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Alexander Coal Project

Alexander Coal Project
Preliminary Geochemical Assessment

SLR Project No.: 750.01080.00006

Report No.: 01

Revision No.: 01

July 2016

Anglo American Inyosi Coal (Pty) Limited

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EXECUTIVE SUMMARY

A preliminary geochemical assessment has been undertaken for the Alexander Coal Project to determine the potential impacts of the mining on the environment. The work will support the Environmental Impact Assessment (EIA) for the mining right application.

The project will involve the development of surface and underground facilities comprising an underground mine, a waste rock dump, topsoil stockpiles, mine related facilities and various support infrastructure and services.

The coal resource forms part of the Highveld coalfield, which consists of five recognised seams, namely No.1 to No.5 from the base upwards. The resource covers an area of approximately 7,300ha, near Kriel in the Mpumalanga Province.

Although the No. 2, 3, 4 and 5 coal seams are all developed within the proposed Project area, only the No. 4 seam is considered within this mining right application. The seams are interbedded with various successions of sandstone with subordinate siltstones, grit and mudstones of the Vryheid Formation. The project area has been extensively intruded by pre-Karoo dolerites in the form of sills and dykes. The intrusions have compartmentalised the coal seams and have caused de-volatilisation of the coal beds in places.

All run-of-mine (ROM) production will be transported via an overland conveyor to the nearby Elders Mine and then to the Goedehoop beneficiation plant.

Site-specific samples were unavailable for geochemical characterisation, therefore the assessment undertaken has involved review of published studies and specialist reports that provide insight into future mine water quality. Due to this limitation, the geochemical assessment is considered to be a 'preliminary' assessment.

Based on data from the neighbouring Elders mine, the only sulphide mineral present in significant quantities within both No.4 Coal Seam and roof material is pyrite. Calcite (dominant neutralising mineral), dolomite and siderite are the key carbonate minerals.

The main sources of potential contamination from the mine will be:

- Excavation of soft and hard overburden around the incline shaft portal.
- Placement of excavated overburden/waste rock into the waste rock dump for use in later rehabilitation.
- Dewatering and exposure.

As the chemical composition of the mine water is of interest to the project, since it may lead to a deterioration of water quality resources near the project area, estimates of the following mine water qualities have been determined:

- Seepage from the waste rock dump (contact water quality).
- Accumulated water in the underground workings, especially after mining ceases (mine water quality).

Water quality associated with the excavation of overburden at the shaft portal is not estimated because the exposed rock faces are unlikely to generate environmentally significant volumes of seepage, and the seepage is expected to be managed as part of the mine dirty water system.

Based on relevant studies from other mines, No. 4 Seam coal and roof rocks at Alexander may show the following acid drainage potential characteristics:

- Sulphur content may average 0.55 %. This correlates with pyrite content, which in No.4 Seam roof rocks can vary considerably from place to place.
- The NP of the No.4 Seam coal can vary considerably and is influenced significantly by fractures filled with the mineral calcite, a source of NP.
- Based on ABA data from other mine sites, there may be sufficient neutralising potential available in the Alexander roof and coal material to prevent the generation of significant amounts of acidity in mine water. However, sufficient site specific samples will need to be collected and analysed to confirm this.

Based on relevant studies from other mines, the Alexander contact water may show the following characteristics:

- pH may be neutral to slightly alkaline.
- Na may be the highest concentration metal in the contact water in both coal and roof materials.
- Ca, Mg, K may be the second highest concentrations of metals.
- Fe, Si, Mn, Al, Zn, Co and Ni may be present in trace concentrations.

Based on monitoring from Brandspruit Colliery (which also mines the No. 4 Seam), Alexander mine water during the operational phase may show the following characteristics:

- Approximately neutral pH.
- Total dissolved solids (TDS) of 3,000 to 4,000 mg/L due to concentrations of Na, Ca, and SO_4.
- Metals of environmental concern, including Fe, Cu, Al, Zn, and Mn present at concentrations in the range 0.1 mg/L to <10 mg/L.

Based on geochemical modelling, mine water in unflooded workings after closure may show the following characteristics:

- pH of the order of 5.5.
- Total dissolved solids (TDS) of the order of 4,500 to 6,500 mg/L due to concentrations of Na, Ca, and SO_4.

Mine water in flooded workings after closure may show the following characteristics:

- Approximately neutral pH.
- Total dissolved solids (TDS) of the order of 1,500 to 2,000 mg/L due to concentrations of Na, Ca, and SO_4.

The above conclusions are indicative and based on geochemical data and modelling from other coal mine sites in the region. The lack of site-specific geochemical information for Alexander should, in future, be addressed when site specific samples are available for sampling and analysis.

Provided that the waste facility design and impact mitigation measures, as determined by the waste design and water specialists, are implemented there is no reason not to proceed with the project. However, on site sampling and analysis in accordance with NEM:WA should be undertaken as a follow on step from this desktop study.

Assessment of Waste and Containment Barrier Design

The Department of Environmental Affairs (DEA) has revised the South African waste classification and assessment system under the National Environmental Management: Waste Act, 2008 (Act 59 of 2008) (NEM:WA). The Waste Classification and Management Regulations (WCMR) (GN R. 634 of 2013) were published in August 2013 and set out the requirements for the Classification of waste and the assessment of waste for disposal. The WCMR references the following Norms and Standards with regards to waste assessment:

- National Norms and Standards for the assessment of waste for landfill disposal (GN R.635 of 2013); and
- National Norms and Standards for disposal of waste to landfill (GN R. 636 of 2013).

Site specific geochemical information of overburden is unavailable for an assessment, in terms of GN R. 635 and GN R.636, to be undertaken.

It is unlikely that overburden will be a Type 4 waste, as it is unlikely for both leachable concentrations and total concentrations of all elements to be below the relevant threshold limits (LCT0 and TCT0). It is also unlikely that overburden will be a Type 0 waste, as it is unlikely that leachable concentrations will be above the LCT3 or total concentrations will be above the TCT2.

It is likely that overburden from the Alexander Coal Project will be either a Type 3, Type 2 or Type 1 waste, and based on the risk based approach, it is likely that the waste will require disposal to facility with a Class D, C, B or A containment barrier design, however site specific sampling and assessment is required to verify these assumptions.

ALEXANDER COAL PROJECT

PRELIMINARY GEOCHEMICAL ASSESSMENT

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ACRONYMS AND ABBREVIATIONS

Below a list of acronyms and abbreviations used in this report.

Acronyms / Abbreviations	**Definition**
AAIC	Anglo American Inyosi Coal (Pty) Ltd
ABA	Acid Base Accounting
AMD	Acid Mine Drainage
AP	Acid Potential
BPG	Best Practice Guidelines for Water Resources Protection in the South African Mining Industry
NAG	Net Acid Generation
NEMA	National Environmental Management Act
NNP	Net Neutralising Potential
NP	Neutralising Potential
NPR	Neutralising Potential Ratio
PAG	Potentially Acid Generating
PHREEQC	PH, Redox, Equilibrium Code. A geochemical modelling code
ROM	Run of Mine
SLR	SLR Consulting (Africa) (Pty) Limited
SPLP	Synthetic Precipitation Leaching Procedure
XRD	X-ray Diffraction

SLR Consulting (Africa) (Pty) Limited

NATIONAL ENVIRONMENTAL MANAGEMENT ACT (NEMA) REGULATIONS (2014) APPENDIX 6: SPECIALIST REPORTING REQUIREMENTS CHECKLIST

Below is a checklist showing information required by specialists in terms of Appendix 6 of NEMA

Item	NEMA Regulations (2014): Appendix 6	Relevant Section in Report
1(a)(i)	Details of the specialist who prepared the report	Section 6 Appendix A
1(a)(ii)	The expertise of that person to compile a specialist report including a curriculum vitae	Appendix A
1(b	A declaration that the person is independent in a form as may be specified by the competent authority	Section 6
1(c)	An indication of the scope of, and the purpose for which, the report was prepared	Section 1.2
1(d)	The date and season of the site investigation and the relevance of the season to the outcome of the assessment	N/A
1(e)	A description of the methodology adopted in preparing the report or carrying out the specialised process	Section 1
1(f)	The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure	N/A
1(g)	An identification of any areas to be avoided, including buffers	N/A
1(h)	A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Figure 2-1 (Page 5)
1(i)	A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 2.5.6
1(j)	A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment	Section 2, 3 and 4
1(k)	Any mitigation measures for inclusion in the EMPr	Section 6
1(l)	Any conditions for inclusion in the environmental authorisation	Section 6
1(m)	Any monitoring requirements for inclusion in the EMPr or environmental authorisation	N/A
1(n)(i)	A reasoned opinion as to whether the proposed activity or portions thereof should be authorised and	Section 6
1(n)(ii)	If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan	Section 6
1(o)	A description of any consultation process that was undertaken during the course of carrying out the study	N/A
1(p)	A summary and copies if any comments that were received during any consultation process	N/A
1(q)	Any other information requested by the competent authority.	N/A

ALEXANDER COAL PROJECT

PRELIMINARY GEOCHEMICAL ASSESSMENT

1 INTRODUCTION

Anglo American Inyosi Coal (Pty) Ltd ("AAIC") is proposing to establish a new underground coal mine through the Alexander Coal Project ("the Project Area"), located near Kriel in the Mpumalanga Province. SLR Consulting (Africa) (Pty) Limited ("SLR") has been commissioned to undertake a preliminary geochemical assessment to determine the potential impacts of the mining on the environment.

This preliminary geochemical assessment comprises a desk study and will be submitted in support of the Environmental Impact Assessment (EIA) for the mining right application.

1.1 BACKGROUND

The Alexander coal resource lies within the current AAIC prospecting right areas (proposed Alexander mining right area) and covers an area of approximately 7,300ha. The project will involve the development of surface and underground facilities comprising an underground mine, a waste rock dump, topsoil stockpiles, mine related facilities and various support infrastructure and services. An overland conveyor is also proposed, to transport Run of Mine (ROM) coal from the proposed Alexander incline shaft to the stockpile area at the Elders Colliery from where it will be transported via the Elders overland conveyor to Goedehoop Colliery for beneficiation purposes.

