Annexure D

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IMPACT ASSESSMENT – USE OF SHALE FOR CONSTRUCTION AT GGC

EXXARO **SEPTEMBER 2022**

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ABBREVIATIONS AND ACRONYMS

The following acronyms are applicable to this document: For more details, please consult the Glossary.

ACRONYM	DESCRIPTION
AMD	Acid Mine Drainage
GG	Grootegeluk Mine
SWL	Static water level
m	Metre
mamsl	Metres above mean sea level
mbgl	Metres below ground level
IWUL	Integrated Water Use License
H_2SO_4	Sulphuric Acid

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1. INTRODUCTION

1.1 SITE DESCRIPTION

1.1.1 Location and background

Exxaro's Grootegeluk Coal Mine is located approximately 20 km west of Lephalale (Figure 1) in the Limpopo Province. Grootegeluk is an opencast coal mine where mining activities started in 1980. The mining area, consisting of six adjoining farms of 6528.54 hectares (ha). The current mining pit cover a surface area of approximately 1223,98 ha and the current depth of mining in the open pit is approximately 132 m. Appelvlakte 448LQ and Goedehoop 457 LQ was included into the Grootegeluk Mining Right in 2018, bringing the total area to 8703.35 hectares (ha), however this portion of the right still needs to be executed.

The coal is sold to Mittal Steel, the export market and to Eskom's Power Stations.

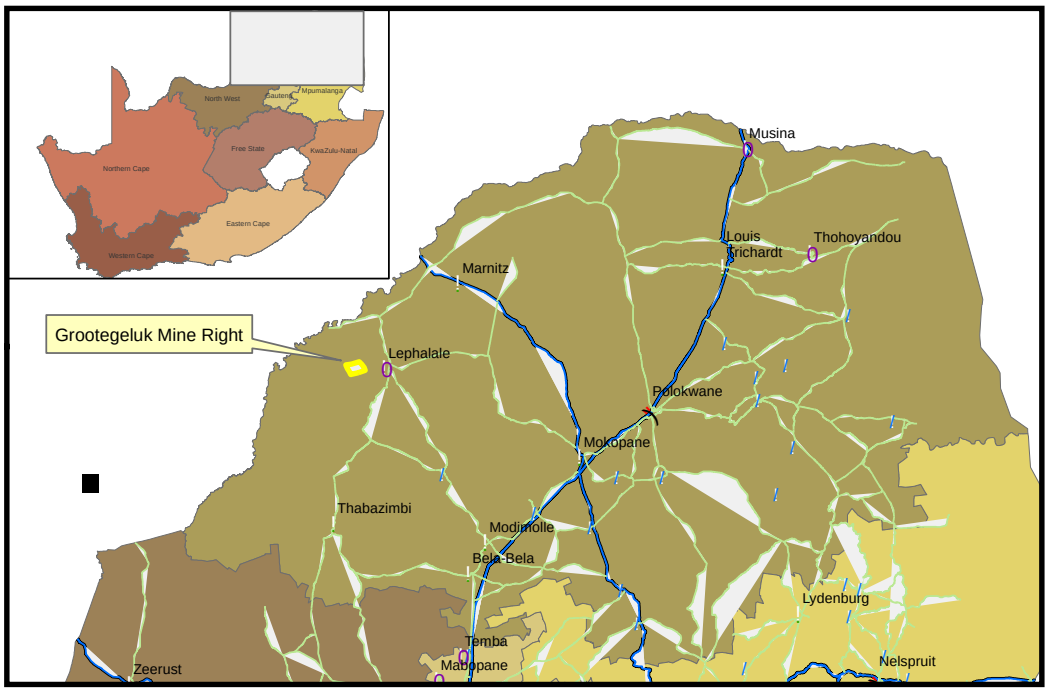

Figure 1: Grootegeluk locality map

1.1.2 Geology

The Waterberg Coal Field is part of the late Palaeozoic to early Mesozoic (~ 290 Ma -180 Ma) Karoo Sequence, a sedimentary basin covering a wide area of the Republic of South Africa.

All the classical units of the Karoo Sequence are present in the Waterberg Coal Field. The subdivision of the Karoo Sequence as encountered at Grootegeluk Mine is presented in Table 1.

