Feasibility Study for the Tharisa Minerals Mine East Above Ground (OG) Waste Rock Dump

epoch resources (pty) ltd

mine residue and environmental engineering consultants

PROJECT NUMBER 144-016 REPORT NO.144-016-003 REV 1 Final October 2021

Feasibility Study for the Tharisa Minerals Mine East Above Ground (OG) Waste Rock Dump

Prepared For

Tharisa Minerals (Pty) Ltd

PROJECT NUMBER 144-016

REPORT NO.144-016-003 REV 1-Final

October 2021

DOCUMENT INFORMATION

Confidentiality	Strictly Confidential
Title	eas b t Study for the Tharisa Minerals Mine East Above Ground (OG) WRD
Project Manager	A Savvas
Author	T Brümmer
Reviewer	GJ Wiid (PrEng)
Client	Tharisa Minerals (Pty) Ltd
Electronic File Name	144-016-003 E OG WRD eas b t Study Report_OCT 2021.pdf
Date last printed	29/10/2021
Date last saved	29/03/2022
Comments	
Keywords	
Project Number	144-016
Report Number	144-016-003 REV 1
Status	Final
Issue Date	March 2022

COMPILED			
TITLE	NAME & SURNAME	SIGNATURE	DATE
Report Author	Tinette Brümmer	DocuSigned by: Tinette Brümmer 1DAA160A752B4DE...	29/03/2022

REVIEWED			
TITLE	NAME & SURNAME	SIGNATURE	DATE
Project Reviewer	Guy J Wiid (PrEng)	DocuSigned by: Guy Wiid C712C6A7A2D848A...	29/03/2022

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

DD	Detailed Design
e.g.	For Example
EIA	Environmental Impact Assessment
FoS	Factor of Safety
I & APs	Interested and Affected Parties
LoM	Life of Mine
mamsl	Meters Above Mean Seal Level
MAP	Mean Annual Precipitation
NGL	Natural Ground Level
PGA	Peak Ground Acceleration
SABS	The South African Bureau of Standards
SANS	South African National Standards
TSF	Tailings Storage Facility
USCS	Unified System Classification of Soils
V:H	Vertical to Horizontal
DEA	Department of Environmental Affairs
NEM:WA	National Environmental Management: Waste Act 59 of 2008
EIA	Environmental Impact Assessment
WRD	Waste Rock Dump
TSF	Tailings Storage Facility
DWS	Department of Water and Sanitation
GN	Government Notice
WCMR	The Waste Classification and Management Regulations
NWA	National Water Act
MG	Middle Group
UG	Upper Group

Project No. 144-016

October 2021

Report No. 144-016-003 REV 1 Final

FEASIBILITY STUDY FOR THE THARISA MINERALS MINE East Above Ground (OG) Waste Rock Dump

1. INTRODUCTION

Epoch Resources (Pty) Ltd (*Epoch*) was requested by Tharisa Minerals (Pty) Ltd (*Tharisa*) to undertake a Feasibility Study (*FS*) of the Tharisa Minerals Mine East Above Ground (OG) Waste Rock Dump (*E OG WRD*). Construction of the E OG WRD forms part of the Life of Mine (*LoM*) waste management plan for the storage of approximately 156.6 million m^3 of waste rock which will be required to be stored in designated above ground storage facilities. This report, along with its supporting appendices, summarises the design of the proposed E OG WRD.

1.1. Project Location

The Tharisa Minerals mine is in the North West Province of South Africa adjacent to the N4 highway and the Marikana road. The closest major town is Rustenburg approximately 30 km west of the mine and located approximately 5 km north of the mine is the small farming town of Marikana.

The mine is subdivided into the so-called East and West mine by the Marikana road. The proposed E OG WRD is located on the Tharisa Minerals East mine, as illustrated in Figure 1-2.

1.1. Project Background

Tharisa Minerals Mine is currently an open pit operation consisting of two pits located on the eastern and western sides of the Marikana Road. It is the mines intention to backfill the open pits with waste rock material on an advancing front basis once the pits have been developed sufficiently. Excess waste rock material mainly due to bulking from blasting, has been used for the construction of the Tailings Storage Facilities (TSFs) containment walls, mine haul roads and as general backfill for various platforms. Waste Rock Dumps are required for storage of the additional excess material not being absorbed by the construction of other facilities.