1.2 TERMS OF REFERENCE

The guideline series Best Practice Guidelines for Water Resource Protection in the South African Mining Industry (BPG), published by the South African Department of Water and Sanitation, includes Guideline G4 *Impact Prediction*. Guideline G4 includes a detailed, and iterative, process for making water quality predictions for mine projects (Figure 1-1).

AAIC/SLR limited this specialist study to the first task of the G4 process, namely, collect background information. Therefore, this report presents a review of published studies and specialist reports that provide insight into future mine water quality at the proposed Alexander Project. Since this study did not include the full G4 process, it has been termed a "Preliminary Geochemical Assessment".

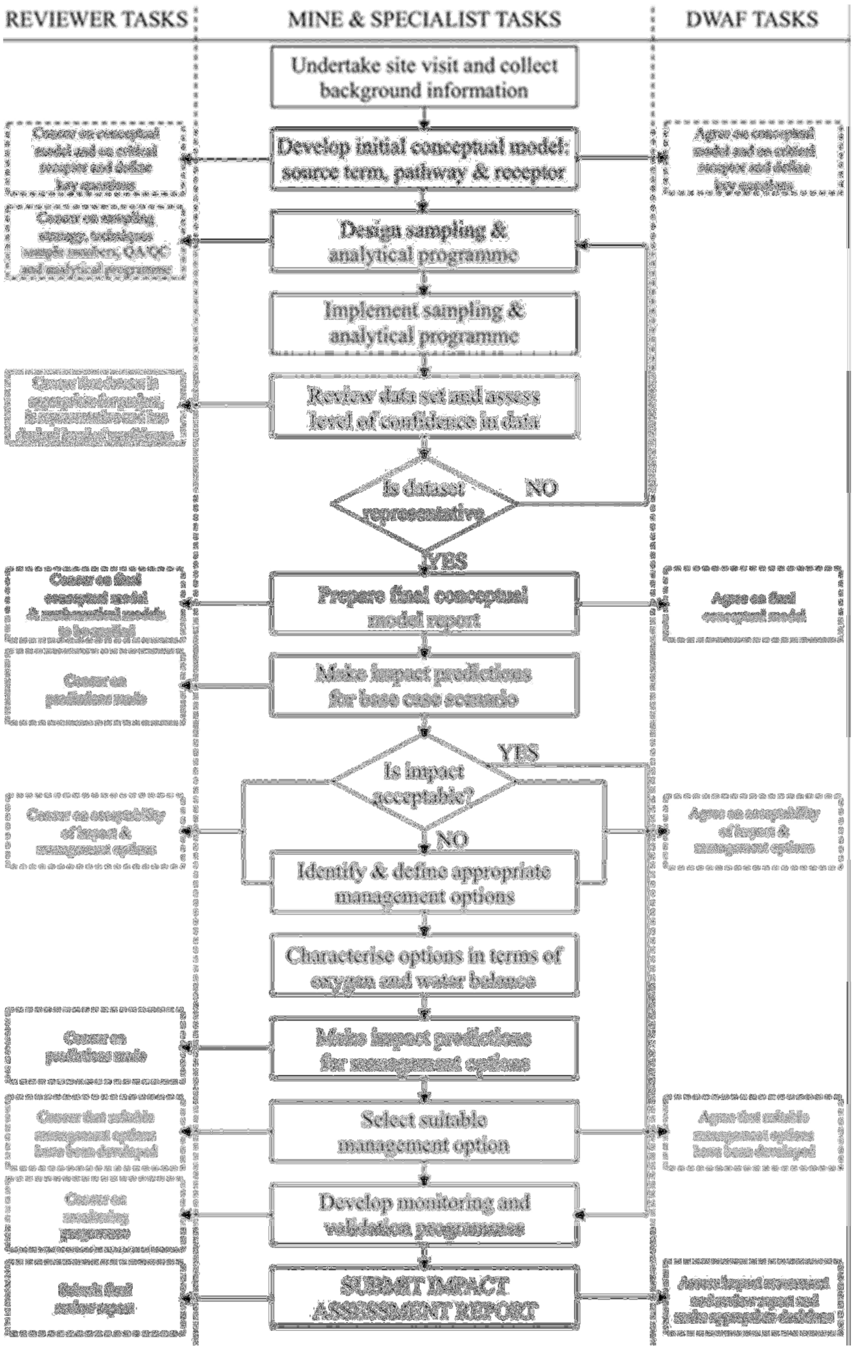


FIGURE 1-1: IMPACT PREDICTION METHODOLOGY

1.3 APPROACH

Samples, for geochemical characterisation, were not available for this assessment. Therefore, the acid mine drainage (AMD) potential and contact water quality from mining operations cannot be quantified on a site-specific basis.

For this reason, SLR has conducted a desk study to identify, at a conceptual and preliminary level, key geochemical risks from the discard dump and underground water quality. This report recommends further work required to clarify site-specific geochemical characteristics and potential risks to groundwater quality.

1.4 REPORT STRUCTURE

The report has been divided accordingly:

- Section 2 presents the results of the desk study.
- Section 3 presents the waste assessment in terms of relevant legislation
- Section 4 discusses the results of the desk study.
- Section 5 concludes the report.
- Section 6 presents recommendations for further work, including details of a proposed sampling and analysis plan.

2 DESK STUDY

This section summarises the site setting, geology, mineralogy and expected geochemistry for the proposed Alexander Coal Project.

2.1 SITE SETTING

The Alexander Project Area covers an area of approximately 7,300ha directly south-east of Kriel and approximately 12 km north-west of Bethal in the Mpumalanga Province. The site location is presented in Figure 2-1.

The coal resource lies between the R547 provincial road to the west and the R35 provincial road to the east, with the R545 provincial road bisecting the resource in a north-west to south-east direction.

2.2 MINING OPERATIONS AND INFRASTRUCTURE

The coal resource at the proposed Alexander Project will be mined through underground mining activities. The mining method will be the traditional Bord and Pillar method with cutting of the coal through Continuous Miner technology, which utilises a large rotating steel drum, equipped with teeth that scrape coal from the seam.

Although the No. 2, 3, 4 and 5 coal seams are all developed within the proposed Alexander Project area, only the No. 4 seam is considered within this mining right application. The No. 4 seam is on average 4.90m thick and occurs at a depth of 63m below surface with the preferred quality situated in the lower two-thirds of the seam (Synergistics, 2016).

It is proposed that two shafts will be required; one incline shaft for material and coal extraction and one vertical shaft with ventilation fans for personnel and small material access. A conveyor belt system will be linked to the incline shaft in order to transport the Run of Mine (ROM) coal extracted underground to the surface. ROM coal will be stored in silos and not on stockpiles.

Overburden removed during the incline and vertical shaft excavations will be stored on a waste rock dump until reuse. Overburden will be used during decommissioning and closure of the Alexander shaft void.

A processing plant will not be required for the proposed Alexander Project, since all run-of-mine (ROM) production will be transported via the overland conveyor to Elders and then to the Goedehoop beneficiation plant.

The expected life of mine (LOM) is between 30 and 35 years.

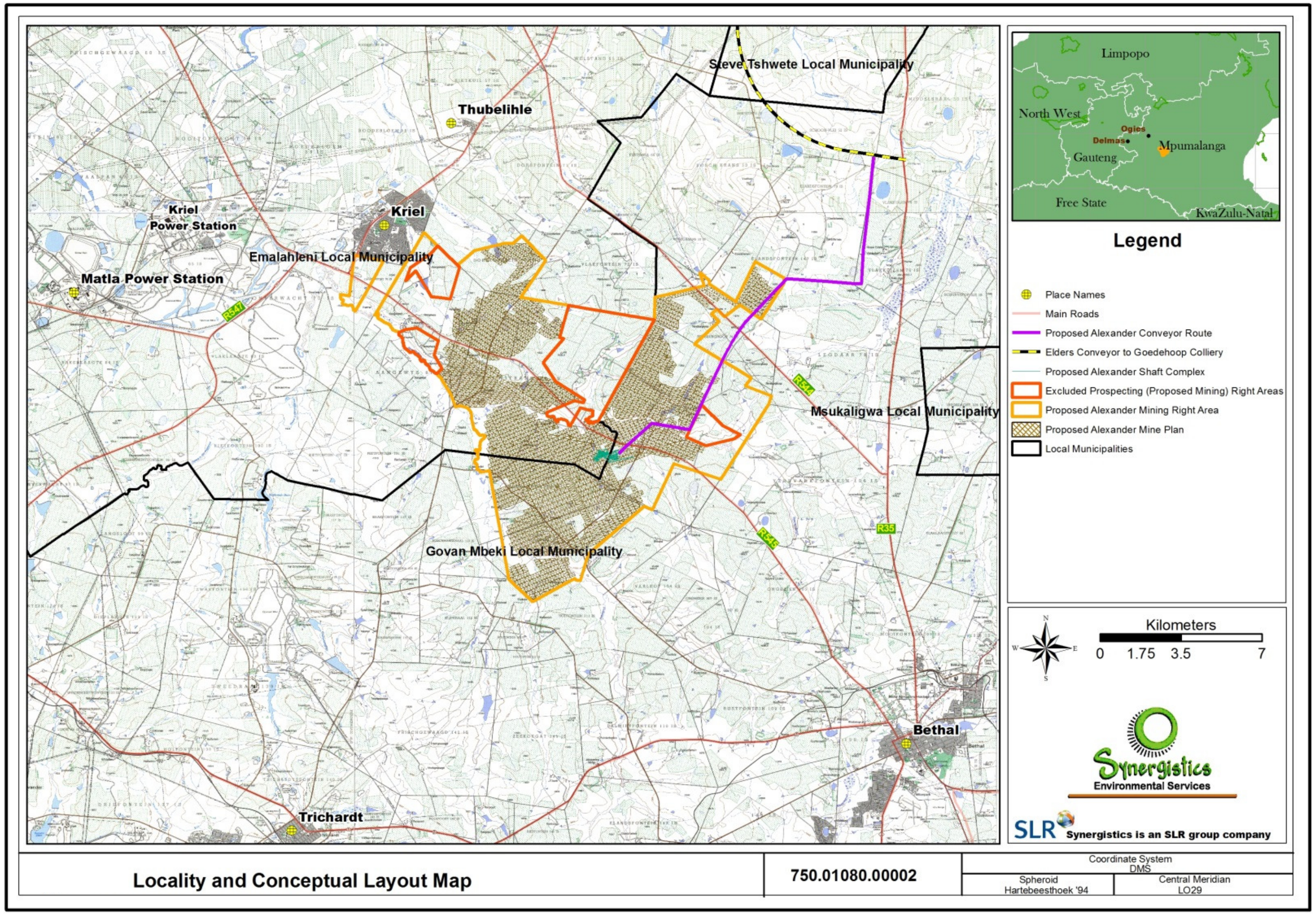


FIGURE 2-1: SITE LOCATION AND SITE LAYOUT

2.3 GEOLOGICAL SETTING

2.3.1 REGIONAL GEOLOGY

The Project Area is located within the Highveld coalfield. The geology beneath the Project Area comprises predominately sedimentary lithological units of the Vryheid Formation. The Vryheid Formation consists of an interbedded succession of sandstone with subordinate siltstones, grit, mudstones and coal beds and forms part of the Ecca Group of the Karoo Supergroup.