Table 1. Stratigraphy of the Karoo Sequence

GROUP	FORMATION (SACS, 1980)	FORMATION (Cilliers, 1951)	Representative Rock Type	Average Thickness
STORMBERG	Drakensberg Basalt	Drakensberg	Lava, purplish to red, amygdaloidal	95m
	Clarens Sandstone	Cave Sandstone	Sandstone, fine grained, white to yellow-brown to reddish	80m
	Elliot	Red Beds	Mudstone, red to chocolate brown, clayey	90m
	Molteno	Molteno	Sandstone, white, medium to coarse grained, scattered pebbles	15m
BEAUFORT	Beaufort	Beaufort	Mudstone, purple and greenish grey, alternating at top, light grey at base	90m
ECCA	Volksrust Shale	Upper Ecca	Intercalated shale and bright coal	60m
	Vryheid	Middle Ecca	Sandstone and grit, intercalated carbonaceous shale, siltstone, few thick coal seams, mainly dull	55m
	Pietermaritzburg Shale	Lower Ecca	Shale and sandstone, grit in lower portions	150m
DWYKA	Dwyka	Dwyka	Tillite	3m

The Waterberg coal field has an east-west striking length of approximately 88km, complemented by a north-south width of ± 40km. The Waterberg coal field also extends westward into Botswana.

The coal seams occur in the Ecca Group (Volksrust and Vryheid formations) of the Karoo sequence. The upper part of the coal deposit, the Volksrust formation (±60m thick), comprises intercalated mudstone or carbonaceous shale and bright coal layers. It displays such a well-developed repetition of coal-shale assemblages that it can be divided into seven discreet sedimentary cycles or zones.

The Volksrust formation is classified as a Thick Interbedded Seam Deposit Type according to the South African guide to the systematic evaluation of coal resources and coal reserves (SANS 10320, 2004).

The Vryheid formation (± 55m thick) forms the lower part of the coal deposit and comprises carbonaceous shale and sandstone with interbedded dull coal seams varying in thickness from 1.5m to 9m. Due to its nature it is classified as a Multiple Seam Deposit Type according to the South African guide to the systematic evaluation of coal resources and coal reserves

(SANS 10320, 2004). There are five coal zones in the Vryheid formation, predominantly dull coal, with some bright coal developed at the base of Zones 2, 3 and 4.

1.1.3 Hydrogeology

Grootegeluk mine is underlain by sedimentary rocks of the Karoo Supergroup. The Karoo sequence, in the area, is situated in a graben structure which is defined by the Zoetfontein fault to the north and the Eenzaamheid fault to the south. The more recent Daarby fault cuts across the whole coalfield and intercepts the mining area between the open pit and plant area.

The aquifers of the Karoo Supergroup (mainly Ecca Group in the mining area) display characteristics of the intergranular and fractured regime. The Ecca Group is not known for the development of major aquifers, but occasional high-yielding boreholes may be present. The aquifers that occur in the area are classified as minor aquifers (low yielding). They are, however, of high importance as they are sometimes the only source of water for farming and rural communities.

The Eenzaamheid and the Daarby faults are groundwater flow boundaries as is evident by the difference in water levels on either side of the faults. Boreholes on the western side of the Daarby fault have deeper water levels than boreholes drilled on the eastern side of the fault. Two principal aquifers have been identified in the project area:

- A shallow aquifer formed in the weathered zone. This aquifer is associated with the weathered horizon normally 5 – 15 metres below ground level (mbgl). These aquifers are recharged by rainfall that infiltrates into the weathered zone. The weathered zone is generally low yielding, but yields may be higher in the Letaba Basalt Formation. The quality of the water in this aquifer is normally excellent and can be attributed to many years of dynamic groundwater flow through the weathered sediments.
- A deeper aquifer formed by fracturing of the Karoo sediments (Ecca Group). The bedrock in the area does not allow for significant groundwater movement. Most of the groundwater flow will occur along fractures, faults, cracks, and joints present within the hard rocks. The fractured rock aquifer associated with the sedimentary formations appears to be lower yielding than the Letaba Basalt to the north and east of the Daarby fault.

