vehicles and machinery shall be kept in good working order and inspected on a regular basis for possible leaks and shall be repaired as soon as possible if required. • Repairs shall be carried out in a dedicated repair area only, unless in-situ repair is necessary as a result of a breakdown. • Drip trays shall at all times be placed under vehicles that require in-situ repairs. • Drip trays shall be emptied into designated containers only and the contents disposed of at a licenced hazardous material disposal facility. • Ensure proper handling of hazardous chemicals and materials (e.g. fuel, oil, cement, concrete, reagents, emulsion etc.) as per their corresponding Safety Data Sheets (SDS) and the	4	2	1	2	14	**Low**

POTENTIAL ENVIRONMENTAL IMPACT	ENVIRONMENTAL SIGNIFICANCE						MITIGATION AND MANAGEMENT MEASURES	ENVIRONMENTAL SIGNIFICANCE					
	Before mitigation							After mitigation					
	M	D	S	P	SP	R		M	D	S	P	SP	R
limited rainfall to drive the leaching process.							Gamsberg Mine spill response procedures. • Accidental spills (concrete, chemicals, process water, hydrocarbons, ore, waste) need to be reported immediately so that effective remediation and clean-up strategies and procedures can be implemented. • Soil that is contaminated by fuel, chemical or oil spills, for example, from vehicles, or ore spillage at the crusher and coarse ore stockpile area will either be collected to be treated at a pre-determined and dedicated location, or will be cleaned up and treated in situ, using sand, soil or a suitable absorption medium.						

9.8 Residual Impacts

It is not anticipated that any residual impacts will remain in the areas where the proposed additional infrastructure will be constructed as the infrastructure platforms will be lifted at closure and the areas topsoiled and rehabilitated back to the at least grazing land capability and grazing land use.

9.9 Cumulative Impacts

With expected soil degradation occurring, a decline in the overall soil quality and health, may hinder the soil suitability for the end land use.

10.0 COMPLIANCE MONITORING

The mechanisms for compliance monitoring and performance assessment against the environmental management programme and reporting thereof, include:

- Monitoring of impact management actions.
- Monitoring and reporting frequency.
- Responsible persons
- Time period for implementing impact management actions.
- Mechanisms for monitoring compliance.

The potential impacts of the proposed infrastructure project on soil, land use and land capability can be monitored by the following methods (Table 5).

Table 5: Soil, Land Use and Land Capability Monitoring Program

Type	Objective	Detailed Actions	Monitoring Location	Parameters	Timeframe/Frequency	Responsibility
Soil quality	Maintain the soil quality along areas that will be developed for the proposed infrastructure as well as areas adjacent to the fuel and emulsion storage areas.	Collection of at least one sample per hectare for developed areas or where visible signs of contamination are noted (spillage or seepage areas/zones)	All areas that will be developed for infrastructure	■ pH and salinity (EC) ■ Major anions and cations ■ Organic matter content for the topsoil ■ Texture and CEC ■ Content of major plant nutrients (P and K) ■ Heavy metals and hydrocarbons	Annually	Environmental Department
Soil stockpiles (if applicable)	Maintain soil quality and minimise the degradation of soil stockpiles	Collection of at least one composite sample per stockpile	Soil stockpiles	■ pH and Salinity (EC) ■ Major anions and cations ■ Organic matter content for the topsoil	Annually	Environmental Department

Type	Objective	Detailed Actions	Monitoring Location	Parameters	Timeframe/Frequency	Responsibility
				■ Texture and CEC ■ Content of major plant nutrients (P, K, and S) ■ Content of major plant nutrients (P and K) ■ Metal and hydrocarbons; ■ Stockpile height (<2 m).		
Soil erosion	Mitigate and minimise soil erosion	Infrastructure and drainage lines to be maintained in accordance with the surface water management plan	Soil stockpiles Developed areas Ephemeral drainage line	■ Assess soil stockpile heights and conditions (i.e. gullies and rills). ■ Assess the condition and effectiveness of vegetation	Annually, after rainy season	Environmental Department

Type	Objective	Detailed Actions	Monitoring Location	Parameters	Timeframe/Frequency	Responsibility
				on the stockpiles. ■ Include periodic site inspection in environmental performance reporting that inspects the effectiveness of the run-off control system and specifically records occurrence or not of any erosion on site or downstream. ■ Assess the effectiveness of water versus other dust suppression substances		

Type	Objective	Detailed Actions	Monitoring Location	Parameters	Timeframe/Frequency	Responsibility
				(e.g. molasses or bitumen)		
Rehabilitated Areas	Maintain the quality and condition of rehabilitated areas	Continuous monitoring of rehabilitated areas for closure compliance	Disturbed areas	■ pH and Salinity (EC) ■ Major anions and cations ■ Texture and CEC ■ Organic content of topsoil. ■ Content of major plant nutrients (P and K). ■ Contamination assessment (pH, metals, hydrocarbons). ■ Volume and depth of soil replaced.	Annually	Environmental Department

11.0 CONCLUSION

The proposed infrastructure will be developed within the existing Gamsberg Mine MRA, with a short section of the potable water pipeline outside the MRA but within an existing pipeline servitude. The proposed project will therefore not impact on any agricultural land or previously undeveloped areas outside the Gamsberg Mine MRA.

There are no conditions resulting from this assessment that need to be included in the environmental authorisation.

Signature Page

Golder Associates Africa (Pty) Ltd.

Marié Schlechter
Environmental Assessment Practitioner

Mark Aken
Land Use and Closure Consultant

MS/MA/ms

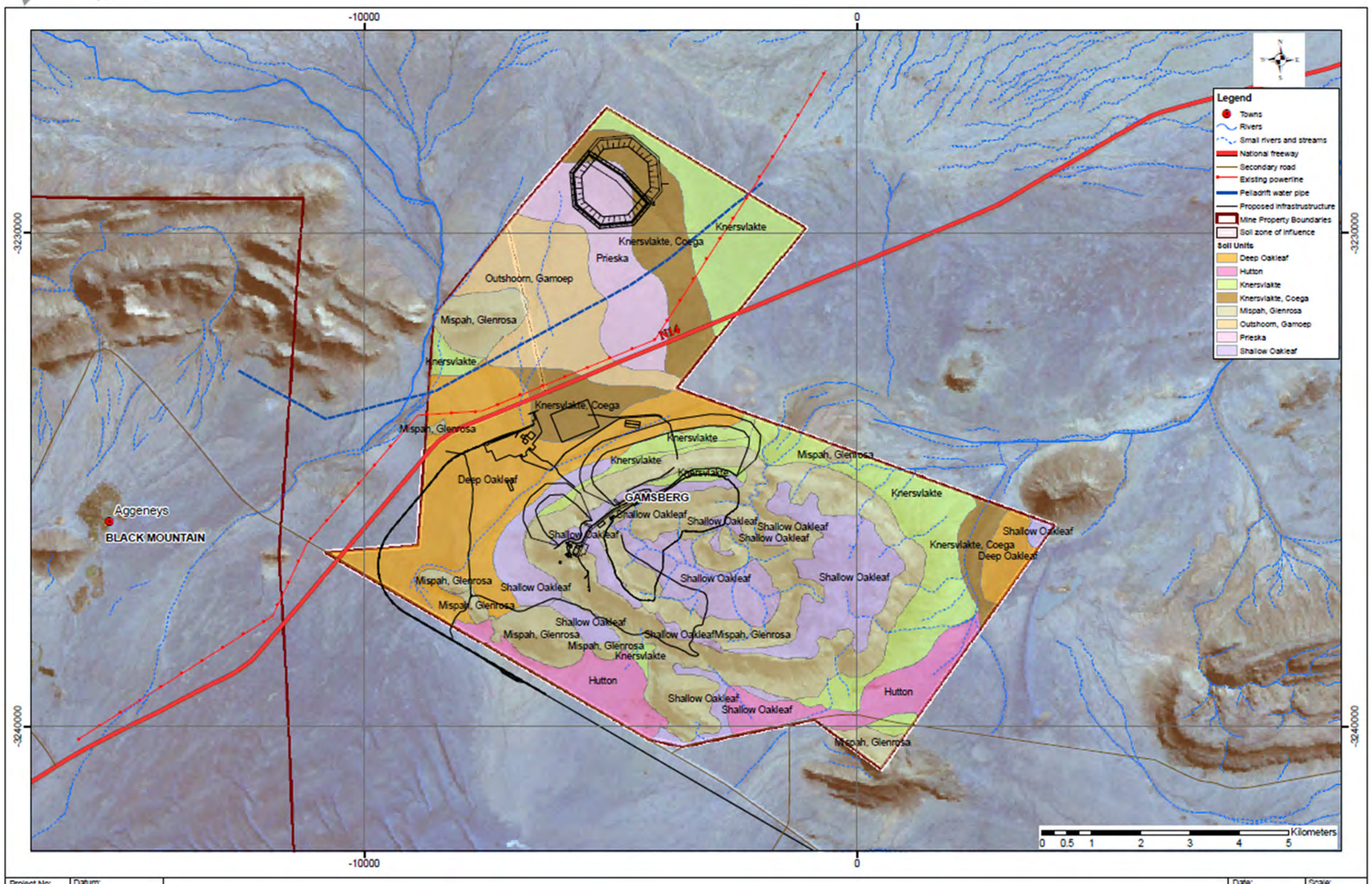
Reg. No. 2002/007104/07

https://golderassociates.sharepoint.com/sites/145886/project files/6 deliverables/final client deliverables/specialist studies/soil assessment/21466019_desktopsoilassessment_final_13apr2022.docx