The Project Area has been extensively intruded by pre-Karoo dolerites in the form of sills and dykes (not shown in Table 2-1).

The formations are covered by alluvium deposits directly next to major watercourses in the Project Area.

The stratigraphic column for the Project Area is presented in Table 2-1 and an extract of the 1:250 000 Geological Map Series of South Africa is presented as Figure 2-2.

TABLE 2-1: STRATIGRAPHIC COLUMN FOR THE ALEXANDER PROJECT AREA

Supergroup	Group	Formation	Description
Karoo Super Group	Ecca	Volksrust Formation	Intercalated mudstones
		Vryheid Formation	Aranaceous Sandstone intercalated carbonaceous shales, mudstones and coal **Main Coal Bearing Horizons**
	Dwyka	Dwyka Formation	Mudrock, diamictite and conglomerates

2.3.2 COAL SEAMS

The Highveld coalfield consists of five recognised seams, namely No.1 to No.5 from the base upwards. The total thickness of the coal unit varies between approximately 60 m to 100 m (SRK, 2012). Seam No. 5 is not present in many areas due to present day erosion.

Coal seam No. 4 is a dull coal with shale lamina near the top and is economically the most important in the Highveld Coal field as it is laterally continuous. Coal Seam No. 4 has an average thickness of 4.96 m (SRK, 2012) and according to the project description, occurs at a depth of approximately 63 m below ground level.

Partings between seams vary from less than 1 m between seams No.3 and No.4 to tens of meters between seams No.4 and No.5 (Van Der Walt, 2012). Parting consists of coarse grained sandstones, transgressing to siltstone or shale at the top (JMA, 2015).

The coal zone is overlain by a second deltaic sequence which consists of grey to white Sandstone and sandy micaeous shale and siltstone (SRK, 2012).

The intrusion of the dolerites within the study area have compartmentalised the coal seams (JMA, 2015) and have caused de-volatilisation of the coal beds in places.

2.3.3 LOCAL GEOLOGY

Due to limited site-specific data being available at the time of writing, the local geological setting for the Alexander Project Area is based on information for the neighbouring Elders Colliery (JMA, 2015).

The general lithological profile, up to, and including the deepest mineable coal seam, comprises:

- Soft Overburden Soil and Clay Units.
- Hard Overburden Sandstone and Siltstone.
- Coal Seam No.4.
- Parting material: Sandstone, Siltstone and Shale.

The following conclusions were made with regard to the stratigraphic composition for the Elders Project:

- The average soft overburden depth is 5.45 m and consists of soils and clay. The soil profile is thin and sporadically developed in areas of rocky outcrops.
- The average depth of highly weathered rock, as observed in the exploration boreholes, is 8.5m.
- The geological weathering profile, as observed in the groundwater monitoring boreholes, shows the average weathered depth to be 15.5 m. This weathered zone generally comprises a highly to moderate weathered zone of up to 11.4 m and a less weathered underlying zone of 15.5 m on average.
- Parting material consists of sandstone (65%-68%), shale, siltstone and minor mudstone. These units vary between non- to highly carbonaceous.
- Dolerite intersections are prominent, mainly in the form of sills, but are below the No.2 coal seam.

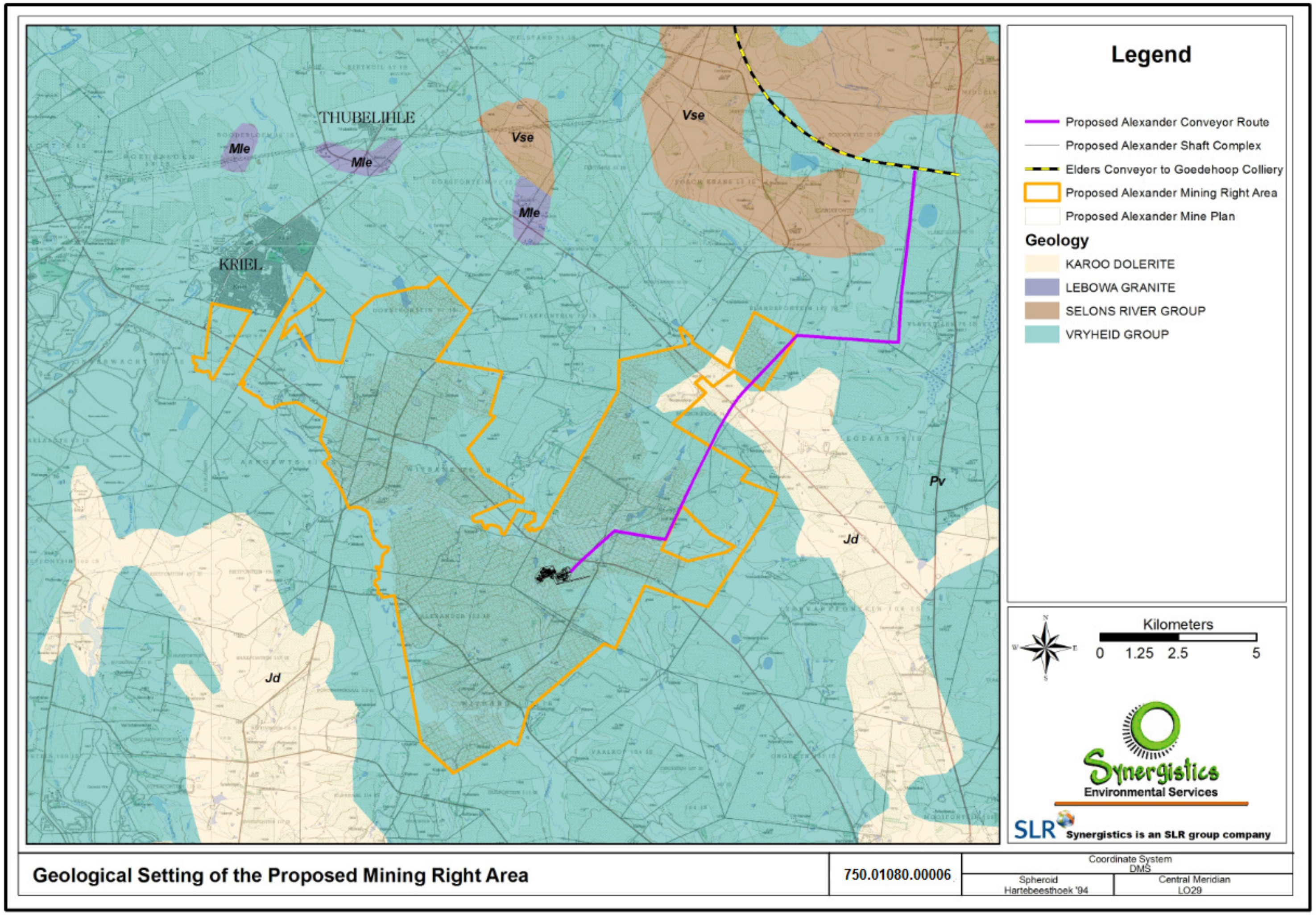


FIGURE 2-2: GEOLOGICAL SETTING

2.4 MINERALOGY

The mineralogy of both No.4 Coal Seam and roof material for the Elders Project (JMA, 2015). was determined through XRD analysis.

A summary of the data is presented in Table 2-2 (Roof material) and Table 2-3 (coal seam) below.

TABLE 2-2: SUMMARY OF MINERALOGY OF ROOF MATERIAL (%)

Mineral	Carbonaceous Siltstone			Sandstone		
	Min.	Ave.	Max.	Min.	Ave.	Max.
Dolomite+/Ankerite	2.0	4.67	7.0	1.0	3.0	5.0
Siderite	3.0	4.50	6.0	1.0	1.0	1.0
Calcite	1.0	4.20	8.0	1.0	1.4	2.0
K-feldspar	1.0	7.60	16.0	1.0	7.3	16.0
Cpx	3.0	3.00	3.0	-	-	-
Plagioclase	2.0	3.00	4.0	2.0	6.8	19.0
Pyrite	1.0	1.50	3.0	1.0	1.0	1.0
Anatase	1.0	1.00	1.0	1.0	1.0	1.0
Quartz	20.0	37.0	56.0	41.0	62.4	91.0
Chlorite	-	-	-	9.0	9.0	9.0
Mica	7.0	10.5	14.0	2.0	5.6	10.0
Kaolinite	22.0	36.0	55.0	6.0	18.3	39.0
Smectite	5.0	5.0	5.0	4.0	4.0	4.0
Il/Sm Interstratification	3.0	5.0	7.0	2.0	2.7	3.0

Note: Carbonaceous siltstone based on five samples. Sandstone based on seven samples

TABLE 2-3: SUMMARY OF MINERALOGY OF COAL SEAM NO.4 (WT %)

Mineral	Minimum	Average	Maximum
Siderite	1.0	4.5	8.0
Calcite	2.0	5.0	10.0
K-feldspar	2.0	5.6	12.0
Plagioclase	7.0	12.5.0	18.0
Pyrite	1.0	1.0	1.0
Goethite	13.0	13.0	13.0
Anatase	1.0	1.0	1.0
Alunite	22.0	22.0	22.0
Quartz	18.0	34.0	77.0
Mica	3.0	9.3.0	16.0
Kaolinite	18.0	39.4	66.0
Smectite	18.0	18.0	18.0
Il/Sm Interstratification	2.0	5.0	8.0

Note: Based on seven samples

The data show that:

- Pyrite is the only sulphide mineral present in significant quantities in both types of sample.