Groundwater monitoring is done twice a year at Grootegeluk. Figure 2 shows the positions of the current groundwater monitoring network.

Figure 2 Groundwater monitoring points

1.1.4 Surface water

Surface drainage is predominantly in a north-eastern direction with very low runoff (5%) due to the sandy soils.

No surface drainage reaches the Mokolo and Limpopo River systems. A large percentage of surface drainage is evaporated by the bushveld vegetation.

The seasonal pans, present in the area are fed from rainwater and localized run-off. Groundwater and the surface water from the seasonal pans are not interlinked, the pans are therefore not fed by baseflow from groundwater.

Figure 3 shows the positions of the surface water pans around the GGC open pit.

Figure 3. Surface water pans around the GGC open pit

2. BACKGROUND INFORMATION

The Shale of the Upper Ecca (Volksrust Formation) can be described as a light brown to brown course shale gravel with ferricrete and sandstone in a matrix of sandy silt: This material classifies as TRH14 G5 or G6 material and can be used to build roads and for other general construction purposes.

This material is in the footprint of the open pit and must be removed as part of the mining process. Due to its availability and material properties, it is the preferred road construction material.

3. IMPACT ASSESSMENT

To assess the potential impact that the use of shale in construction (mainly roads) can have on the environment the following process was used:

- Development of a source-pathway-receptor conceptual model.
- Sampling and analyses – samples were taken and submitted for waste characterization analyses (see tables below).
- Assessment of the potential impacts on the receiving environment.
- Recommendations to manage potential impacts.

3.1 CONCEPTUAL MODEL (SOURCE – PATHWAY – RECEPTOR)

3.1.1 SOURCE CHARATERIZATION - SAMPLING AND ANALYTICAL RESULTS

Two composite samples of the shale material were taken directly from the mining face. One composite sample from fresh shale [GGC-Shale (black)] and the other from weathered shale [GGC-Rock (brown)]. The analytical results are given in Table 2 (Total concentrations) and Table 3 (Distilled water leachate).

From the analytical results the following can be deduced:

- None of the leachable concentrations (LCT) exceed any of the waste classification criteria.
- Material classifies as a Type 4 waste and requires a Class D barrier if it is disposed of.

Table 2. Total concentrations

Analyses	GGC-Shale (black)		GGC-Rock (brown)				
Sample Number	161649		161650		TCT0 mg/kg	TCT1 mg/kg	TCT2 mg/kg
Digestion	HNO3 : HF		HNO3 : HF				
Dry Mass Used (g)	0.25		0.25				
Volume Used (mℓ)	100		100				
Units	mg/ℓ	mg/kg	mg/ℓ	mg/kg			
As, Arsenic	<0.001	<0.400	<0.001	<0.400	5.8	500	2000
B, Boron	0.071	28	0.178	71	150	15000	6000
Ba, Barium	0.096	38	0.495	198	62.5	6250	25000
Cd, Cadmium	<0.001	<0.400	<0.001	<0.400	7.5	260	1040
Co, Cobalt	0.058	23	0.084	34	50	5000	20000
$Cr_{Total,}$ Chromium Total	0.157	63	0.159	64	46000	800000	N/A
Cu, Copper	0.064	26	0.068	27	16	19500	78000
Hg, Mercury	0.001	0.400	<0.001	<0.400	0.93	160	640
Mn, Manganese	0.181	72	1.68	672	1000	25000	100000
Mo, Molybdenum	<0.025	<10	<0.025	<10	40	1000	4000
Ni, Nickel	<0.025	<10	<0.025	<10	91	10600	42400
Pb, Lead	0.062	25	0.071	28	20	1900	7600
Sb, Antimony	<0.001	<0.400	0.004	1.60	10	75	300
Se, Selenium	<0.001	<0.400	<0.001	<0.400	10	50	200
V, Vanadium	0.239	96	0.232	93	150	2680	10720
Zn, Zinc	0.107	43	0.164	66	240	160000	640000
Inorganic Anions	mg/ℓ	mg/kg	mg/ℓ	mg/kg			
Cr(VI), Chromium (VI) Total [o]	---	<2	---	<2	6.5	500	2000
Total Fluoride [o]	---	43.17	---	32.93	100	10000	40000
Total Cyanide as CN [o]	---	<1.55	---	<1.55	14	10500	42000