APPENDIX A

Soils Map (SRK, 2009)

SRK Consulting
Engineers and Scientists



Project No:	Datum:			
396036	HH94	**GAMSBERG**	Date: 26/10/2009	Scale: 1:70,000
	Projection: TM	SOIL TYPE DISTRIBUTION IN THE SOIL ZONE OF INFLUENCE	Compiled by: N.Didiza	Fig No: 5.2
	Central Meridian/Zone: LO19			

Path: J:\Proj\396036_Gamsberg\8GIS\GISPROJ\MXD\WATER\Soil Report_Oct09\27Jan2010\396036_Fig5.3_BroadLandusePattern_In_soilzol_26_102009.mxd

Revision B Date: 26/01/2010

golder.com

DETAILS OF THE SPECIALIST

Table 1: Details of specialist

Specialist Information	
Name:	Dr Mark E. Aken
Phone number:	083 389 3331
Email:	mark.aken@wsp.com
Professional Registration Number	SACNASP (*Pr. Sci. Nat. – 400001/92)*
Curriculum vitae:	Appended

Declaration of Independence by Specialist

I, Mark Ernest Aken, declare that I –

- Act as the independent specialist for the undertaking of a specialist section for the proposed project.
- Do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed;
- Do not have nor will have a 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 information that have or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan, or document.

Mark E. Aken

APPENDIX J

Palaeontology Impact Assessment Report

Gamsberg Zinc Mine and Associated Infrastructure, Northern Cape

Khâi-Ma Local Municipality, Namakwa District Municipality, Northern Cape Province

Farm: Portions 1 Bloemhoek 61, Portion 1 and 4 Gams 60, Aroams 57

Fourie, H. Dr heidicindy@yahoo.com

012 322 7632/079 940 6048

Palaeontological Impact Assessment: Desktop Study

Facilitated by: APelser Archaeological Consulting cc

833B St Bernard Street, Garstfontein, 0081

Tel: 083 459 3091

2022/03/02

Ref: Pending

B. Executive summary

Outline of the development project: APelser Archaeological Consulting cc has facilitated the appointment of Dr H. Fourie, a palaeontologist, to undertake a Palaeontological Impact Assessment (PIA), Phase 1: Field Study of the Gamsberg Zinc Mine and Associated Infrastructure, Northern Cape in the Khâi-Ma Local Municipality, Namakwa District Municipality on Farm: Portions 1 Bloemhoek 61, Portion 1 and 4 Gams 60, Aroams 57.

The applicant, Black Mountain Mining (Pty) Ltd. Gamsberg Mine currently requires further environmental related applications to authorise additional activities that are required for ongoing operations and which were not included in the previous authorisations, and authorise changes required in infrastructure layout as a result of optimised planning..

The Project includes one locality Option (see Figure 1):
Alternative 1: An area indicated with infrastructure in colour with the town of Aggenys to the northwest.

Legal requirements:-

The National Heritage Resources Act (Act No. 25 of 1999) (NHRA) requires that all heritage resources, that is, all places or objects of aesthetic, architectural, historical, scientific, social, spiritual, linguistic or technological value or significance are protected. The Republic of South Africa (RSA) has a remarkably rich fossil record that stretches back in time for some 3.5 billion years and must be protected for its scientific value. Fossil heritage of national and international significance is found within all provinces of the RSA. South Africa's unique and non-renewable palaeontological heritage is protected in terms of the National Heritage Resources Act. According to this act, palaeontological resources may not be excavated, damaged, destroyed or otherwise impacted by any development without prior assessment and without a permit from the relevant heritage resources authority.

The main aim of the assessment process is to document resources in the development area and identify both the negative and positive impacts that the development brings to the receiving environment. The PIA therefore identifies palaeontological resources in the area to be developed and makes recommendations for protection or mitigation of these resources.

"palaeontological" means any fossilised remains or fossil trace of animals or plants which lived in the geological

past, other than fossil fuels or fossiliferous rock intended for industrial use, and any site which contains such fossilised remains or traces.

For this study, resources such as geological maps, scientific literature, institutional fossil collections, satellite images, aerial maps and topographical maps were used. It provides an assessment of the observed or inferred palaeontological heritage within the study area, with recommendations (if any) for further specialist palaeontological input where this is considered necessary.

A Palaeontological Impact Assessment is generally warranted where rock units of LOW to VERY HIGH palaeontological sensitivity are concerned, levels of bedrock exposure within the study area are adequate; large scale projects with high potential heritage impact are planned; and where the distribution and nature of fossil remains in the proposed area is unknown. The specialist will inform whether further monitoring and mitigation are necessary.

Types and ranges of heritage resources as outlined in Section 3 of the National Heritage Resources Act (Act No.25 of 1999):
(i) (i) objects recovered from the soil or waters of South Africa, including archaeological and palaeontological objects and material, meteorites and rare geological specimens.

This report adheres to the guidelines of Section 38 (1) of the National Heritage Resources Act (Act No. 25 of 1999). Subject to the provisions of subsections (7), (8) and (9), any person who intends to undertake a development categorised as (a) the construction of a road, wall, power line, pipeline, canal or other similar form of linear development or barrier exceeding 300 m in length; (b) the construction of a bridge or similar structure exceeding 50 m in length; (c) any development or other activity which will change the character of a site (see Section 38); (d) the re-zoning of a site exceeding 10 000 m² in extent; (e) or any other category of development provided for in regulations by SAHRA or a PHRA authority.

This report aims (1c) to provide comment and recommendations on the potential impacts that the proposed development could have on the fossil heritage of the area and to state if any mitigation or conservation measures are necessary.

Outline of the geology and the palaeontology:

The geology was obtained from map 1:100 000, Geology of the Republic of South Africa (Visser 1984) and the 1:250 000 geological map of Pofadder 2918 (Agenbacht and Praelkelt 2001).

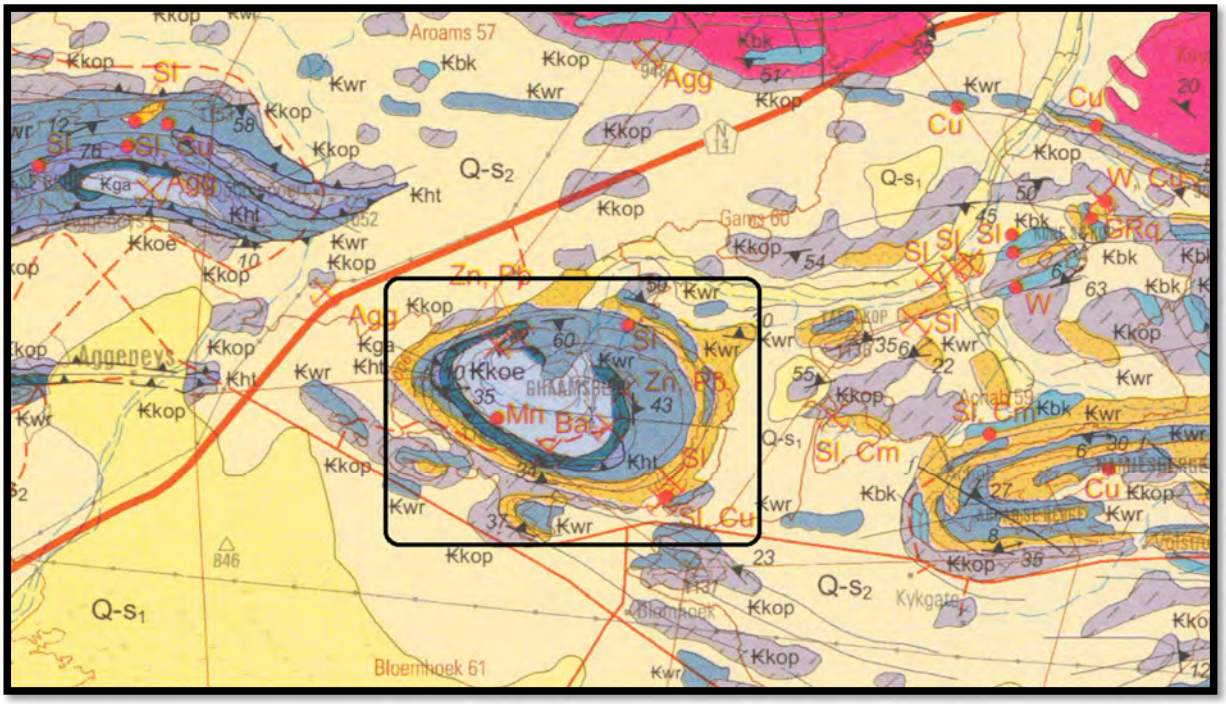


Figure: The geology of the development area.

Legend to Figure and short explanation.

Q-s1 – Red wind-blown sand and dunes (dark yellow). Gordonia Formation, Kalahari Group. Quaternary.

Q-s2 – Sand, scree, rubble, sandy soil (yellow). Unnamed. Quaternary.

Namaqua Metamorphic Province:

Nsm – Yellow-brown to- grey-weathering biotite-hornblende augen gneiss (red). Swartmodder gneiss.

Bushmanland Group:

Kkoe – Brown-weathering psammitic schist, conglomerate, amphibolite and quartzite.