- The average pyrite content was:
  - 1.5% for the carbonaceous siltstone
  - 1.0% for the sandstone
  - 1.0% for the No.4 coal seam
- Calcite, dolomite and siderite are the key carbonate minerals.
- Calcite is the primary neutralising mineral. The average calcite content was
  - 4.2% for the carbonaceous siltstone
  - 1.4% for the sandstone
  - 5.0% for the No.4 coal seam

2.5 MINE WATER QUALITY

The following section presents estimates of mine water quality associated with the proposed Alexander Project.

2.5.1 SOURCES OF GEOCHEMICAL IMPACTS

The following geochemical impact zones have been identified from the project description:

- Excavation of soft and hard overburden around the incline shaft portal.
- Placement of excavated overburden/waste rock into the waste rock dump for use in later rehabilitation.
- Dewatering and exposure of the No.4 coal seam, roof, and floor rocks due to mining.

These geochemical impact zones are sources of mine water. The chemical composition of the mine water is of interest to the project since it may lead to a deterioration of water quality resources near the Alexander Project. Therefore, this section of this report considers available information to develop estimates of the following mine water qualities:

- Seepage from the waste rock dump (contact water quality).
- Accumulated water in the underground workings, especially after mining ceases (mine water quality).

For the purposes of this assessment, water quality associated with the excavation of overburden at the shaft portal is not estimated. This is because the exposed rock faces are unlikely to generate environmentally significant volumes of seepage, and the seepage is expected to be managed as part of the mine dirty water system. If required, contact water quality may provide a preliminary analogue of portal seepage.

2.5.2 INFORMATION REVIEW

This assessment reviewed two key sources of geochemical information relevant to the proposed Alexander Project:

- Zhao *et al* (2010) conducted a detailed assessment and geochemical modelling of water quality in an underground mining compartment (S7) at Brandspruit Colliery, some 30 km south of the proposed Alexander Project. Compartment S7 accessed the No. 4 Seam (lower) at a depth of 120 m to 150 m. This is the same seam but considerably deeper than the ±60 m depth anticipated at Alexander. Compartment S7 includes Bord and Pillar mined areas, the same mining method proposed at Alexander. These points of comparison suggest the S7 compartment is a credible analogue of compartments in the proposed Alexander underground workings.
- JMA (2015) collected samples for geochemical characterisation from nine groundwater exploration boreholes drilled at the Elders Project immediately east of the Alexander Project area. The Elders Project proposes to access the No.4 Seam at depth of about 45 m, somewhat shallower than the 60 m depth anticipated at Alexander. JMA (2015) used the data to geochemically model water quality in the underground workings and seepage from the Elders waste rock dump. The similarity in geological context and geographical proximity suggests the geochemical characterisation results might be indicative of conditions at Alexander.

Information on acid rock drainage potential and contact water quality from the above information sources is summarised in the following sections.

2.5.3 ACID ROCK DRAINAGE POTENTIAL

Zhao *et al* (2010) analysed 24 samples from the No.4 Seam and six samples of roof material by acid base accounting (ABA), as presented in Table 2-4.

TABLE 2-4: ABA RESULTS FROM NO.4 SEAM ROOF ROCKS AND COAL OF THE BRANDSPRUIT COMPARTMENT S7

Sample	Lithology	Paste pH	NAG[1] pH	Sulphur (wt %)	AP[2] ($kgCaCO_3/t$)	NP[3] ($kgCaCO_3/t$)	NPR[4]	Category
BHR1R-a	Roof	7.58	3.68	0.29	9	13	1.4	Uncertain
BHR2R-a	Roof	8.67	4.66	0.36	11.4	18	1.6	Non-PAG
BHR1R-b	Roof	7.57	3.03	0.27	8.4	6.4	0.8	PAG
BHR2R-b	Roof	7.85	4.02	0.66	20.6	23.6	1.1	Uncertain
BHR1R-c	Roof	7.27	3.32	0.58	18.1	18.4	1.0	Uncertain
BHR2R-c	Roof	7.27	2.56	1	31.3	16.8	0.5	PAG
Average	**Roof**			**0.53**	**16.5**	**16.0**		
BS7 S-1	No.4 Seam	7.62	4.3	0.52	16.3	28.2	1.7	Uncertain
BS7 S-4	No.4 Seam	8.58	4.79	0.32	10	60.6	6.1	Non-PAG

[1] NAG – Net Acid Generation - pH determined after oxidation of pyrite with hydrogen peroxide
[2] AP – Acid Potential - Acid potential (assumed to be associated with pyrite in the sample)
[3] NP – Neutralising Potential - (assumed to be associated with the mineral calcite in the sample)
[4] NPR – Neutralising Potential Ratio - NP/AP

Sample	Lithology	Paste pH	NAG[1] pH	Sulphur (wt %)	AP[2] (kgCaCO$_3$/t)	NP[3] (kgCaCO$_3$/t)	NPR[4]	Category
BS7 S-7	No.4 Seam	9.04	4.59	0.21	6.7	27.8	4.1	Non-PAG[5]
BS7 S-10	No.4 Seam	8.55	4.65	0.34	10.6	35.3	3.3	Non-PAG
BS7 S-13	No.4 Seam	8.02	4.94	0.52	16.1	88.1	5.5	Non-PAG
BS7 S-16	No.4 Seam	8.17	2.91	0.46	14.3	18.1	1.3	Uncertain
BHR1C-a	No.4 Seam	8.19	2.09	0.84	26.2	30.8	1.2	Uncertain
BHR2C-a	No.4 Seam	8.08	2.24	0.85	26.5	34.7	1.3	Uncertain
BS7 S-2	No.4 Seam	8.19	4.86	0.87	27.1	70.8	2.6	Non-PAG
BS7 S-5	No.4 Seam	9.1	4.77	0.12	3.9	42.8	11.0	Non-PAG
BS7 S-8	No.4 Seam	9.15	5.06	0.03	0.8	67.6	84.5	Non-PAG
BS7 S-11	No.4 Seam	9.14	5.03	0.08	2.4	48.6	20.3	Non-PAG
BS7 S-14	No.4 Seam	8.71	4.86	0.32	10.1	59.4	5.9	Non-PAG
BS7 S-17	No.4 Seam	9.03	5.05	0.12	3.8	56.4	14.8	Non-PAG
BHR1C-b	No.4 Seam	8.39	4.86	0.19	5.9	58.5	9.9	Non-PAG
BHR2C-b	No.4 Seam	7.78	2.14	1.73	54.2	59.2	1.1	Uncertain
BS7 S-3	No.4 Seam	8.83	5.06	0.03	0.8	68.9	86.1	Non-PAG
BS7 S-6	No.4 Seam	8.53	4.41	1.45	45.3	68.6	1.5	Uncertain
BS7 S-9	No.4 Seam	7.18	1.89	1.76	54.9	52.5	1.0	PAG
BS7 S-12	No.4 Seam	9	5.07	0.11	3.6	53.8	14.9	Non-PAG
BS7 S-15	No.4 Seam	8.58	3.05	1.15	36	54.6	1.5	Uncertain
BS7 S-18	No.4 Seam	8.79	5.09	0.73	22.8	63.5	2.8	Non-PAG
BHR1C-c	No.4 Seam	8.18	5.02	0.51	16	46.6	2.9	Non-PAG
BHR2C-c	No.4 Seam	8.54	4.68	0.1	3	51.3	17.1	Non-PAG
Average	**No.4 Seam**			**0.56**	**17.4**	**51.9**		

These results contrast with data from the Elders project adjacent to Alexander (Table 2-5). The average sulphur of the roof rock at Elders is approximately double that determined for Brandspruit. However, the No.4 Seam sulphur averages are similar. Note that the sulphur content of 0.5% corresponds to a pyrite content of approximately 1%, which is consistent with the mineralogy results (Table 2-2 and Table 2-3).

TABLE 2-5: ABA RESULTS FROM ELDERS MINE

Sample	Lithology	Paste pH	NAG pH	Sulphur (wt %)	AP (kgCaCO$_3$/t)	NP (kgCaCO$_3$/t)	NPR	Category
Average	Roof	-	-	1.10	34.7	22.4	1.9	Non-PAG
Average	No.4 Seam	-	-	0.55	17.3	8.5	0.5	PAG

The same difference in sulphur content is reflected in the AP. The NP of the roof rocks is similar between the two sites. These ABA data suggest that pyrite content, which correlates with sulphur, in No.4 Seam roof rocks can vary considerably from place to place. This is consistent with the geological variability of the coal field that arises from fluvial deposition.

It is significant that the NP of the No.4 coal seam is considerably higher at Brandspruit than at Elders. Zhao *et al* (2010) indicate that the coal contains fractures filled with the mineral calcite. Calcite contributes significantly to NP. As a stress feature, fracturing of the coal seam is not likely to be consistent from one place to the next, even within the same project area. JMA (2015) indicate calcite

[5] Potentially Acid Generating (PAG) - based on NPR and the criteria of Price (2009)

content in No.4 coal seam ranging from non-detect to 10 wt%. A similar variation at Alexander could be expected.

Zhao *et al* (2010) concluded that there is sufficient neutralising potential available in the roof and coal samples to prevent the generation of significant amounts of acidity in the S7 compartment. They based this on the following:

- Low sulphur content of several samples: less than 0.3 wt% is unlikely to sustain long-term acid generation (Usher *et al* 2003).
- The combined neutralisation potential of all samples significantly exceeds the combined acid potential (Figure 2-3).