FIGURE 1-1: LOCATION OF THARISA MINERALS MINE

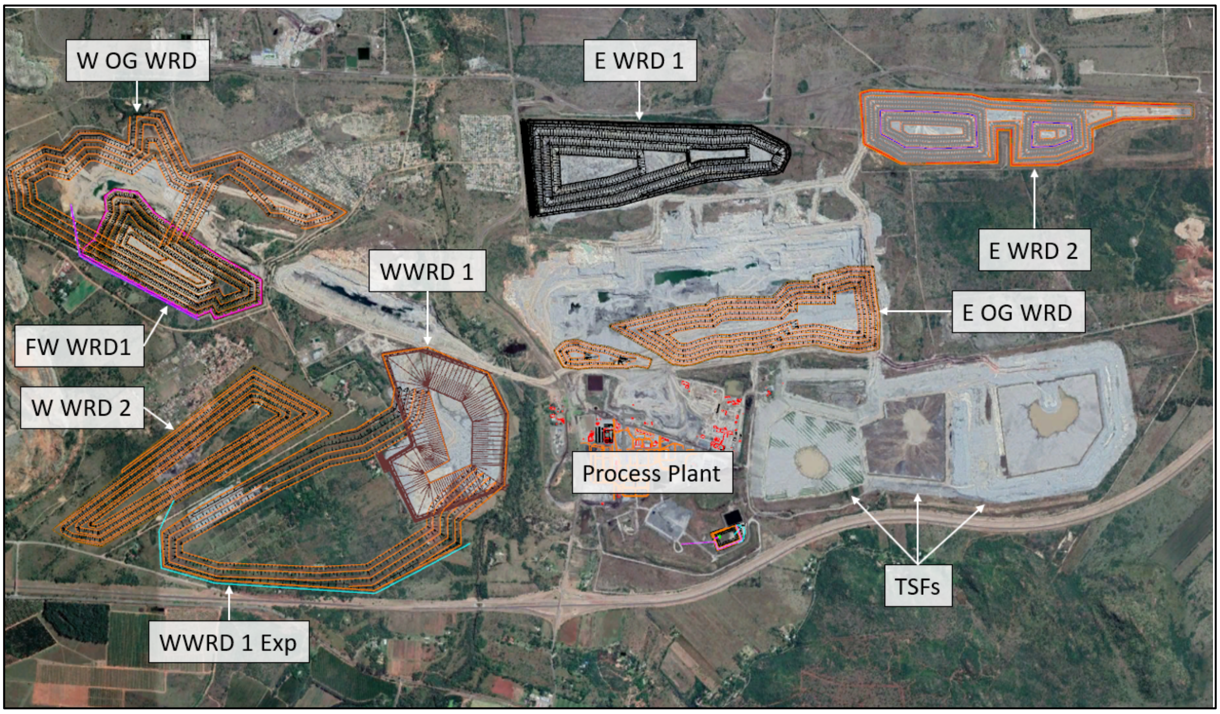

FIGURE 1-2: THARISA MINERALS SITE LAYOUT

This report describes the design of the E OG WRD and summarises guidelines for its development and operation in accordance with the requirements and minimum standards of the National Environmental Management: Waste Act 59 of 2008 (NEM:WA) and South African National Standards #10286 (*SANS 10286*) respectively.

2. TERMS OF REFERENCE

The terms of reference for the project were to undertake a feasibility design of the E OG WRD, situated over the mine's eastern open pit, as well as the stormwater management measures for this facility in accordance with the requirements of NEM:WA.

2.1. SCOPE OF WORK

The scope of work associated with the design of the E OG WRD comprised of the following:

- Collecting and reviewing all information pertinent to the study.
- Confirmation of the residue deposit design criteria;
- Confirmation of the area delineated for the development;
- Design of the residue deposit with specific reference to the specification of its geometry and the surface water diversion, infiltration water and containment structures required;
- Calculation of the storage capacity and site development strategy;
- Characterisation of the residues as required in terms of NEM:WA;
- Hazard rating of the Waste Rock Dump (*WRD*) in accordance with SANS 10286;
- The production of construction drawings; and
- The compilation of a design report outlining the development and operation of the E OG WRD for reference purposes.