Kga – Sulphide-bearing magnetite-grunerite-garnet-pyroxene rocks, cordierite fels, sillimanite schist and quartzite.

Kht – Rhythmically layered quartzite, quarts-feldspar-biotite gneiss ± sillimanite nodules, quartz-biotite-sillimanite schist.

Kwr – Layered sequence of mainly medium- to thick-bedded, white quartzite and pelitic schist (▒) with interbedded sillimanite bodies. Minor lenticular quartzite, biotite gneiss and massive amphibolite/calc-silicate gneiss.
Kbk – Fine- to medium-grained, massive to finely layered calc-silicate gneiss, amphibolite, biotite gneiss and marble (‡).
Gladkop Metamorphic Suite:
Kkop – Red-brown-weathering, medium- to coarse-grained leucogneiss, in places biotite-rich with abundant augen.
---f--- – (black) Fault.
……. – Undifferentiated linear structure.
□ – Approximate position of expansion (in black on figure).

Mining Activities in study area on Figure above
Zn – Zinc ore.

Summary of findings: The Palaeontological Impact Assessment: Phase 1: Field Study was undertaken in February 2022 in a wet summer with hot conditions (Appendix 6 of Act, 1(d)) during the official Level 1 lockdown of the Covid-19 virus. The following is reported:

The development is taking place over several geological formations.

Over areas totalling fully 40% of Southern Africa the 'hard rocks', from the oldest to the Quaternary, are concealed by normally unconformable deposits – principally sand, gravel, sandstone, and limestone. Inland deposits are much more extensive than marine deposits and are terrestrial and usually unfossiliferous. Some of these deposits date back well into the Tertiary, whereas others are still accumulating. Owing to the all-to-often lack of fossils and of rocks suitable for radiometric or palaeomagnetic dating, no clear-cut dividing line between the Tertiary and Quaternary successions could be established (Kent 1980).

The Kalahari deposits extend in age down to at least the Late and probably the Early Tertiary (65 million years ago). Fossils are scarce, and are of terrestrial plants and animals with close affinity to living forms. Included in the Kalahari Group are the Quaternary alluvium, terrace gravels, surface limestone, silcrete, and aeolian sand. Four major types of sands have been delineated (Kent 1980, Visser 1989). The Kalahari Group is underlain by the Uitenhage and Zululand Groups (McCarthy and Rubidge 2005).

The rocks of the Namaqua Metamorphic Province are mostly gneissic in character. It is present along the Orange River from Prieska in the east to the Atlantic Ocean. The radiometric age vary from 1 350 to 2 000 Ma. The Koperberg Suite is at the top as an intrusive, followed by the Spektakel Suite, Keimoes Suite, Hoogoor Suite, Little Namaqualand Suite, Gladkop Suite, Vioolsdrif Suite, underlain by the metasedimentary and volcanic rocks of the Orange River Group, Okiep Group, Bushmanland Group, Korannaland Sequence and at the bottom, the Marydale and Kaaien Groups (Kent 1980).

The Bushmanland Group comprises the pregranitic succession in Bushmanland. Subgroups present are the Pella (Swartmodder Gneiss), Gaudom, Hom, Aggeneys (Namies Schist and Gams formations) (now Wortel, Witputs, Skelmpoort, T'hammaberg, Hotson, Koeris). Outcrops are mostly present as inselberge with an age of 1 305 – 1 415 Ma (Kent 1980, Visser 1989, Cornell *et al.* 2006).

The Gladkop Metamorphic Suite derives its name from a hill or inselberg consisting of the Steinkopf Gneiss, Brandewynsbank Gneiss near Springbok and intrusive in the Steinkopf Gneiss, and the Noenoemaasberg Gneiss intrusive into the Brandewynsbank Gneiss near Ratelpoort (Kent 1980).

Palaeontology - Fossils in South Africa mainly occur in rocks of sedimentary nature and not in rocks from igneous or metamorphic nature. Therefore, the palaeontological sensitivity can generally be LOW to VERY HIGH, and here in the development LOW and VERY LOW (SG 2.2 SAHRA APMHOB, 2012) (Almond and Pether 2009).

The more recent Phanerozoic deposits (Cenozoic) are of importance in the study of life during the last 300 million years. Large areas in the western part of the Northern Cape Province are underlain by Cenozoic (Tertiary, Quaternary) deposits of the Kalahari Group. The palaeontology of the Kalahari Group in the Northern Cape is poorly studied, but palynomorphs, root casts (rhizomorphs), burrows, rare vertebrate remains (mammals, fish, ostrich egg shell), diatom-rich limestones, freshwater stromatolites, freshwater and terrestrial shells (gastropods, bivalves), ostracods, and charophytes may occur (Almond and Pether 2009).

The Budin Formation may contain numerous calcified root casts, as can be seen at Sishen Ore Mine. Fossils such as numerous ostracods, bivalves, gastropods, as well as diatoms are present in the Lonely Formation (Partridge *et al.* 2006).

Recommendation:
The impact of the proposed additional infrastructure and activities on the fossil heritage is LOW. A Phase 1 Palaeontological Impact Assessment: Field Study was done. A Phase 2: Mitigation is recommended if fossils are found during excavating, drilling, clearing or blasting (according to SAHRA protocol).

Table 2: Criteria used (Fossil Heritage Layer Browser/SAHRA):

Rock Unit	Significance/vulnerability	Recommended Action
Kalahari	Low	Desktop study not required, however protocol for chance finds is
Namaqua Metamorphic	Very Low	No action required
Bushmanland Group	Low	Desktop study not required, however protocol for chance finds is

The Project includes one locality Option (see Figure 1):
Alternative 1: An area indicated with infrastructure in colour with the town of Aggenys to the northwest.

The PIA done by Pether 2013 is relevant.

The mining of the zinc ore will take place in the unfossiliferous Bushmanland Group with a LOW sensitivity.

Concerns/threats to be added to the EMPr (1k,l,m):

1. The overburden and inter-burden must always be surveyed for fossils. Special care must be taken during the clearing, digging, drilling, blasting and excavating of foundations, trenches, channels and footings and removal of overburden not to intrude fossiliferous layers (probably not relevant for this project).
2. Threats are earth moving equipment/machinery (front end loaders, excavators, graders, dozers) during construction, the sealing-in, disturbance, damage or destruction of the fossils by development, vehicle traffic, prospecting, mining, and human disturbance.

The recommendations are (1g):

1. Mitigation is needed if fossils are found, permission needed from SAHRA.
2. No consultation with parties was necessary.

3. The development may go ahead with caution, but the ECO must survey for fossils before or after blasting or excavating in line with the legally binding Environmental Management Programme (EMPr) this must be updated to include the involvement of a palaeontologist/ archaeozoologist when necessary.
4. The EMPr already covers the conservation of heritage and palaeontological material that may be exposed during construction activities. The protocol is to immediately cease all construction activities if a fossil is unearthed, construct a 30 m no-go barrier, and contact SAHRA for further investigation.

Stakeholders: Developer – Black Mountain Mining (Pty) Ltd. Gamsberg Mine
Environmental – APelser Archaeological Consulting cc. 833B St Bernard Street, Garstfontein, 0081, Tel: 083 459 3091.
Landowner – Black Mountain Mining (Pty) Ltd.

C. Table of Contents

D. Background information on the project

Report

This report is part of the environmental impact assessment process under the National Environmental Management Act, as amended (Act No. 107 of 1998) (NEMA) and includes Appendix 6 (GN R38282 of 4 December 2014) of the Environmental Impact Assessment Regulations (see Appendix 1). It is also in compliance with SG 2.2 SAHRA APMHOB Guidelines, 2012. Minimum standards for palaeontological components of Heritage Impact Assessment Reports, Pp 1-15 (2).

Outline of development

This report discusses and aims to provide the developer with information regarding the location of palaeontological material that will be impacted by the development. In the pre-mining phase it may be necessary for the developer to apply for the relevant permit from the South African Heritage Resources Agency depending on the presence or absence of fossils (SAHRA / PHRA).

The applicant, Black Mountain Mining (Pty) Ltd. Gamsberg Mine currently requires further environmental related applications to authorise additional activities that are required for ongoing operations and which were not included in the previous authorisations, and authorise changes required in infrastructure layout as a result of optimised planning.

They currently mine zinc, lead, copper and silver at an opencast mine near Aggeneys. The Gamsberg inselberg is being mined via upperground operations. An estimated 1.5 billion tons of waste rock will be generated during the Life of Mine. The haul trucks transport the waste material to the edge of the inselberg where it is tipped over the edge to form a waste rock dump expected to cover 490 hectares.

Local benefits of the proposed development include benefits to the local economy, job creation and social development for the community.