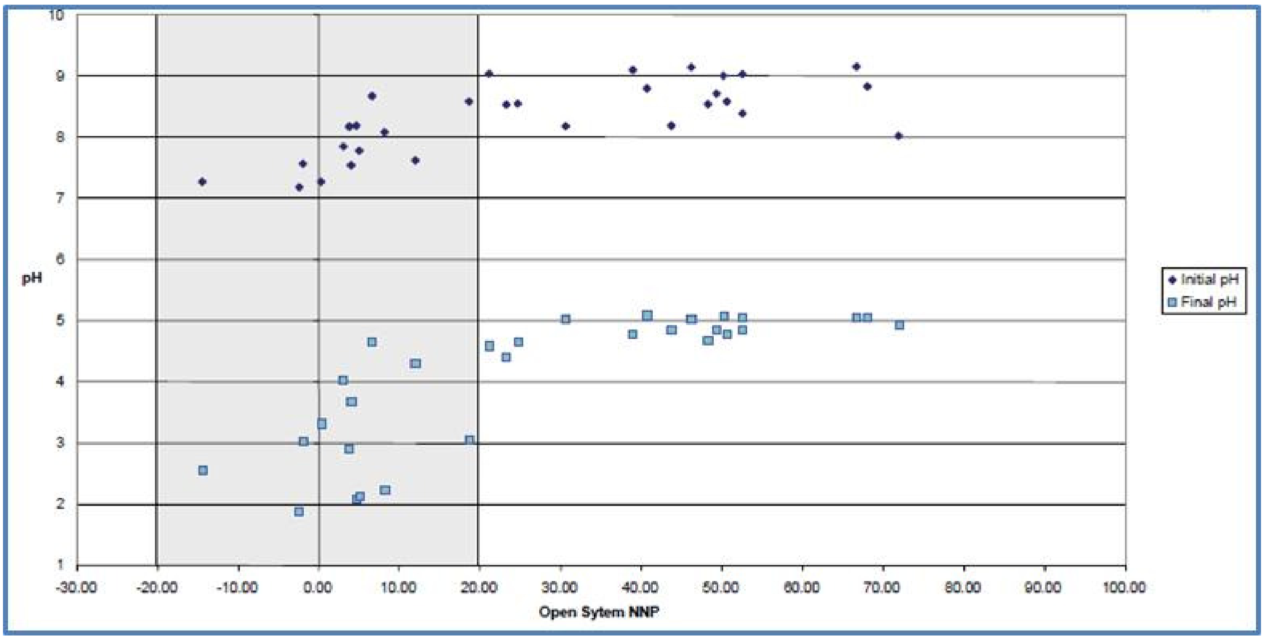


FIGURE 2-3: DISTRIBUTION OF NNP IN SAMPLES FROM COMPARTMENT S7 SHOWING PREDOMINANCE OF POSITIVE NNP VALUES INDICATING EXCESS NEUTRALISATION POTENTIAL

Statistical analysis of the ABA data by Zhao et al (2010) indicated the following:

- Mean NNP[6] of 27kg $CaCO_3$/t with the 95% confidence range extending from 18 to 36. This suggests that acidification is unlikely.
- Mean NPR of 10 with the 95% confidence range extending from 2.5 to 17.6. According to the Price (2009) criteria this range is non-PAG.

[6] Net Neutralisation Potential – the difference between AP and NP (i.e. AP – NP)

2.5.4 CONTACT WATER QUALITY

Zhao *et al* (2010) analysed elements solubilised during a 3:1 water-sample interaction for roof (Table 2-6) and No.4 coal seam (Table 2-7).

Contact water is characterised by the following:

- Na is the highest concentration metal in the contact water in both coal and roof materials.
- Ca, Mg, K are the second highest concentrations of metals.
- Fe, Si, Mn, Al, Zn, Co and Ni are present in trace concentrations.
- Coal contact water has lower dissolved solid concentrations than roof contact water, probably due to high concentrations of carbon and minor amounts of inorganic mineral phases. However, the metal leachability from the coal is higher than the roof materials if the coal is normalised by exclusion of carbon (carbon >90 wt% in coal).

TABLE 2-6: RANGE OF CONTACT WATER QUALITY DERIVED FROM SIX SAMPLES OF 4 SEAM ROOF ROCKS

Parameter	Minimum [mg/L]	Maximum [mg/L]	Mean [mg/L]	Standard Deviation [mg/L]
pH	7.18	9.15	8.32	0.60
Na	15.41	38.64	25.68	8.06
Mg	0.26	5.75	2.27	2.59
Al	0	0.68	0.31	0.28
Si	0.21	0.76	0.41	0.2
K	0.73	1.72	1.31	0.41
Ca	0.87	13.31	5.93	5.83
Ba	0.1	0.25	0.15	0.06
Mn	0.02	0.43	0.16	0.18
Fe	0	1.47	0.61	0.7
Co	0	0.09	0.03	0.03
Ni	0.01	0.14	0.05	0.05
Cu	0	0.01	0.01	0.01
Zn	0.08	0.25	0.13	0.07

Zhao et al (2010) did not tabulate data on sulphate and other anions. Graphical results suggest sulphate concentrations of 33 to 333mg/L. For the purposes of the Alexander Project, the concentration range in Table 2-6 may be considered an estimate of the operational phase seepage quality from the waste rock dump.

TABLE 2-7: RANGE OF CONTACT WATER QUALITY DERIVED FROM SIX SAMPLES OF NO.4 SEAM COAL

Parameter	Minimum [mg/L]	Maximum [mg/L]	Mean [mg/L]	Standard Deviation [mg/L]
Na	8.15	15.64	12.16	2.91
Mg	0.31	0.61	0.42	0.12

Parameter	Minimum [mg/L]	Maximum [mg/L]	Mean [mg/L]	Standard Deviation [mg/L]
Al	0	0.07	0.04	0.04
Si	0	0.22	0.11	0.09
K	0	0.33	0.13	0.15
Ca	1.49	2.75	2.34	0.45
Ba	0.08	0.28	0.18	0.08
Mn	0	0.01	0.01	0.01
Fe	0	0.18	0.06	0.08
Co	0	0	0	0
Ni	0	0	0	0
Cu	0	0.01	0	0
Zn	0	0.12	0.03	0.04

2.5.5 MINE WATER QUALITY (OPERATIONAL PHASE)

Zhao *et al* (2010) presented analytical data from 20 samples of mine water from the S7 compartment (Table 2-8). The results indicate that mine water chemistry is characterised by total dissolved solids (TDS) of 3,000 to 4,000mg/L which is mainly due to concentrations of Na, Ca, and SO_4. Metals of environmental concern, including Fe, Cu, Al, Zn, and Mn are present at concentrations in the range 0.1 mg/L to <10mg/L.

For the purposes of the Alexander Project, the concentration range in Table 2-8 may be considered an estimate of operational phase underground mine water quality.

TABLE 2-8: RANGE OF CONTACT WATER QUALITY DERIVED FROM SIX SAMPLES OF NO.4 SEAM COAL

Sample	Units	Minimum	Maximum	Average
pH	pH	7.07	8.06	7.40
TDS	mg/L	1 904	6 696	3 568
Alkalinity (as $CaCO_3$)	mg/L	210	911	738
F	mg/L	0.82	4.01	2.48
Cl	mg/L	14	254	85
SO_4	mg/L	22	4 200	1 925
Na	mg/L	29	1 635	859
K	mg/L	6.65	20	9.93
Ca	mg/L	46	465	144
Mg	mg/L	37	310	121
Al	mg/L	0.00	70	8.90
Fe	mg/L	0.11	18	4.62
Mn	mg/L	0.00	5.00	0.96
Cu	mg/L	0.00	5.00	0.74
Pb	mg/L	0.00	0.60	0.15
Zn	mg/L	0.00	0.56	0.21

2.5.6 MINE WATER QUALITY (LONG-TERM)

After closure, the proposed Alexander underground workings will flood. During flooding, pyrite oxidation in the walls and roof of the workings will contribute acid drainage to the water body in the mine.

The compositions of long-term mine water in Brandspruit compartment S7 and the Elders project have been estimated through geochemical modelling using measurements of sulphate production and general assumptions regarding geochemical conditions.

Zhao *et al* (2010) developed a kinetic geochemical model to predict long-term water quality in the S7 compartment. This took into account the rate of pyrite oxidation determined from laboratory tests and theoretical considerations. The model also considered a wide range of site-specific information including geochemical characterisation of S7 samples, the area of the S7 compartment, local measurements of groundwater quality and groundwater inflow rates. As a result, the predictions of Zhao *et al* (2010) are of general relevance to the Alexander Project.

Similarly, JMA (2015) developed a kinetic geochemical model for the Elders Project underground water. This was also based on limited geochemical characterisation data. Table 2-9 compares the results of the two models.

TABLE 2-9: MODELLED UNDERGROUND WATER QUALITY IN THE LONG TERM

Parameter	Units	JMA (2015)	Zhao *et al* (2010)
Years		17+	20 – 100
pH	pH	5.5	6.6 – 6.9
TDS	mg/L	4 500 – 6 500	1 451 – 1 968
Ca	mg/L	950 – 750	6 – 134
Mg	mg/L	250	10 – 28
Na	mg/L	250 – 800	359
K	mg/L	30 – 80	---
SO4	mg/L	1 600 – 4 500	596 – 805
Total Alkalinity	mg/L	5	343 – 492
Al	mg/L	<5	---
Fe	mg/L	<10	---

Higher concentrations in the JMA prediction are due to formation of local AMD “hot spots” where available neutralisation potential is insufficient to balance acid production from pyrite oxidation. This is a result of the heterogeneous distribution of pyrite and carbonate minerals and the use of average mineral concentrations in the modelling.

Zhao *et al* (2010) used particle sizes determined from samples of <5mm material collected from rubble in the compartment. This assumed that material coarser than 5mm would have a negligible impact on water quality due to the orders of magnitude lower exposed surface area. Sieving of the particles yielded an average grain size of 0.91mm, from which the surface areas of minerals were estimated for geochemical modelling.