Table 3. Distilled water leachate

Analyses	GGC-Shale (black)	GGC-Rock (brown)				
Sample Number	161649	161650				
TCLP / Borax / Distilled Water	Distilled Water	Distilled Water				
Ratio*	1:20	1:20				
Units	mg/ℓ	mg/ℓ	LCT0 mg/l	LCT1 mg/l	LCT2 mg/l	LCT3 mg/l
As, Arsenic	0.001	<0.001	0.01	0.5	1	4
B, Boron	<0.025	<0.025	0.5	25	50	200
Ba, Barium	<0.025	0.131	0.7	35	70	280
Cd, Cadmium	<0.001	<0.001	0.003	0.15	0.3	1.2
Co, Cobalt	<0.025	<0.025	0.5	25	50	200
$Cr_{Total,}$ Chromium Total	<0.025	<0.025	0.1	5	10	40
Cr(VI), Chromium (VI)	<0.010	<0.010	0.05	2.5	5	20
Cu, Copper	<0.010	<0.010	2.0	100	200	800
Hg, Mercury	<0.001	<0.001	0.006	0.3	0.6	2.4
Mn, Manganese	<0.025	<0.025	0.5	25	50	200
Mo, Molybdenum	<0.025	<0.025	0.07	3.5	7	28
Ni, Nickel	<0.025	<0.025	0.07	3.5	7	28
Pb, Lead	<0.001	<0.001	0.01	0.5	1	4
Sb, Antimony	<0.001	<0.001	0.02	1.0	2	8
Se, Selenium	0.002	<0.001	0.01	0.5	1	4
V, Vanadium	<0.025	<0.025	0.2	10	20	80
Zn, Zinc	<0.025	<0.025	5.0	250	500	2000
Inorganic Anions	mg/ℓ	mg/ℓ				
Total Dissolved Solidsat 180°C	32	30	1000	12 500	25 000	100 000
Chloride as Cl	<2	<2	300	15 000	30 000	120 000
Sulphate as SO4	6	5	250	12 500	25 000	100 000
Nitrate as N	0.1	0.3	11	550	1100	4400
Nitrite as N	<0.05	<0.05				
Fluoride as F	0.4	0.3	1.5	75	150	600
Total Cyanide as CN [o]	<0.07	<0.07	0.07	3.5	7	28
pH	7.8	7.3				

3.1.2 PATHWAY CONCEPTULIZATION

The pathways of concern for contaminant transport in this case are surface water and groundwater.

Surface Water

Figure 4 shows the distribution of various overburden material around the GGC pit. Fresh (un-weathered) shale is depicted as light-yellow polygon and weathered shale as a light blue polygon around the pit. The occurrence of clayey overburden is presented by the pink polygon.

Figure 5 is a photograph of the in-situ shale. Removal of the overburden is done ahead of mining to expose the coal layers (Figure 6). Pre-stripping is part of the mining operations and therefore a dynamic process that moves with the pit expansion. Surface water run-off in the pre-stripped areas will report to the mine pit as these areas are topographically lower, therefore diverting rainwater into the mine's dirty water system. The yellow line in Figure 6 represents the approximate catchment area of the pre-stripped overburden.

Any contaminants that leach from the shale and are transported by surface water will therefore, because of the mining method, report into the mine's dirty water system. Surface water transport is therefore not a pathway of concern for off-site contamination.