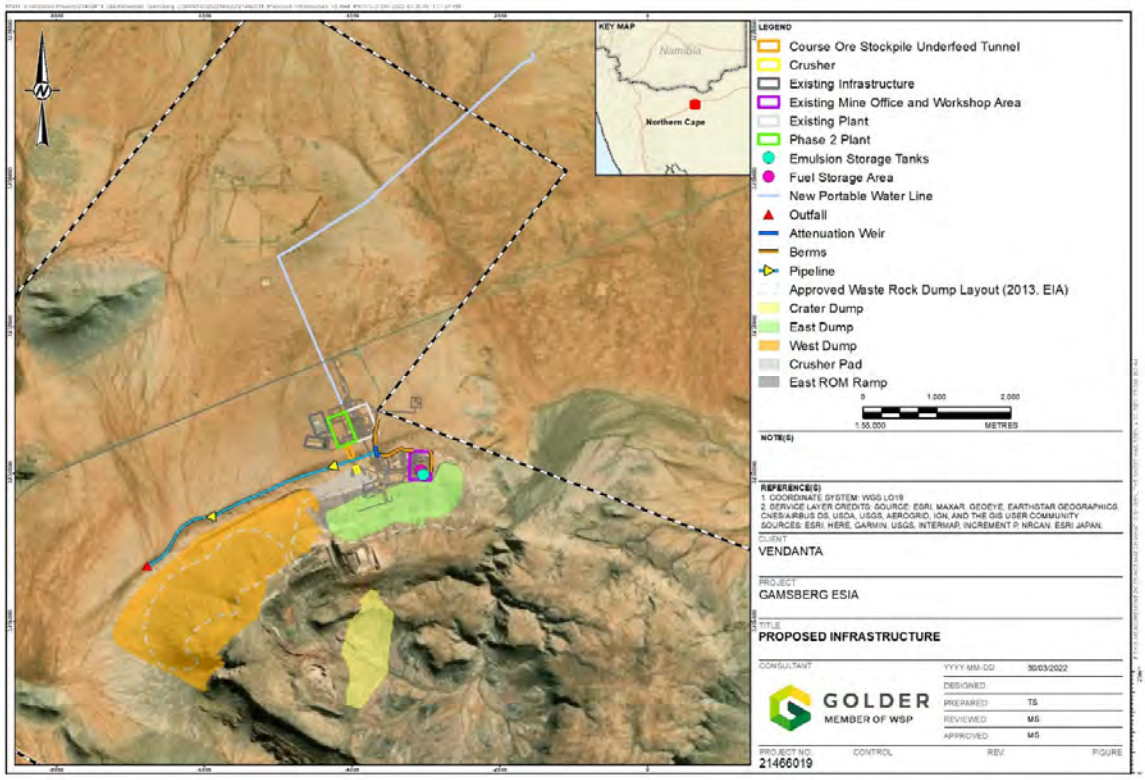


Figure 1: Map showing planned infrastructure (Golder).

The following infrastructure is anticipated (± 746.89 hectares):

1. New potable water pipeline
2. Expansion of dangerous goods storage facilities
3. River diversion
4. Redefined layout for the waste rock dump and quartzite rock dump/berm
5. Defined layout for the crusher and coarse ore stockpile for the 2nd phase of the concentrator plant.

The Project includes one locality Option (see Figure 1):
Alternative 1: An area indicated with infrastructure in colour with the town of Aggenys to the northwest.

Rezoning/ and or subdivision of land: No.
Name of Developer and Consultant: Black Mountain Mining (Pty) Ltd. Gamsberg Mine and APelser Archaeological Consulting cc.

Terms of reference: Dr H. Fourie is a palaeontologist commissioned to do a palaeontological impact assessment to ascertain if any palaeontological sensitive material is present in the development area. This study will advise on the impact on fossil heritage mitigation or conservation necessary, if any.

Short Curriculum vitae (1ai,ii): Dr Fourie obtained a Ph.D from the Bernard Price Institute for Palaeontological Research (now ESI), University of the Witwatersrand. Her undergraduate degree is in Geology and Zoology. She specialises in vertebrate morphology and function concentrating on the Therapsid Therocephalia. For the past 15 years she carried out field work in the Eastern Cape, Limpopo, Mpumalanga, Gauteng, Free State and Kwazulu Natal Provinces. Dr Fourie has been employed at the Ditsong: National Museum of Natural History in Pretoria (formerly Transvaal Museum) for 26 years.

Legislative requirements: South African Heritage Resources Agency (SAHRA) for issue of permits if necessary. National Heritage Resources Act (Act No. 25 of 1
999). An electronic copy of this report must be supplied to SAHRA.

E. Description of property or affected environment

Location and depth:

The Gamsberg Zinc Mine and associated infrastructure is situated in the Khâi-Ma Local Municipality, Namakwa District Municipality, Northern Cape, on portion 1 of farm Bloemhoek 61, portion 1 of farm Gams 60 and remainder of farm Aroams 57.

Depth is determined by the related infrastructure, such as the foundations to be developed and the thickness of the formation. Details of the location and distribution of all significant fossil sites or key fossiliferous rock units are often difficult to determine due to thick topsoil, subsoil, overburden and alluvium. Depth of the overburden may vary a lot. Geological maps do not provide depth or superficial cover it only provides mappable surface outcrops.

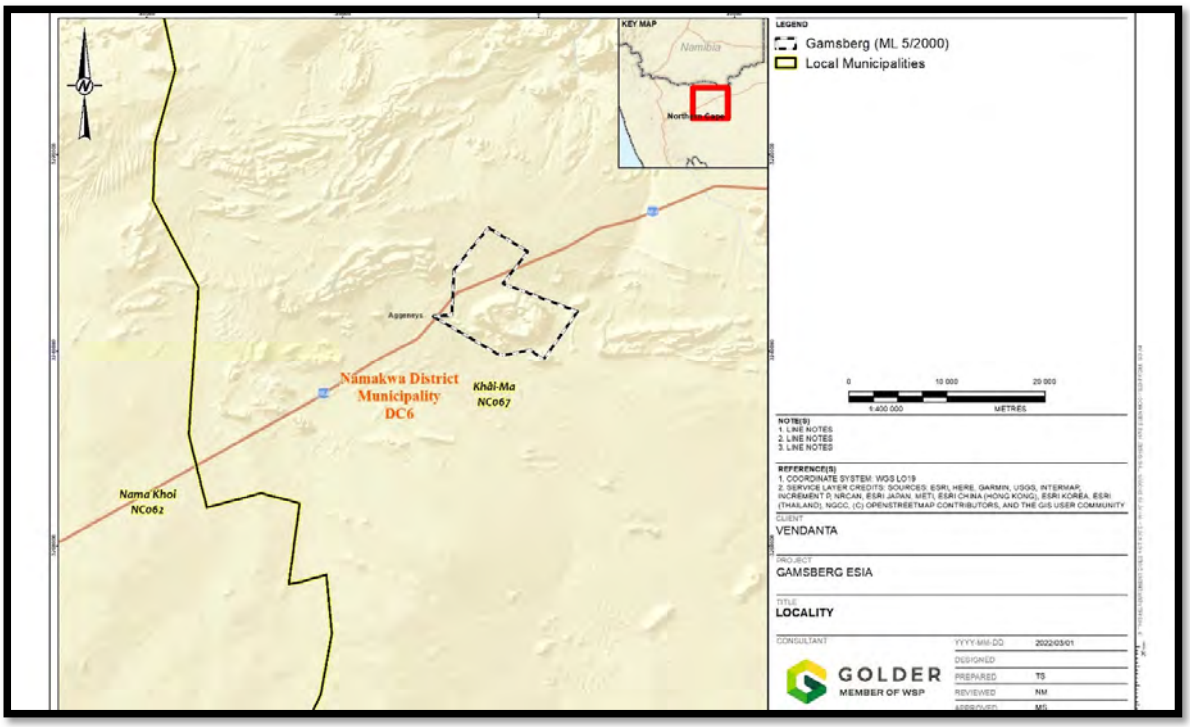


Figure 2: Location map Google Earth (Golder).

F. Description of the Geological Setting

Description of the rock units:

Over areas totalling fully 40% of Southern Africa the 'hard rocks', from the oldest to the Quaternary, are concealed by normally unconformable deposits – principally sand, gravel, sandstone, and limestone. Inland deposits are much more extensive than marine deposits and are terrestrial and usually unfossiliferous. Some of these deposits date back well into the Tertiary, whereas others are still accumulating. Owing to the all-to-often lack of fossils and of rocks suitable for radiometric or palaeomagnetic dating, no clear-cut dividing line between the Tertiary and Quaternary successions could be established (Kent 1980). The alluvium sands were deposited by a river system and reworked by wind action (Snyman 1996). A thick cover of Kalahari reddish sand blankets most outcrops and is dominated by the typical Kalahari thornveld (Norman and Whitfield 2006).

The Kalahari deposits extend in age down to at least the Late and probably the Early Tertiary (65 million years ago). Fossils are scarce, and are of terrestrial plants and animals with close affinity to living forms. Included in the Kalahari Group are the Quaternary alluvium, terrace gravels, surface limestone, silcrete, and aeolian sand. Four major types of sands have been delineated (Kent 1980, Visser 1989). The alluvium sands were deposited by a river system and reworked by wind action (Snyman 1996). A thick cover of Kalahari reddish sand blankets most outcrops and is dominated by the typical Kalahari thornveld (Norman and Whitfield 2006). The Kalahari Group is underlain by the Uitenhage and Zululand Groups (McCarthy and Rubidge 2005).

The Kalahari Group consists of the Wessels Formation at the base, followed by the Budin Formation, the Eden Formation, Mokalanen Formation, Obobogorop Formation and the Gordonia Formation at the top. The Lonely Formation is also present (Partridge *et al.* 2006).

The Gordonia Formation (Qg) is of Late Pliocene / Pleistocene to Recent in age (the well-known "Kalahari Sands"). It can be up to 30 m thick and form part of a vast dune sea or erg that stretches northwards to the equator and beyond (Almond and Pether 2009).