JMA (2015) determined particles sizes in clastic sedimentary units and coal seams. It is not clear what material was used to determine the particle size distribution as the samples were reportedly obtained from groundwater boreholes. Assuming the boreholes were drilled using air percussion, this suggests that the particle size distributions reported in JMA (2015) are the result of the drill bit acting on the intact sample material, rather than the inherent grain size of the material. Approximately 80% of the particles were finer than 0.5 mm. This suggests that the higher concentrations determined by JMA (2015) may be due to increased surface area of minerals in the geochemical model.

Given the lack of site-specific data, inherent uncertainties and assumptions in the modelling, the modelled qualities in Table 2-9 can be considered a range of potential long-term mine water qualities. In general, the JMA column of Table 2-9 may represent conservative scenarios with significant pyrite oxidation impact, while the Zhao *et al* column may represent some moderate pyrite oxidation impact scenarios and/or scenarios considering dilution.

3 ASSESSMENT OF WASTE AND CONTAINMENT BARRIER DESIGN

The Department of Environmental Affairs (DEA) has revised the South African waste classification and assessment system under the National Environmental Management: Waste Act, 2008 (Act 59 of 2008) (NEM:WA). The Waste Classification and Management Regulations (WCMR) (GN R. 634 of 2013) were published in August 2013 and set out the requirements for the Classification of waste and the assessment of waste for disposal. The WCMR references the following Norms and Standards with regards to waste assessment:

- National Norms and Standards for the assessment of waste for landfill disposal (GN R.635 of 2013); and
- National Norms and Standards for disposal of waste to landfill (GN R. 636 of 2013).

An assessment is required for overburden / waste rock material.

3.1 GN R. 635 OF 2013

In terms of Regulation 8 (1)(a) of the Waste Classification and Management Regulations (WCMR), waste generators must ensure that their waste is assessed in accordance with the Norms and Standards for Assessment of Waste for Landfill Disposal (GN R. 635) prior to the disposal of the waste to landfill.

3.1.1 TOTAL CONCENTRATIONS

The Total Concentration (TC) of chemicals substances specified in Section 6 of GN R. 635 that are known to occur, likely to occur or can reasonably be expected to occur must be determined. The TC of the chemical substances is compared to the total concentration threshold (TCT) limits specified in Section 6 of GN R. 635.

3.1.2 LEACHABLE CONCENTRATIONS

The Leachable Concentrations (LC) of the chemical substances must be determined and compared to the leachable concentration threshold (LCT) limits specified in Section 6 of GN R. 635.

3.1.3 ASSESSMENT

The TC and LC limits of elements and chemical substances in the waste material exceeding the corresponding TCT and LCT limits will determine the specific waste type according to Section 7 of GN R. 635. Figure 3-1 presents a flow diagram of the general process to be followed to determine the waste type.

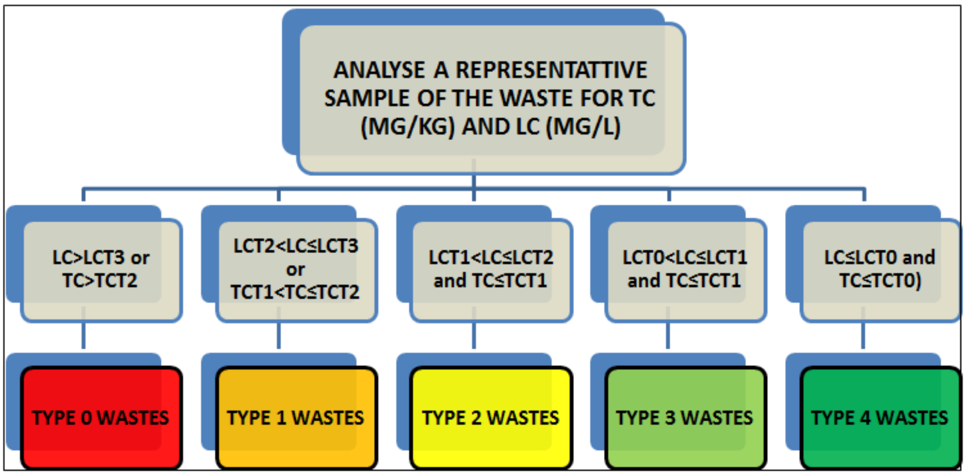


FIGURE 3-1: FLOW DIAGRAM FOR ASSESSING WASTE IN TERMS OF GN R. 635 OF 2013

3.2 GN R. 636 OF 2013

In terms of Regulation 8 (1)(b) of the WCMR, waste generators must ensure that the disposal of their waste to landfill is done in accordance with the Norms and Standards for Disposal of Waste to Landfill (GN R. 636).

GN R. 636 sets out the landfill classification (Class A to D) and containment barrier design for each waste type as determined by the waste assessment in accordance with GN R. 635. These are presented in Table 3-1 below.

Section 3(2)(d) of GN R. 636 sets out the alternative elements of proven equivalent performance which can be considered when applying for a waste management licence for a disposal site.

3.3 RISK BASED APPROACH

Notwithstanding, the Chamber of Mines of South Africa requested, in a meeting with the National Department of Water and Sanitation (DWS) on 8th June 2016, that a risk based approach be followed when processing mining water use license application, specifically for mine residue deposits and stockpiles, due to challenges faced, particularly with the requirement of a lining systems for such material.

The Chamber of Mines proposed that the DWS follow a risk based approach, on a case by case basis, in order to allow for representations on an alternative barrier system based on a risk approach. The risk based approach shall enable an evaluation of the efficacy of the alternative barrier system to prevent pollution as required in terms of Section 19(1) and (2) of the act, thus informing a decision on an application for a water use licence for the related facilities.

The DWS accepted the proposal by the Chamber of Mines provisionally that the decision on the affected water use licence application will be based on the DWS satisfaction that the alternative proposed barrier system will achieve the objective of preventing pollution of the water resources or be equivalent of the prescribed barrier system. The above is documented in a letter from Mr. A B Singh, Deputy Director General of the Department of Water and Sanitation; Water Sector Regulation, to Mr. N Lesufi, Senior Executive: Environment and Health, Chamber of Mines of South Africa, dated 1st July 2016,

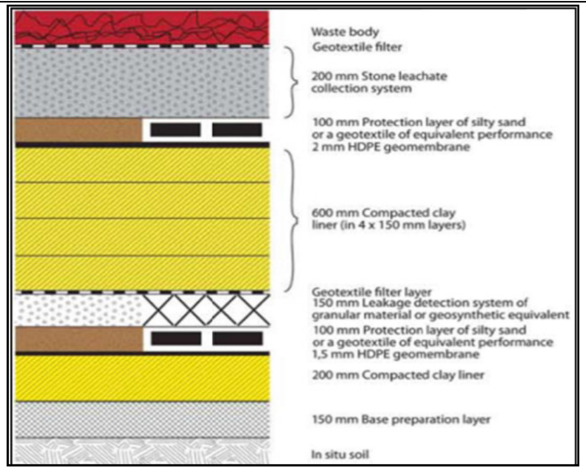
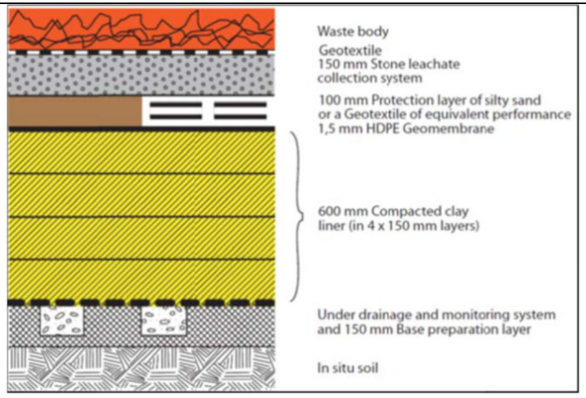
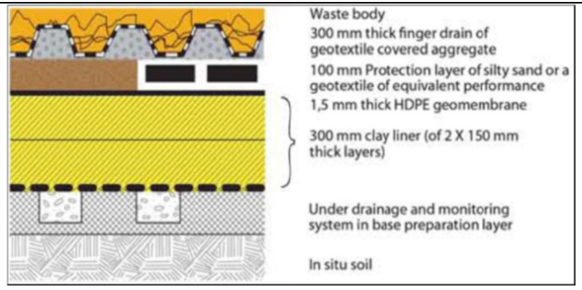
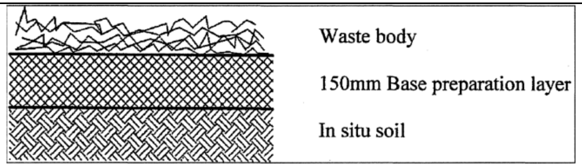
3.4 ASSESSMENT FOR ALEXANDER PROJECT

Site specific geochemical information of overburden is unavailable for an assessment, in terms of GN R. 635 and GN R.636, to be undertaken.

It is unlikely that overburden will be a Type 4 waste, as it is unlikely for both leachable concentrations and total concentrations of all elements to be below the relevant threshold limits (LCT0 and TCT0). It is also unlikely that overburden will be a Type 0 waste, as it is unlikely that leachable concentrations will be above the LCT3 or total concentrations will be above the TCT2.

It is likely that overburden from the Alexander Coal Project will be either a Type 3, Type 2 or Type 1 waste, and based on the risk based approach, it is likely that the waste will require disposal to facility with a Class D, C, B or A containment barrier design, however site specific sampling and assessment is required to verify these assumptions.

TABLE 3-1: LANDFILL DISPOSAL REQUIREMENTS DETAILED IN THE NATIONAL NORMS AND STANDARDS FOR DISPOSAL OF WASTE TO LANDFILL (GN R. 636).