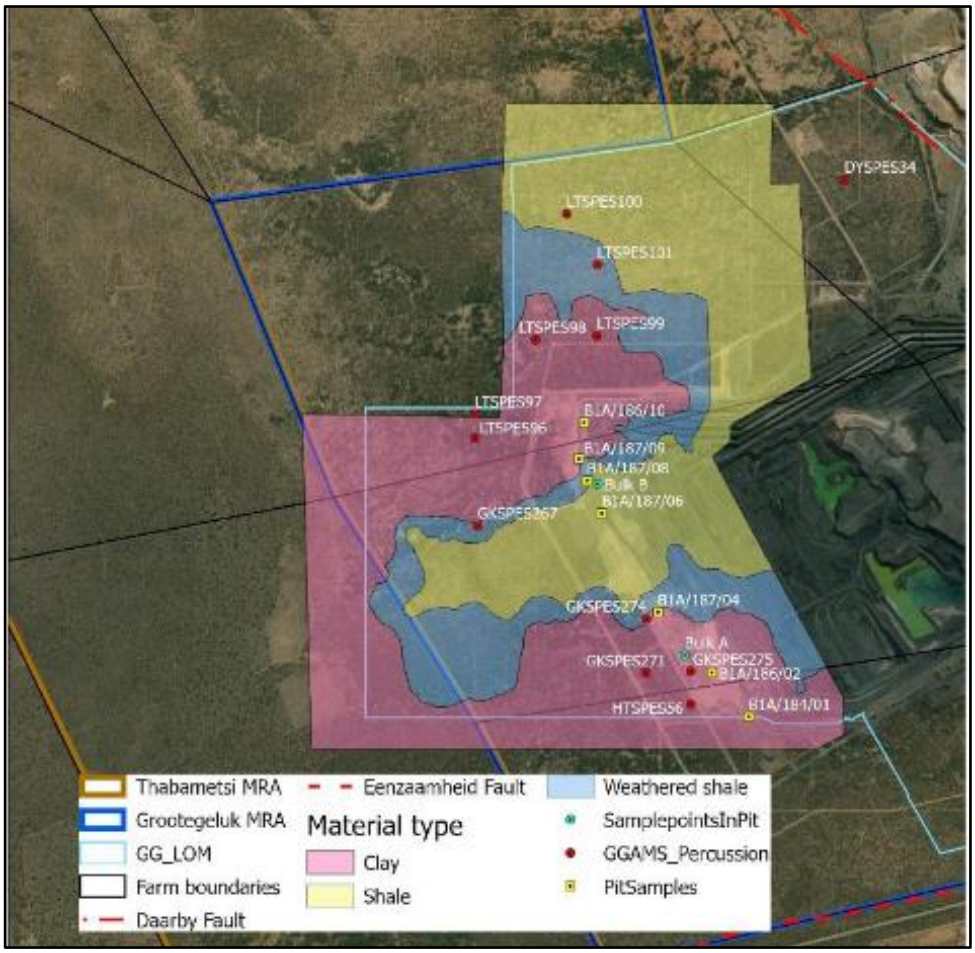

Figure 4. Overburden material around GGC open pit

Figure 5. Shale used as construction material

Figure 6. Areas where shale is used for road construction

Groundwater

Groundwater levels in the Gootegeluk area range between 10 and 60 metres below ground level. Figure 7 shows the water level distribution around the Grootegeluk complex as contours in metres above mean sea level (mamsl). From this figure the groundwater levels north of the Daarby fault have a higher elevation (i.e., closer to the surface) than those south of the fault. The Daarby fault can therefore be described as a flow barrier. The deeper groundwater levels to the south of the Daarby fault (light green contours) can be ascribed to the impact of dewatering due to mining.

Groundwater flow around the GGC open pit is towards the mining area and any contamination that is generated within the drawdown cone will flow towards the open pit. Groundwater is therefore not seen as a pathway of concern for off-site contamination.