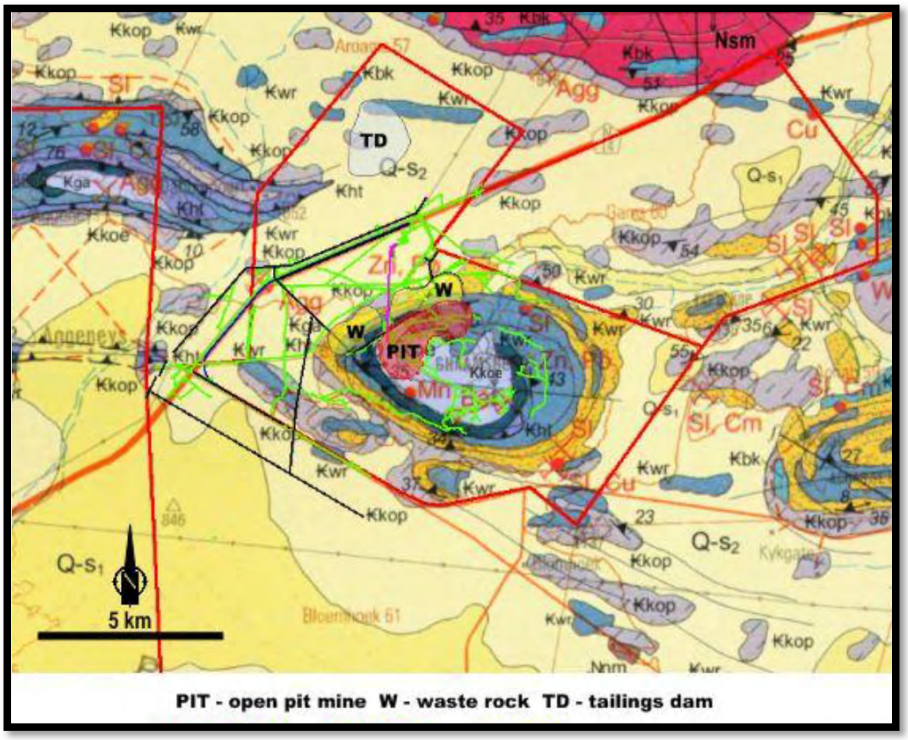


Figure 3: Geology of the area (Agenbacht and Praekelt 2001) (Pether 2013) (1h).
Legend to Figure and short explanation.

Kalahari Group:

Q-s1 – Red wind-blown sand and dunes (dark yellow). Gordonia Formation, Kalahari Group. Quaternary.

Q-s2 – Sand, scree, rubble, sandy soil (yellow). Unnamed. Quaternary.

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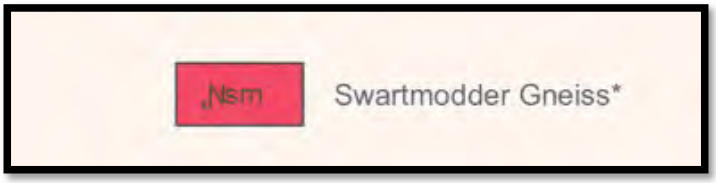

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Kht – Rhythmically layered quartzite, quarts-feldspar-biotite gneiss ± sillimanite nodules, quartz-biotite-sillimanite schist.

Kwr – Layered sequence of mainly medium- to thick-bedded, white quartzite and pelitic schist (▒) with interbedded sillimanite bodies. Minor lenticular quartzite, biotite gneiss and massive amphibolite/calc-silicate gneiss.

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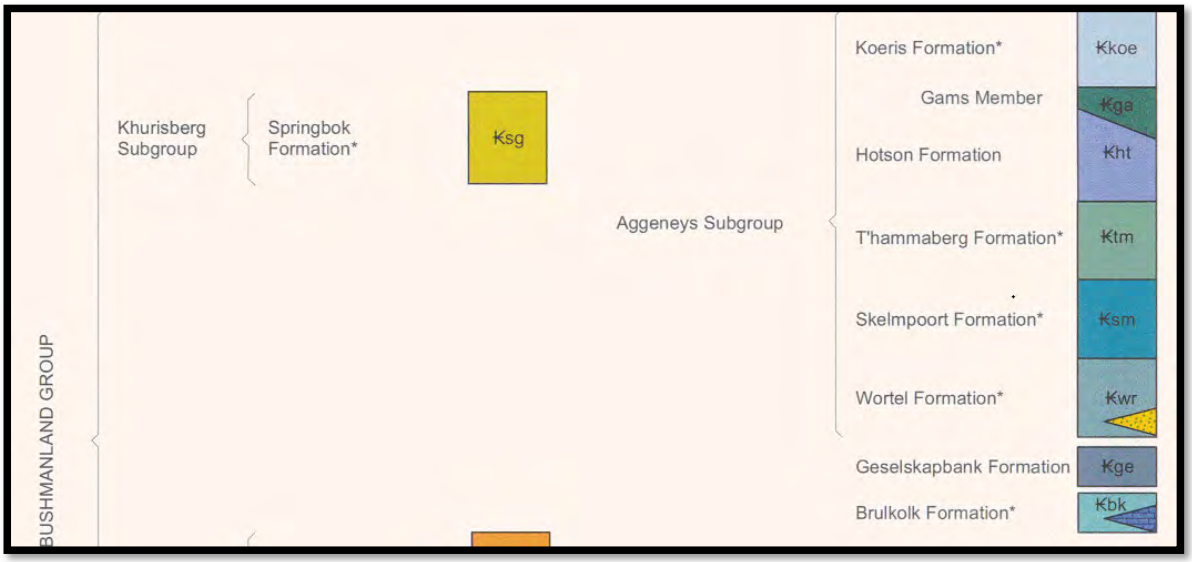

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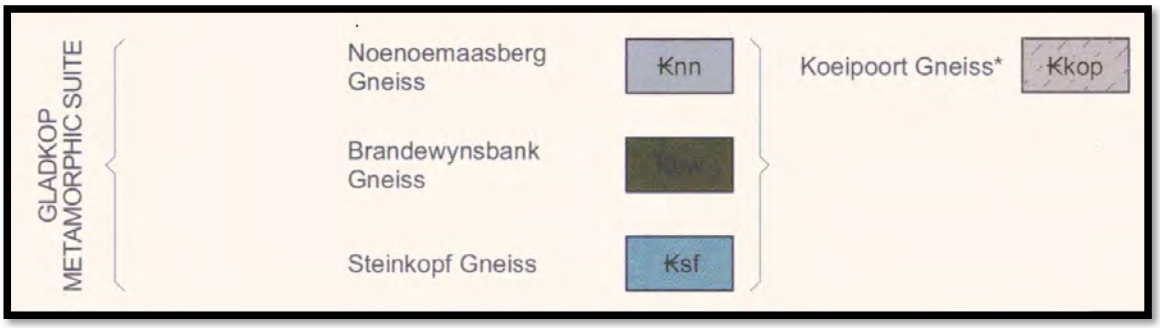
Kkop – Red-brown-weathering, medium- to coarse-grained leucogneiss, in places biotite-rich with abundant augen.



---f--- – (black) Fault.
……. – Undifferentiated linear structure.
□ – Approximate position of mining right (in black on figure).

Mining Activities in study area on Figure above

Agg – Aggregate Ba – Barytes Mn – Manganiferous iron ore Pb – Lead
Sl – Sillimanite Zn - Zinc.

The mining past and present has an influence on this development.

The rocks of the Namaqua Metamorphic Province are mostly gneissic in character. It is present along the Orange River from Prieska in the east to the Atlantic Ocean. The radiometric age varies from 1 350 to 2 000 Ma. The Koperberg Suite is at the top as an intrusive, followed by the Spektakel Suite, Keimoes Suite, Hoogoor Suite, Little Namaqualand Suite, Gladkop Suite, Vioolsdrif Suite, underlain by the metasedimentary and volcanic rocks of the Orange River Group, Okiep Group, Bushmanland Group, Korannaland Sequence and at the bottom, the Marydale and Kaaien Groups (Kent 1980).

The Bushmanland Group comprises the pregranitic succession in Bushmanland. Subgroups present are the Pella (Swartmodder Gneiss), Gaudom, Hom, Aggeneys (Namies Schist and Gams formations) (now Wortel, Witputs, Skelmpoort, T'hammaberg, Hotson, Koeris). Outcrops are mostly present as inselberge with an age of 1 305 – 1 415 Ma (Kent 1980, Visser 1989, Cornell *et al.* 2006).

The Gladkop Metamorphic Suite derives its name from a hill or inselberg consisting of the Steinkopf Gneiss, Brandewynsbank Gneiss near Springbok and intrusive in the Steinkopf Gneiss, and the Noenoemaasberg Gneiss intrusive into the Brandewynsbank Gneiss near Ratelpoort (Kent 1980).

Aggeneys is situated near the N14 National Road with the plains covered by thick Kalahari deposits, including numerous stabilised red sand dunes and thick calcrete. The Gamsberg orebody is low grade, but large (Norman and Whitfield 2006).

Field Observation – Access on this mine is controlled therefore one cannot move around freely to observe the site.

Figure 4: Present waste rock dump area.

Figure 5: Another view of the waste rock dump area – V cut area.

Figure 6: Area to the left of the V-cut area.

Figure 7: View of opencast area.

Figure 8: Another view of the open pit area.

Figure 9: View of middle section of the open pit area.