Waste Type	Listed Wastes	Landfill Disposal requirements	Landfill Design specifications
Type 0	None	The disposal of Type 0 waste is not allowed to landfill. These wastes must be treated before being reassessed for landfill disposal.	n/a
Type 1	NA	Type 1 waste may only be disposed of at a Class A Landfill.	
Type 2	Domestic Waste. Business waste not containing hazardous waste or hazardous chemicals. Non-infectious animal carcasses. Garden Waste.	Type 2 waste may only be disposed of at a Class B Landfill.	
Type 3	Post-consumer packaging. Waste tyres.	Type 3 waste may only be disposed of at a Class C Landfill	
Type 4	Building and demolition waste not containing hazardous waste or hazardous chemicals. Excavated earth material not containing hazardous waste or hazardous chemicals.	Type 4 waste may only be disposed of at a Class D Landfill	

4 DISCUSSION

This section considers the relevance of the geochemical characterisation data and mine water estimates presented in the previous section. The potential duration of the geochemical impacts is also discussed.

4.1 ASSESSMENT LIMITATIONS

As indicated in the introduction to this report, no site-specific characterisation of coal seam or overburden is available for the Alexander Project. BPG G4 indicates that an appropriate sampling programme is critical to any impact prediction. Therefore, the lack of site-specific geochemical information for Alexander is considered a key information gap. Sampling is required to address this gap.

Usher *et al* (2003) indicate that there is insufficient data to develop a generic guideline for sample numbers at South African coal mines. Therefore, they recommend an iterative sampling programme with statistical evaluation of each sample set to guide the next iteration.

Usher *et al* (2003) indicate that a sample set of 70 to 80 samples per geologic unit may be sufficient to determine parameters such as acid potential (AP) to a confidence level of 80%. However, this should be confirmed from the results of site-specific sampling.

Based on the above, the proposed Alexander project requires sampling and analysis of 140 to 160 samples of No.4 Seam and No.4 Seam roof rocks to assess the geochemical impact to a suitable level of confidence.

4.2 SEEPAGE RATES

Estimates of seepage rates are required for modelling potential groundwater impacts from the mine water qualities presented in this report. As discussed in Section 2.5.1, seepage from the following sources could impact on surrounding groundwater:

- Seepage from the waste rock dump.
- Accumulated water in the underground workings, especially after mining ceases.

Water flow in rock piles depends on numerous, interrelated characteristics including: grain size distribution, degree of compaction, and stratification of the pile material (Fala *et al* 2003). Infiltration of waste rock dumps is commonly assumed to be approximately 50% of annual rainfall, although there is a general lack of field data to confirm this (Rohde and Williams 2009). For the purposes of this preliminary assessment, and given the lack of characterisation of the waste rock dump, seepage is estimated as 25% of annual rainfall.

Seepage from accumulated water in the underground workings will depend on the hydraulic gradient between the workings and the surrounding aquifer. During mining when the workings are dewatered, the gradient will be into the workings and seepage will be negligible. After mining, the gradient, and hence the seepage, will change over time. A suitably calibrated numerical groundwater model can estimate this time-varying change in seepage.

4.3 IMPACT DURATION

Seepage from the waste rock dump will occur for as long as the dump remains. If the closure plan indicates the waste rock be used to backfill the shaft portal on closure, then waste rock dump seepage will affect surrounding water resources for 30 to 35 years. The extent of the impact will depend on water management options applied at the dump.

After closure, seepage from the portal backfill will drain into the workings. The quality and volume of seepage will depend on the geochemistry of the backfill material, how the backfill is placed, and whether a cover is placed on the backfill. These design elements are unresolved at this time. However, as an initial estimate, operational phase contact water quality may be assumed to seep into the mine workings from the portal backfill after closure.

During operation, the net hydraulic gradient will be towards the mine workings and no significant contamination of groundwater at the depth of the mine workings is expected. After mine closure the workings will flood. Pyrite oxidation will significantly affect mine water quality until the air space in the workings fills with water. Qualitatively, this period immediately after closure will result in the worst quality of mine water (perhaps represented by the JMA column of Table 2-9). However, the hydraulic gradient will contain this water in the workings.

Under flooded conditions, pyrite oxidation in the mine workings will be slower than during the operational phase. This implies that the mine water will gradually be diluted by upstream groundwater and recharge from surface. Generally, water quality in the workings will improve. However, the slower pyrite oxidation rate will add acidity, iron, and sulphate to the water in the workings, albeit at a slower rate than during the operational phase. As a preliminary estimate, the immediate post-closure mine water concentrations may trend towards the quality represented by the Zhao *et al* column of Table 2-9. The duration of this improvement trend will depend on site specific pyrite oxidation rates and the flow regime of the underground workings, which will determine the rates of dilution and seepage.

5 CONCLUSION

SLR has undertaken a preliminary geochemical assessment for the Alexander Coal Project, a proposed underground coal mine near Kriel in the Mpumalanga Province of South Africa.

Site specific data was unavailable for this assessment. Therefore, in accordance with Best Practice Guidelines proposed by the South African Department of Water and Sanitation, a desk study was undertaken to identify key geochemical risks from the proposed mining project. SLR identified geochemical impact zones that are sources of mine water. These zones may lead to deterioration of water quality resources near the Alexander Project. Therefore, mine water qualities of the following have been estimated:

- Seepage from the waste rock dump (contact water).
- Accumulated water in the underground workings, especially after mining ceases (mine water quality).

Based on relevant studies from other mines, No. 4 Seam coal and roof rocks at Alexander may show the following acid drainage potential characteristics:

- Sulphur content may average 0.55 %. This correlates with pyrite content, which in No.4 Seam roof rocks can vary considerably from place to place.
- The NP of the No.4 Seam coal can vary considerably and is influenced significantly by fractures filled with the mineral calcite, a source of NP.
- Based on ABA data from other mine sites, there may be sufficient neutralising potential available in the Alexander roof and coal material to prevent the generation of significant amounts of acidity in mine water. However, sufficient site specific samples will need to be collected and analysed to confirm this.

Based on relevant studies from other mines, the Alexander contact water may show the following characteristics:

- pH may be neutral to slightly alkaline
- Na may be the highest concentration metal in the contact water in both coal and roof materials.
- Ca, Mg, K may be the second highest concentrations of metals.
- Fe, Si, Mn, Al, Zn, Co and Ni may be present in trace concentrations.

Based on monitoring from Brandspruit Colliery (which also mines the No. 4 Seam), Alexander mine water during the operational phase may show the following characteristics:

- Approximately neutral pH
- Total dissolved solids (TDS) of 3,000 to 4,000 mg/L due to concentrations of Na, Ca, and SO_4.
- Metals of environmental concern, including Fe, Cu, Al, Zn, and Mn present at concentrations in the range 0.1 mg/L to <10 mg/L.

Based on geochemical modelling, mine water in unflooded workings after closure may show the following characteristics:

- pH of the order of 5.5
- Total dissolved solids (TDS) of the order of 4,500 to 6,500 mg/L due to concentrations of Na, Ca, and SO_4.

Mine water in flooded workings after closure may show the following characteristics:

- Approximately neutral pH
- Total dissolved solids (TDS) of the order of 1,500 to 2,000 mg/L due to concentrations of Na, Ca, and SO_4.

The above conclusions are indicative and based on geochemical data and modelling from other coal mine sites in the region. The lack of site-specific geochemical information for Alexander should in future be addressed when site specific samples are available for sampling and analysis.

Provided that the waste facility design and impact mitigation measures, as determined by the waste design and water specialists, are implemented there is no reason not to proceed with the project. However, on site sampling and analysis in accordance with NEM:WA should be undertaken as a follow on step from this desktop study.

6 DECLARATION OF INDEPENDENCE

The independent Environment Assessment Practitioner

I, ***Jenny Ellerton***, declare that I:

- Act as an independent Environmental Practitioner for the Alexander Coal Project.
- Do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the Environmental Impact Assessment Regulations, 2014.
- Have no and will not have any vested interest in the proposed activity proceeding.
- Have no and will not engage in conflicting interests in the undertaking of the activity.
- Undertake to disclose, to the competent authority, any material information that has or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the Environmental Impact Assessment Regulations, 2014.
- Will ensure that information containing all relevant facts in respect of the application are distributed or made available to interested and affected parties and the public.

Signature of Specialist:

Date: July 2016

The independent Environment Assessment Practitioner

I, ***Terry Harck***, declare that I:

- Act as an independent Environmental Practitioner for the Alexander Coal Project.
- Do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the Environmental Impact Assessment Regulations, 2014.
- Have no and will not have any vested interest in the proposed activity proceeding.
- Have no and will not engage in conflicting interests in the undertaking of the activity.
- Undertake to disclose, to the competent authority, any material information that has or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the Environmental Impact Assessment Regulations, 2014.
- Will ensure that information containing all relevant facts in respect of the application are distributed or made available to interested and affected parties and the public.

Signature of Specialist:

Date: July 2016

Jenny Ellerton and Terry Harck (Solution H+)	**Mihai Museran**	**Terry Harck**
(Report Author)	**(Project Manager)**	**(Project Reviewer)**

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Synergistics Environmental Services (March 2016) *Scoping Report For The Proposed Alexander Project.* Project Number.: 750.01080.00002

Usher BH, Cruywagen L-M, De Necker E, and Hodgson FDI (2003) *On-site and Laboratory Investigations of Spoil in Opencast Collieries and the Development of Acid-Base Accounting Procedures*. Water Research Commission Report 1055/1/03, September 2003.

Van Der Walt, Byron (2012) *The Petrology, petrography and geochemistry of anomalous Borehole Core Sequence in the Highveld Coalfield, South Africa: A case Study for Diatreme Activity*. MSc Thesis. University of Johannesburg.

Zhao B, Usher BH, Yibas B, and Pulles W (2010) *Evaluation and Validation of Geochemical Prediction Techniques for Underground Coal Mines in the Witbank/Vryheid Regions.* Water Research Commission Report 1249/1/10, August 2010.