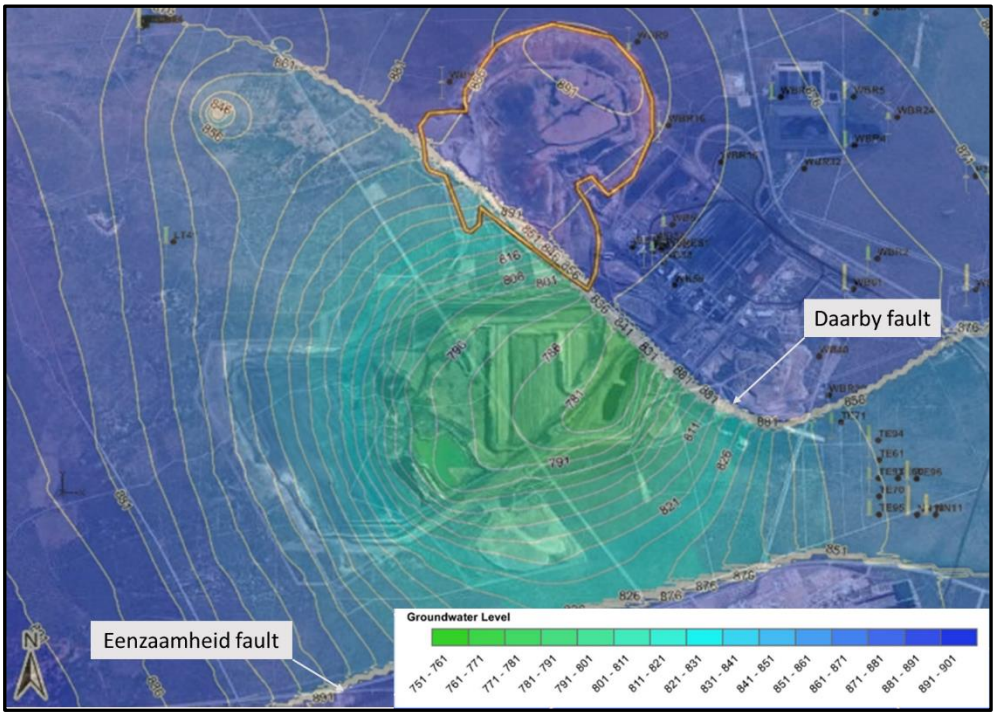

Figure 7 Groundwater level contours around Grootegeluk mine (mamsl)

3.1.3 RECEPTOR ANALYSIS

Potential receptors around the GGC open pit are:

- Surface water from the seasonal pans. Surface water run-off from the GGC area does not reach any rivers or dams other than the natural pans around the mine. Due to the pre-stripping of overburden the catchment area of surface water is continuously expanded ahead of mining, therefore capturing any run-off into the mine's dirty water system. Surface water pans are therefore not seen as potential receptors of contaminated water from the mining area.
- Groundwater sources. All the farms adjacent to the mine pit belongs to Exxaro and no groundwater users are present within 2 km from the mine pit. Due to the depth of the open pit a drawdown cone has developed around the mine and any contamination that is generated within this cone will report to the pit and therefore the mine's dirty water system.

3.1.4 IMPACT ASSESSMENT

The material classified as a Type 4 waste, based on the total concentrations of Barium, Copper and Lead. Except for Barium (0.131 mg/l) none of the contaminants of concern were detected in the distilled water leach.

Based on the above discussion of the Source-Pathway-Receptor model and the low risk of contamination leaching from the shales, the anticipated risk is low. Table 4 presents the impact assessment and proposed mitigation measures.

Table 4. Impact assessment with mitigation measures

Aspect	Potential Impact	Risk	Supporting information	Mitigation/Control
Leachate of contaminants	Surface water contamination	Low	No contaminants were leached from material in laboratory tests Material classifies as Type 4 waste - low risk Material is used in pre-strip mine area - surface run-off is captured in mine's dirty water system	Material is used within mine's dirty water system Surface water monitoring
	Groundwater contamination	Low	Low risk of contaminants leaching out of material - see lab results Groundwater is drawn down under pre-strip areas around mine pit Groundwater flow is towards the pit - any contamination will be captured into pit	Continued groundwater monitoring

4. CONCLUSION

Shale from the Volksrust Formation is present in the overburden material that needs to be stripped to expose the coal layers at Grootegeluk Mine. This shale has been classified as a G5 or G6 material and can be used to build roads and for other general construction purposes. It therefore makes sense to use this shale rather than to stockpile it and import construction material.

An impact assessment was required to evaluate the likelihood that the shale can pose an environmental risk. Samples were submitted for waste classification and the results showed that no metals or other contaminants leached from the shale.

In the unlikely event that some contaminants leach from the exposed shale, the mining system (pre-stripping) will divert all surface run-off to the pit, effectively eliminating the risk to the surface water environment.

The groundwater table has been drawn down around the pit and flow is towards the mining area. Any contaminants entering the groundwater system will therefore flow towards the open pit ena report to the mine’s dirty water system.

It can therefore be concluded that the shale poses allow (acceptable) risk of contamination of the environment and that mining operations will capture any contaminants into its dirty water system.