G. Background to Palaeontology of the area

Summary: When rock units of moderate to very high palaeontological sensitivity are present within the development footprint, a desk top and or field scoping (survey) study by a professional palaeontologist is usually warranted. The main purpose of a field scoping (survey) study would be to identify any areas within the development footprint where specialist palaeontological mitigation during the construction phase may be required (SG 2.2 SAHRA AMPHOB, 2012).

'Algal microfossils' have been reported from shales and are probably of diagenetic origin (Eriksson 1999), these may be present here. Stromatolites are significant indicators of palaeoenvironments and provide evidence of algal growth between 2640 and 2432 million years ago. Significant fossil remains of Cenozoic aged terrestrial organisms have been recorded from the sedimentary rocks of the Kalahari Group. These fossils are rarely found and are allocated a HIGH palaeontological sensitivity as they are important indicators of palaeo-environmental conditions (Groenewald and Groenewald 2014).

The palaeontology of the Kalahari Group in the Northern Cape is poorly studied, but palynomorphs, root casts (rhizomorphs), burrows, rare vertebrate remains (mammals, fish, ostrich eggshell), diatom-rich limestones, freshwater stromatolites, freshwater and terrestrial shells (gastropods, bivalves), ostracods, and charophytes may occur (Almond and Pether 2009). The more recent Phanerozoic deposits (Cenozoic) are of importance in the study of life during the last 300 million years. Large areas in the western part of the Northern Cape Province are underlain by Cenozoic (Tertiary, Quaternary) deposits of the Kalahari Group.

The Gamoep Suite near Platbakkies yielded pollen flora, leaves, wood, frogs, and insects. The teeth and bones of the dinosaur *Kangnasaurus* were found at the farm Kangnas 77 (Pether 2013). The Kao Valley has yielded fossils of *Gomphotherium*, bovids, giraffids, a rhinocerotid, tortoises, rodents, crocodile teeth, and catfish. At Areb, teeth of the extinct horse *Hipparion* were found (Pether 2013) just to mention a few fossil localities in the greater area.

Figure 11: Example of a Stromatolite (Photograph: E. Butler).

Table 1: Taken from Palaeotechnical Report (Almond and Pether 2009) (1cA, 1cB).

18. KALAHARI GROUP **Wessels (Tw), Budin (Tb), Eden (Te), Mokalanen (T-Qm), Obobogorop, Gordonia (Qg) and Lonely Formations**	Fluvial gravels, sands, lacustrine and pan mudrocks, diatomites and diatomaceous limestones, evaporites, consolidated to unconsolidated aeolian sands, pedocretes (especially calcrete) Late Cretaceous to Recent <90 Ma → 0 Ma	Palynomorphs, root casts (rhizomorphs / rhizoliths) and burrows (*eg* termitaria), rare vertebrate remains (mammals, fish, ostrich egg shell *etc*), diatoms, freshwater stromatolites, freshwater and terrestrial shells (gastropods, bivalves), ostracods, charophytes	Fossils mainly associated with ancient pans, lakes and river systems Palaeontology poorly studied. Basal Late Cretaceous gravels and lacustrine clays probably fossiliferous (bones, teeth, petrified wood, palynomorphs?) but v. rarely exposed.
4. NAMAQUA METAMORPHIC PROVINCE **large number of subunits (M*….)**	Igneous and metamorphic rocks (including high grade metasediments) Early to Mid Proterozoic (Mokolian) *c.* 2-1 Ga	NO FOSSILS RECORDED	

Fossils in South Africa mainly occur in rocks of sedimentary nature and not in rocks from igneous or metamorphic nature. Therefore, if there is the presence of Karoo Supergroup strata the palaeontological sensitivity is generally LOW to VERY HIGH.

Table 2: Criteria used (Fossil Heritage Layer Browser/SAHRA):

Rock Unit	Significance/vulnerability	Recommended Action
Kalahari	Low	Desktop study is not required, but protocol for chance find
Namaqua Metamorphic	Very Low	No action required
Bushmanland Group	Low	Desktop study is not required, but protocol for chance find

Databases and collections: Ditsong: National Museum of Natural History.

Impact: LOW for the Kalahari age sediments and for the Bushmanland Group. There are significant fossil resources that may be impacted by the development and if destroyed are no longer available for scientific research or other public good.

The Project includes one locality option (Figure 1) (1f,j) with a LOW palaeontological sensitivity.
Alternative 1: An area indicated with infrastructure in colour with the town of Aggenys to the northwest. The approximate size of the waste rock dump is 250 hectares.

All the land involved in the development was assessed (ni,nii) and none of the property is unsuitable for development (see Recommendation B).

H. Description of the Methodology (1e)

The palaeontological impact assessment: desktop study was undertaken in February 2022. A Phase 1: Field Study will entail a walkthrough of the affected portion with photographs (in 20 mega pixels) taken of the site with a digital camera (Canon PowerShot SX620HS). A Global Positioning System (GPS (Garmin eTrex 10) can be used to record the outcrops. A literature survey is included and the study relied on literature, geological maps, google.maps and google.earth images.

Assumptions and Limitations 1(i):-
The accuracy and reliability of the report may be limited by the following constraints:

1. Most development areas have never been surveyed by a palaeontologist or geophysicist.
2. Variable accuracy of geological maps and associated information.
3. Poor locality information on sheet explanations for geological maps.
4. Lack of published data.
5. Lack of rocky outcrops.
6. Inaccessibility of site.
7. Insufficient data from developer and exact lay-out plan for all structures.

A Phase 1 Palaeontological Impact Assessment: Field Study will include:

1. Recommendations for the future of the site.
2. Background information on the project.
3. Description of the property of affected environment with details of the study area.
4. Description of the geological setting and field observations.
5. Background to palaeontology of the area.
6. Field Rating.
7. Stating of Significance (Heritage Value).

A Phase 2 Palaeontological Impact Assessment: Mitigation will include:

1. Recommendations for the future of the site.
2. Description of work done (including number of people and their responsibilities).
3. A written assessment of the work done, fossils excavated, not removed or collected and observed.
4. Conclusion reached regarding the fossil material.
5. A detailed site plan.
6. Possible declaration as a heritage site or Site Management Plan.

The National Heritage Resources Act No. 25 of 1999 further prescribes:

Act No. 25 of 1999. National Heritage Resources Act, 1999.
National Estate: 3 (2) (f) archaeological and palaeontological sites,
(i)(1) objects recovered from the soil or waters of South Africa, including archaeological and palaeontological objects and material, meteorites and rare geological specimens,
Heritage assessment criteria and grading: (a) Grade 1: Heritage resources with qualities so exceptional that they are of special national significance;
(b) Grade 11: Heritage resources which, although forming part of the national estate, can be considered to have special qualities which make them significant within the context of a province or a region; and (c) Grade 111: Other heritage resources worthy of conservation.
SAHRA is responsible for the identification and management of Grade 1 heritage resources.
Provincial Heritage Resources Authority (PHRA) identifies and manages Grade 11 heritage resources.
Local authorities identify and manage Grade 111 heritage resources.

No person may damage, deface, excavate, alter, remove from its original position, subdivide or change the planning status of a provincially protected place or object without a permit issued by a heritage resources authority or local authority responsible for the provincial protection.
Archaeology, palaeontology and meteorites: Section 35.
(2) Subject to the provisions of subsection (8) (a), all archaeological objects, palaeontological material and meteorites are the property of the State.
(3) Any person who discovers archaeological or palaeontological objects or material or a meteorite in the course of development or agricultural activity must immediately report the find to the responsible heritage resources authority, or to the nearest local authority offices or museum, which must immediately notify such heritage resources authority.

Mitigation involves planning the protection of significant fossil sites, rock units or other palaeontological resources and/or excavation, recording and sampling of fossil heritage that might be lost during development, together with pertinent geological data. The mitigation may take place before and / or during the construction phase of development. The specialist will require a Phase 2 mitigation permit from the relevant Heritage Resources Authority before a Phase 2 may be implemented.

The Mitigation is done in order to rescue representative fossil material from the study area to allow and record the nature of each locality and establish its age before it is destroyed and to make samples accessible for future research. It also interprets the evidence recovered to allow for education of the public and promotion of palaeontological heritage.

Should further fossil material be discovered during the course of the development (*e. g.* during bedrock excavations), this must be safeguarded, where feasible *in situ,* and reported to a palaeontologist or to the Heritage Resources authority. In situations where the area is considered palaeontologically sensitive (*e. g.* Karoo Supergroup Formations, ancient marine deposits in the interior or along the coast) the palaeontologist might need to monitor all newly excavated bedrock. The developer needs to give the palaeontologist sufficient time to assess and document the finds and, if necessary, to rescue a representative sample.

When a Phase 2 palaeontological impact study is recommended, permission for the development to proceed can be given only once the heritage resources authority has received and approved a Phase 2 report and is satisfied that (a) the palaeontological resources under threat have been adequately recorded and sampled, and (b) adequate development on fossil heritage, including, where necessary, *in situ* conservation of heritage of high significance. Careful planning, including early consultation with a palaeontologist and heritage management

authorities, can minimise the impact of palaeontological surveys on development projects by selecting options that cause the least amount of inconvenience and delay.

Three types of permits are available; Mitigation, Destruction and Interpretation. The specialist will apply for the permit at the beginning of the process (SAHRA 2012).

I. Description of significant fossil occurrences

Details of the location and distribution of all significant fossil sites or key fossiliferous rock units are often difficult to determine due to thick topsoil, subsoil, overburden and alluvium. Depth of the overburden may vary a lot.