APPENDIX A: CURRICULUM VITAE OF SPECIALISTS

Jenny Ellerton
Senior Hydrogeologist / Geochemist

Curriculum Vitae

Qualifications

MSc	2005	Hydrogeology – University of Birmingham
BSc (Hons)	2002	Geology and Physical Geography Dual Honours - Keele University (Upper Second)
FGS	Since 2006	Fellow of the Geological Society

Key Areas of Expertise

Jenny has **10 years** of professional experience gained in both the UK and South Africa. Key areas of Jenny's expertise are summarised below

Groundwater Assessments	Groundwater Assessments – to support environmental impact assessments, water use licence applications and engineering design.
Hydrogeological Site Investigation	Supervising drilling contractors for numerous types of site investigations and undertaking aquifer tests.
Environmental Monitoring	Groundwater, surface water, leachate & gas monitoring.
Development of Conceptual Site Models	Analysis & interpretation of geological and hydrogeological information.
Acid Rock Drainage Assessments	Geochemical assessment and remediation of mine related water pollution.
Project Management	Experience in management of field based hydrogeological studies and desk based projects.

Summary of Experience and Capability

Jenny is a Senior Hydrogeologist within SLR with 10 years of geological and hydrogeological experience gained through a master's degree and environmental consultancy both in the UK and South Africa.

Jenny has undertaken projects covering all aspects of hydrogeology and specialises in the following:

- Site investigation, including the installation of groundwater and gas monitoring boreholes and the detailed logging of soil and rock samples.
- Undertaking monitoring and sampling of surface water, groundwater, landfill gas and leachate and undertaking field permeability tests and data analysis.
- Qualitative and quantitative Hydrogeological Risk Assessments.
- Groundwater assessments for Environmental Statements in support of planning applications for mineral extraction operations, landfill developments, and other industrial and commercial developments.

- Geochemical and Acid Rock Drainage (ARD) assessments to characterise the expected waste rock material associated with the mineral extraction process of various types of mining operations in accordance with best practice.
- Waste classification in terms of the National Norms and Standards for the Assessment of Waste for Landfill Disposal (No. R. 635) and Disposal of Waste to Landfill (No. R 636).
- Soil contamination assessment to determine the level of soil contamination in terms of soil screening values as presented in National Norms and Standards for the Remediation of Contaminated land and Soil Quality.

Recent Project Experience

Key aspects of Jenny's recent project experience are summarised below.

Project	Date	Jenny's Role
Siyanda Chrome Smelter Project (South Africa)	Current	Responsible for managing and co-ordinating the groundwater and geochemical studies. Work includes geophysical investigations, drilling and pump testing, collection of samples, development of a conceptual site model and source term and a numerical groundwater model to assess the potential impact of the site on surrounding water resources.
Kudumane Manganese Project (South Africa)	Current	Responsible for co-ordinated drilling to drill boreholes within the riverbed of the Ga-mogara River and to undertake an study to understand the groundwater / surface water interaction at the site in support of the Water Use License Application.
Manica Gold Project (Mozambique)	Current	Involved in both the groundwater and geochemical assessments for the project in support of the Environmental Impact Assessment for the Project.
Lofdal REE Project (Namibia)	Current	Responsible for the selection of representative waste samples for geochemical characterisation and undertaking an assessment of the potential for acid mine drainage (AMD) and metal leaching in support of an Environmental and Social Impact Assessment (ESIA).
Panda Hill Gold Project (Tanzania)	Current	Geochemical assessment to support engineering design work and assess potential impact on groundwater. Work included geochemical modelling and development of a salt balance.
Mokala Manganese Project (South Africa)	September 2015	Waste assessment in terms of the National Norms and Standards to determine the waste type and the class of landfill (liner specification) required to dispose of mining waste.
Alfred Knight Due Diligence Project (South Africa)	August 2014	Responsible for the selection of samples, sample analysis and interpretation of results in terms of the National Norms and Standards for the Remediation of Contaminated land and Soil Quality to determine 'baseline' condition of the soil.
Hinda Phosphate Project (Congo)	September 2013	Responsible for co-ordination and undertaking the supervision of the drilling of boreholes and pumping tests. Interpretation of field data and reporting.

Publications

None to date

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PROFESSIONAL PROFILE

Environmental Geochemist. Mine drainage quality prediction. Acid Mine Drainage (AMD) assessment. Mine water management. Integration of geochemistry, groundwater and surface water studies.

BIOGRAPHY

Terry advises Southern African and international clients on the management of acid rock drainage and contaminated seepage at mine sites. He has been practicing as a consultant for over 20 years. He was the manager and lead consultant of a team of 11 specialists before going solo as Solution[H+].

Terry is a member of the International Mine Water Association (IMWA), the Groundwater Division of the Geological Society of South Africa (GWD-GSSA), and the South African chapter of the International Association of Hydrogeologists (IAH-SA), for which he serves as Treasurer.

PROFESSIONAL EXPERIENCE

Solution[H+], Pretoria, South Africa
Principal Consultant — **February 2012 – present**
Environmental Geochemist

Golder Associates Africa, Johannesburg, South Africa
Senior Geochemist and Divisional Leader — **May 2004 – February 2012**
Specialist impact prediction studies with special reference to the geochemistry and groundwater aspects of mining impacts. Integration of hydrogeological and geochemical aspects of contamination assessment projects for the mining and related industries.

Responsible for 10 professionals: internal coordination, marketing, developing proposals, project management, commissioning specialists, report development, client liaison and budget management.

Coffey Geosciences, Sydney, Australia
Senior Geoscientist — **July 1997 – December 2003**
Led a business unit comprising four employees. Project managed mine environmental specialist studies. Business development. Internal auditor for office Quality Management System

Wates, Meiring and Barnard, Johannesburg, South Africa
Contaminant Geohydrologist/Geochemist — **July 1996 – June 1997**
Specialist hydrogeological and geochemical studies for mining and industrial clients.

Steffen, Robertson and Kirsten, Johannesburg, South Africa
Contaminant Hydrogeologist/Geochemist — **May 1995 – June 1996**
Specialist hydrogeological and geochemical studies for mining and industrial clients.

E Martinelli and Associates, Johannesburg, South Africa
Geologist — **January 1991 – December 1993**
Geophysical surveys, contractor supervision, groundwater development work.

EDUCATION

University of Cape Town, Cape Town, South Africa
M.Sc. in Environmental Geochemistry 1995
Thesis: "A Geochemical Investigation of the Aquatic Sediments, Groundwater and Surface water of the Verlorenvlei Coastal Lake, With Special Reference to Nitrate Transformations."

University of the Witwatersrand, Johannesburg, South Africa
M.Sc. in Geology 1994
Thesis: "Depositional Systems and Syndepositional Tectonics of the Basal Griqualand West Sequence, Northern Cape"

University of the Witwatersrand, Johannesburg, South Africa
B.Sc. Honours in Geology 1987

PUBLICATIONS AND PAPERS

Pretorius JA, Harck T, and Gunther P "Brine Disposal / Storage of Brine in Underground Mining Compartments – A Case Study" Solution Mining Research Institute (SMRI) Fall 2011 Conference, 2-5 October 2011, York, UK.

T Harck "Mobilisation of salts from mine waste. A pinch or a pound?" Symposium of the International Mine Water Association. September 2010, Sydney, Nova Scotia

T Harck and M Peters "Reprocessing Kimberlite tailings: A square contaminant source in a big hole?" 11th International Mine Water Association Congress. October 2009, Pretoria, South Africa

T Harck et al "Impact prediction of the reactivation of an unused tailings dam," 11th International Mine Water Association Congress. October 2009, Pretoria, South Africa

Ochieng L, Harck T, and Peters M "Net Neutralisation Potential NNP) in Kimberley Diamond Tailings and Slimes Waste Materials" 11th International Mine Water Association Congress. October 2009, Pretoria, South Africa

T Harck "Managing the Groundwater Impact of Mine Water Treatment Waste", 10th International Mine Water Association Congress. June 2008, Karlovy Vary, Czech Republic.

T Harck "Are biodiversity offsets a licence to plunder natural resources?", IAIAsa Newsletter. August 2005, South Africa.

T Harck "Old mines yield history", Australian Geographic. July – September 2002, Australia

T Harck, Willis JP, and Fey MV "Denitrification of nitrate-rich ground water entering Verlorenvlei Lake on the west coast of South Africa" Proceedings of the 4th International symposium on Environmental Geochemistry, Oct. 5-10 1997, Vail, CO, United States

T Harck "Identification and Characterisation of a Source of Contaminated Seepage", Young Water, Environmental & Geotechnical Engineers Conference, July 1996, KwaZulu Natal, South Africa.

PRESENTATIONS AND TEACHING

University of Pretoria, Pretoria, South Africa **2012-2014**
Volunteer lecturer: "Environmental Geochemistry" GTX715

Principles of low temperature geochemistry, geochemistry and origin of acid mine water, acid-mineral reactions; industrial effluents, remediation methods, waste disposal, environmental sampling and data analysis, geochemical modelling.

North West University, Potchefstroom, South Africa **2012-2013**
Extraordinary lecturer

Presented course "An introduction to Hydrogeochemistry". This included themes such as: Chemical equilibrium, Contents of Water, and Solids and water. Topics included: equilibrium constants, pH, pe, solubility, dissolved gases, alkalinity, speciation, redox reactions, ion exchange, colloids, sulphide mineral oxidation and introduction to the PHREEQC geochemical modelling code.
Supervised honours degree student during their honours project fieldwork and write-up

Golder Associates, Johannesburg, South Africa **2012-2014**
Facilitator: "Understanding and Applying Best Practice Management of Acid Rock Drainage"

Developed syllabus and course structure, and coordinated the course

Golder Associates, Johannesburg, South Africa **2011**
Facilitator: "Technical Writing"

Co-presented training material developed in-house

Department of Water Affairs and Forestry and Water Institute of South Africa – Mine Water Division **2008-2010**
Presenter: "The value of impact prediction from case studies." Second Symposium on Best Practice Guidelines"

Three geochemical prediction studies from project experience

Geological Society of South Africa – Ground Water Division **11-12 February 2009**
Presenter: "Re-evaluation of Cr(VI) Contamination After Remediation"

Case study not included in the conference proceedings

International Association for Impact Assessment – South African chapter (IAIAsa) **October 2007**
Presenter: "Does the new Mining Act further sustainability in the mining industry?"

Discussion paper not included in the conference proceedings

University of Cape Town, Cape Town, South Africa **October 2005**
Tutor

Teaching support for laboratory sessions

RECORD OF REPORT DISTRIBUTION

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