'Algal microfossils' have been reported from shales and are probably of diagenetic origin (Eriksson 1999), these are present here. Stromatolites are significant indicators of palaeoenvironments and provide evidence of algal growth between 2640 and 2432 million years ago. Significant fossil remains of Cenozoic aged terrestrial organisms have been recorded from the sedimentary rocks of the Kalahari Group. These fossils are rarely found and are allocated a HIGH palaeontological sensitivity as they are important indicators of palaeo-environmental conditions (Groenewald and Groenewald 2014).

The Budin Formation may contain numerous calcified root casts, as can be seen at Sishen Ore Mine. Fossils such as numerous ostracods, bivalves, gastropods, as well as diatoms are present in the Lonely Formation (Partridge *et al.* 2006).

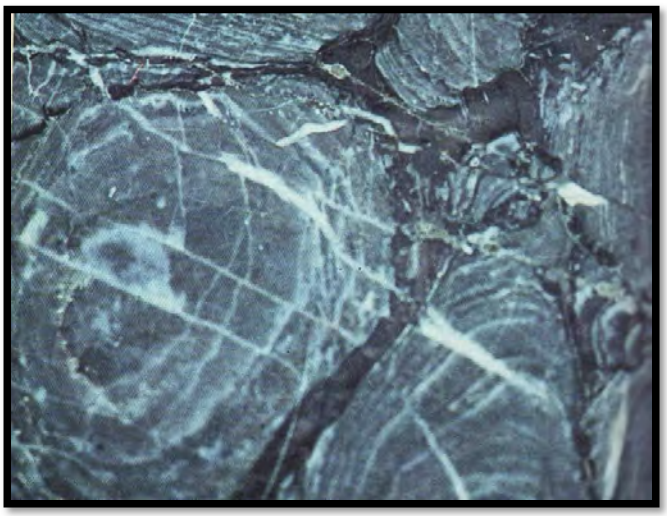


Figure 12: Thin section of a stromatolite (De Zanche and Mietto 1977).

The Quaternary Formation to Holocene may contain fossils. A very wide range of possible fossil remains, though these are often sparse, such as: mammalian bones and teeth, tortoise remains, ostrich eggshells, non-marine mollusc shells, ostracods, diatoms, and other micro fossil groups, trace fossils (e.g. calcretised termitaria, rhizoliths, burrows, vertebrate tracks), freshwater stromatolites, plant material such as peats, foliage, wood, pollens, within calc tufa. Stromatolite structures range from a centimetre to several tens of metres in size (Groenewald and Groenewald 2014).

The threats are:

- Earth moving equipment/machinery (front end loaders, excavators, graders, dozers) during construction,

- The sealing-in or destruction of fossils by development, vehicle traffic, clearing, prospecting, mining, and human disturbance. See Description of the Geological Setting (F) above.

J. Recommendation (1o,p,q)

a. There is no objection (see Recommendation B) to the development, it was necessary to request a Phase 1: Palaeontological Impact Assessment: Field Study and if fossils are found during excavating, clearing, drilling, or blasting a Phase 2: Mitigation will be necessary. The palaeontological sensitivity is LOW, but fossils (stromatolites) may be present.
b. This project may benefit the economy, the growth of the community and social development in general.
c. Preferred choice: Only one locality option is presented and possible.
d. Care must be taken during the grading of roads, digging of foundations and removing topsoil, subsoil and overburden (see Executive Summary) or blasting of bedrock. The following should be conserved: if any palaeontological material is exposed during digging, excavating, drilling or blasting SAHRA must be notified. All construction activities must be stopped, a 30 m no-go barrier constructed and a palaeontologist should be called in to determine proper mitigation measures.
e. No consultation with parties was necessary (1o,p,q).
f. This report must be submitted to SAHRA/PHRA together with the Heritage Impact Assessment (Archaeological).

Sampling and collecting:
Wherefore a permit is needed from the South African Heritage Resources Agency (SAHRA / PHRA).

a. Objections: Cautious. See heritage value and recommendation.
b. Conditions of development: See Recommendation.
c. Areas that may need a permit: Yes.
d. Permits for mitigation: Needed from SAHRA/PHRA if fossils are found.

K. Conclusions

a. All the land involved in the development was assessed and none of the property is unsuitable for development (see Recommendation B).
b. All information needed for the Palaeontological Impact Assessment Study was provided by the Consultant. All technical information was provided by APelser Archaeological Consulting cc.
c. Areas that would involve mitigation and may need a permit from the South African Heritage Resources Agency are discussed.
d. The following should be conserved: if any palaeontological material is exposed during digging, excavating, drilling or blasting, SAHRA must be notified. All development activities must be stopped, a 30 m no-go barrier constructed, and a palaeontologist should be called in to determine proper mitigation measures, for example, shallow caves.
e. Condition in which development may proceed: It is further suggested that a Section 37(2) agreement of the Occupational, Health and Safety Act 85 of 1993 is signed with the relevant contractors to protect the environment (fossils) and adjacent areas as well as for safety and security reasons.

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Acknowledgement: To staff of the mine that assisted with the signing in (Pieter Venter) and for driving us (Neil) and showing us the different aspects of the development a huge thank you.

Declaration (Disclaimer) (1b)

I, Heidi Fourie, declare that I am an independent consultant and have no business, financial, personal or other interest in the proposed development project for which I was appointed to do a palaeontological assessment. There are no circumstances that compromise the objectivity of me performing such work.

I accept no liability, and the client, by receiving this document, indemnifies me against all actions, claims, demands, losses, liabilities, costs, damages and expenses arising from or in connection with services rendered, directly or indirectly by the use of the information contained in this document.

It may be possible that the Desktop Study may have missed palaeontological resources in the project area as the presence of outcrops are not known or visible due to vegetation while others may lie below the overburden of earth and may only be found once development commences.

This report may not be altered in any way and any parts drawn from this report must make reference to this report.

POPI Act 2013 Statement

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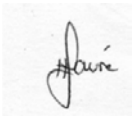

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Heidi Fourie
2022/03/02

Appendix 1: Mammal fossils that may be present (MacRae 1999).

Silhouette representation of the larger vertebrates whose remains are represented in Members 1-3 of the Swartkrans site on the outskirts of the town of Krugersdorp. Numbers after each taxon comprise minimum numbers of individuals represented in the remains of the lower bank (Member 1), hanging remnant (Member 1), Member 2 and Member 3 respectively.
Courtesy of Dr C.K. Brain,
Museum of Natural History, Pretoria

FAUNA FROM MEMBERS 1 - 3, SWARTKRANS (Makapanian Mammal Age)
Courtesy Dr B. Brain, - Museum of Natural History, Pretoria

1: *Homo erectus* (man) 1,3,2,0. **2**: *Australopithecus robustus* (robust apeman) 13,87,17,9. **3**: *Parapapio jonesi* 0,8,0,0. **4**: *Cercopithecoides* sp. 1,0,0,0. **5**: *Papio hamadryas robinsoni* 6,38,8,11. **6**: *Theropithecus oswaldi danieli* 1,17,1,14. **7**: *Dinopithecus ingens* 1,26,0,0. **8**: *Panthera pardus* (leopard) 4,12,2,5. **9**: *Dinofelis* sp. (false sabre-toothed cat) 0,1,0,0. **10**: *Megantereon* sp. (dirk-toothed cat) 0,1,0,1. **11**: *Acinonyx jubatus* (cheetah) 0,1,0,1. **12**: *Felis caracal* (caracal) 1,0,0,0. **13**: *Felis lybica* (African wild cat) 0,0,0,1. **14**: *Felis serval* (serval) 1,0,0,0. **15**: *Panthera leo* (lion) 1,1,0,0. **16**: *Hyaena brunnea* (brown hyaena) 1,4,2,3. **17**: *Chasmaporthetes nitidula* (hunting hyaena) 2,8,1,2. **18**:*Crocuta crocuta* (spotted hyaena) 0,2,1,1. **19**: *Proteles* sp. (large fossil aardwolf) 1,1,0,1. **20**: *Vulpes* sp. (fox) 0,2,0,3. **21**: *Canis mesomelas* (black-backed jackal) 3,4,4,5. **22**: Large canid gen. and sp. indet. 0,0,1,1. **23**: *Aonyx capensis* (Cape clawless otter) 2,0,1,2. **24**: *Atilax* sp. (water mongoose) 0,0,1,1. **25**: *Cynictis penicillata* (yellow mongoose) 0,0,1,1. **26**: *Herpestes ichneumon* (large grey mongoose) 1,0,0,0. **27**: *Suricata suricatta* (suricate) 0,0,2,1. **28**: *Genetta tigrina* (large-spotted genet) 0,0,0,1. **29**: *Manis* sp. (pangolin) 0,0,0,1. **30**: *Orycteropus afer* (antbear) 1,0,1,1. **31**: cf. *Elphas* sp. 2,0,0,1. **32**: *Procavia transvaalensis* (large fossil dassie) 3,8,3,5. **33**: *Procavia antiqua* (fossil dassie) 17,16,10,11. **34**: *Hipparion lybicum steytleri* (three-toed horse) 1,1,1,1. **35**: *Equus capensis* (giant Cape horse) 2,6,3,5. **36**: *Equus burchelli* (Burchell's zebra) 0,0,0,1. **37**: *Phacochoerus* sp. (warthog) 1,0,3,1. **38**: cf. *Tapinochoerus meadowsi* (large fossil pig) 1,7,1,1. **39**: *Hippopotamus* sp. (hippopotamus) 1,0,0,1. **40**: Giraffid 0,1,1,1. **41**: *Megalotragus* sp. (giant hartebeest) 0,3,1,3. **42**: *Connochaetes* sp. (wildebeest) 7,19,7,7. **43**: Medium alcelaphine: *Alcelaphus* sp. or *Beatragus* sp. (hartebeest) 3,22,3,6. **44**: *Rabaticerus porrocornutus* 0,2,0,0. **45**: *Damaliscus* sp. (blesbok) 2,4,6,6. **46**: *Antidorcas marsupialis australis* (springbok) 11,0,10,18. **47**: *Antidorcas recki* 0,6,2,1. **48**: cf. *Gazella* sp. (gazelle) 5,6,5,14. **49**: *Oreotragus oreotragus* (klipspringer) 1,0,0,1. **50**: *Oreotragus major* (fossil klipspringer) 0,1,0,0. **51**: *Raphicerus campestris* (steenbok) 1,0,1,3. **52**: *Makapania* sp. (musk ox) 0,3,0,0. **53**: *Syncerus* sp. (buffalo) 2,3,2,3. **54**: *Taurotragus oryx* (eland) 0,0,1,1. **55**: *Tragelaphus strepsiceros* (kudu) 0,4,0,1. **56**: *Hippotragus* cf. *niger* (sable) 0,0,1,3. **57**: *Pelea* sp. (rhebck) 0,2,0,2. **58**: *Redunca arundinum* (reedbuck) 0,1,0,0. **59**: Lagomorph gen. and sp. indet. (hare) 9,0,4,7. **60**: *Pedetes* sp. (springhare) 1,0,1,1. **61**: *Hystrix africaeaustralis* (porcupine) 2,2,1,2. **62**: *Chelonia* indet. (tortoise) 1,0,2,2.

Left: Teeth of the white rhino *Ceratotherium simum* from Makapansgat. **Right**: View from above shows the sharp cutting edges of the tooth row of this predominant grazer. Specimen 170 mm long.
In the collection of the Bernard Price Institute for Palaeontological Research, University of the Witwatersrand, Johannesburg.
Photograph C.S. MacRae

Appendix 2: Table 3: Listing points in Appendix 6 of the Act and position in Report (in bold).

Section in Report	Point in Act	Requirement
B	1(c)	Scope and purpose of report
B	1(d)	Duration, date and season
B	1(g)	Areas to be avoided
D	1(ai)	Specialist who prepared report
D	1(aii)	Expertise of the specialist
F Figure 3	1(h)	Map
F	1(ni)	Authorisation

F	1(nii)	Avoidance, management, mitigation and closure plan
G Table 1	1(cA)	Quality and age of base data
G Table 2	1(cB)	Existing and cumulative impacts
G	1(f)	Details or activities of assessment
G	1(j)	Description of findings
H	1(e)	Description of methodology
H	1(i)	Assumptions
J	1(o)	Consultation
J	1(p)	Copies of comments during consultation
J	1(q)	Information requested by authority
Declaration	1(b)	Independent declaration
Appendix 2	1(k)	Mitigation included in EMPr
Appendix 2	1(l)	Conditions included in EMPr
Appendix 2	1(m)	Monitoring included in EMPr
D	2	Protocol or minimum standard

Appendix 3: Management Plan and Protocol for Chance Finds (1k,l,m).

This section covers the recommended protocol for a Phase 2 Mitigation process as well as for reports where the Palaeontological Sensitivity is LOW; this process guides the palaeontologist / palaeobotanist on site and should not be attempted by the layman / developer. As part of the Environmental Authorisation conditions, an Environmental Control Officer (ECO) will be appointed to oversee the construction activities in line with the legally binding Environmental Management Programme (EMPr) so that when a fossil is unearthed they can notify the relevant department and specialist to further investigate. Therefore, the EMPr must be updated to include the involvement of a palaeontologist during the digging and excavation (ground breaking) phase of the development.

The EMPr already covers the conservation of heritage and palaeontological material that may be exposed during construction activities.

- When a fossil is found the area must be fenced-off with a 30 m barrier and the construction workers must be informed that this is a no-go area.
- If fossils have already been found they must be kept in a safe place for further inspection.
- The ECO should familiarise him- or herself with the formations and its fossils. A site visit after blasting, drilling, clearing or excavating is recommended and the keeping of a photographic record when feasible.
- Most museums and universities have good examples of fossils.
- The developer must survey the areas affected by the development and indicate on plan where the construction / development / mining will take place. Trenches have to be dug to ascertain how deep the sediments are above the bedrock (can be a few hundred metres). This will give an indication of the depth of the topsoil, subsoil, and overburden, if need be trenches should be dug deeper to expose the interburden.

Mitigation will involve recording, rescue and judicious sampling of the fossil material present in the layers sandwiched between the geological / coal layers. It must include information on number of taxa, fossil abundance, preservational style, and taphonomy. This can only be done during mining or excavations. In order for this to happen, in case of coal mining operations, the process will have to be closely scrutinised by a professional palaeontologist / palaeobotanist to ensure that only the coal layers are mined and the interlayers (siltstone and mudstone) are surveyed for fossils or representative sampling of fossils are taking place.

The palaeontological impact assessment process presents an opportunity for identification, access and possibly salvage of fossils and add to the few good plant localities. Mitigation can provide valuable onsite research that can benefit both the community and the palaeontological fraternity.

A Phase 2 study is very often the last opportunity we will ever have to record the fossil heritage within the development area. Fossils excavated will be stored at a National Repository.

A Phase 2 Palaeontological Impact Assessment: Mitigation will include (SAHRA) -

1. Recommendations for the future of the site.
2. Description and purpose of work done (including number of people and their responsibilities).
3. A written assessment of the work done, fossils excavated, not removed or collected and observed.
4. Conclusion reached regarding the fossil material.
5. A detailed site plan and map.
6. Possible declaration as a heritage site or Site Management Plan.
7. Stakeholders.
8. Detailed report including the Desktop and Phase 1 study information.
9. Annual interim or progress Phase 2 permit reports as well as the final report.
10. Methodology used.

Three types of permits are available; Mitigation, Destruction and Interpretation. The specialist will apply for the permit at the beginning of the process (SAHRA 2012).

The Palaeontological Society of South Africa (PSSA) does not have guidelines on excavating or collecting, but the following is suggested:

1. The developer needs to clearly stake or peg-out (survey) the areas affected by the mining/ construction/ development operations and dig representative trenches and if possible supply geological borehole data.
2. When clearing topsoil, subsoil or overburden and hard rock (outcrop) is found, the contractor needs to stop all work.
3. A Palaeobotanist / palaeontologist (contact SAHRIS for list) must then inspect the affected areas and trenches for fossiliferous outcrops / layers. The contractor / developer may be asked to move structures, and put the development on hold.
4. If the palaeontologist / palaeobotanist is satisfied that no fossils will be destroyed or have removed the fossils, development and removing of the topsoil can continue.
5. After this process the same palaeontologist / palaeobotanist will have to inspect and offer advice through the Phase 2 Mitigation Process. Bedrock excavations for footings may expose, damage or destroy previously buried fossil material and must be inspected.
6. When permission for the development is granted, the next layer can be removed, if this is part of a fossiliferous layer, then with the removal of each layer of sediment, the palaeontologist / palaeobotanist must do an investigation (a minimum of once a week).
7. At this stage the palaeontologist / palaeobotanist in consultation with the developer / mining company must ensure that a further working protocol and schedule is in place. Onsite training should take place, followed by an annual visit by the palaeontologist / palaeobotanist.

Fossil excavation, if necessary, during Phase 2:

1. Photography of fossil / fossil layer and surrounding strata.
2. Once a fossil has been identified as such, the task of extraction begins.

3. It usually entails the taking of a GPS reading and recording lithostratigraphic, biostratigraphic, date, collector and locality information.
4. Use Paraloid (B-72) as an adhesive and protective glue, parts of the fossil can be kept together (not necessarily applicable to plant fossils).
5. Slowly chipping away of matrix surrounding the fossil using a geological pick, brushes and chisels.
6. Once the full extent of the fossil / fossils is visible, it can be covered with a plaster jacket (not necessarily applicable to plant fossils).
7. Chipping away sides to loosen underside.
8. Splitting of the rock containing palaeobotanical material should reveal any fossils sandwiched between the layers.

SAHRA Documents:
Guidelines to Palaeontological Permitting Policy.
Minimum Standards: Palaeontological Component of Heritage Impact Assessment reports.
Guidelines for Field Reports.
Palaeotechnical Reports for all the Provinces.

Appendix 4: Impact Statement

The development footprint is situated on a geological layer with a low palaeontological sensitivity. The nature of the impact is the destruction of Fossil Heritage. Loss of fossil heritage will have a negative impact. The extent of the impact only extends in the region of the development activity footprint and may include transport routes. The expected duration of the impact is assessed as potentially permanent. The intensity/magnitude of the impact is moderate as it may continue in a modified way. The probability of the impact occurring is improbable with a low likelihood.

Mitigation procedures (should fossil material be present within the affected area) will not be necessary. The loss of resources occurs but natural cultural and social processes continue, albeit in a modified manner. The cumulative impact is low. Impacts on palaeontological heritage during the construction and preconstruction phase will potentially not occur. The significance of the impact occurring will be S= (2+5+8)2

S = 30 Moderate (30-60).