2.2. BATTERY LIMITS

The battery limits in addressing the scope of work for the FS are as follows:

- The downstream toe of the WRD; and
- The boundary fence around the WRD;

2.3. EXCLUSIONS

The following is excluded from Epoch's scope of work:

- Ground survey work;
- Liaising or obtaining permission from various government authorities e.g. licences, permits, relocation of major services etc.;

- Hydrological, Geohydrological and other environmental investigations or studies required for the Environmental Impact Assessment (EIA) or for engineering design purposes. Some of the results from these studies are however required for the design of WRD;
- Geotechnical investigation of the underlying soils within the footprint of the proposed facility;
- Determination of flood lines along water courses;
- Stream diversions;
- Water supply studies;
- Participation and consultation with Interested and Affected Parties (*I & Aps*); and
- The design and costing of mechanical works e.g. pumps, electrics, process controls and instrumentation.

3. AVAILABLE INFORMATION

The following information was made available for the design of the E OG WRD:

- A 1 m contour interval digital terrain model covering the project area;
- The mine infrastructure plan and surrounding property demarcations;
- A digital terrain model for the design of the Tharisa Mine West Pit;
- Conceptual Design and Management of Surface Water and Waste Facilities for the Proposed Tharisa Project report compiled by Metago Environmental Engineers (*Metago*), report number 1, project number T014-02, May 2008;
- EIA study compiled by SLR in September 2014 titled: "*Environmental impact assessment and management programme report for changes to the pit, tailings dam and waste rock facilities; a chrome sand drying plant and other operational and surface infrastructure changes*";
- A lithology study compiled by SLR in December 2019 titled: "*Tharisa mine waste rock dump assessment report*";
- Actual daily rainfall figures from the Buffelspoort II Agricultural Weather Station from 1938 to 2008 (No. 0511855 A9, latitude: 25.7500, longitude: 27.5830, altitude 1230 mamsl.) This weather station is situated approximately 3.5 km north of the Buffelspoort Dam and approximately 2 km south west of the site;
- Average monthly evaporation figures from the Department of Water and Sanitation (*DWS*) weather station, namely Buffelspoort Dam Station No. A2E005, based on actual monthly figures from 1925 to 1997;

- Average monthly rainfall figures from the Buffelspoort II Agricultural Weather Station based on data from 1925 to 2007;
- Average monthly evaporation figures from the Buffelspoort II Agricultural Weather Station based on data from 1976 to 1991; and
- South African Legislation regarding mine residue facilities including:
    - National Environmental Management: Waste Act;
    - Mineral and Petroleum Resources Development Act; and
    - National Water Act.

3.1. Legislative Requirements

The legislative requirements pertaining to the design of WRDs are covered in a range of statutes and regulations as summarised below.

3.1.1. National Environmental Management: Waste Act 59 of 2008 (NEM:WA)

The requirements for the design of waste dumps in terms of NEM:WA are contained in a number of regulations published in terms of the Act.

The definition of waste was amended through the NEM:WA Amendment Act 26 of 2014 and defined as "*any substance, material or object, that is unwanted, rejected, abandoned, discarded or disposed of, by the holder of that substance, material or object, whether or not such substance, material or object can be re-used, recycled or recovered and includes all wastes as defined in Schedule 3 to this Act*".

Schedule 3 contains a list of defined wastes divided into two categories, namely Category A: Hazardous waste and Category B: General waste. The following waste type is recognised within Category A:

Wastes resulting from exploration, mining, quarrying, and physical and chemical treatment of minerals including:

- Mineral excavation;
- Physical and chemical processing of metalliferous minerals;
- Physical and chemical processing of non-metalliferous minerals; and
- Wastes from drilling muds and other drilling operations.

Part 4 of the NEM:WA pertains to listed waste management activities. These are considered to be activities that have, or are likely to have, a detrimental effect on the environment. In accordance with section 19(1) of the NEM:WA, the Minister published a schedule of listed waste management activities in Government Notice (GN) 921 of 29 November 2013. According to section 2 of GN 921, no entity may commence, undertake, or conduct a listed waste management activity unless a licence is issued in respect of that activity.

Residue stockpiles and deposits were previously excluded from waste management licensing. However, the National Environmental Management Laws Amendment Act 25 of 2014 amended the NEM:WA so that a waste management license is required, from 2 September 2014, for residue stockpiles and deposits relating to prospecting, mining, and exploration or production activities.

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 and assessment of waste for disposal. The WCMR references the following norms and standards regarding waste type assessments:

- 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).

Regulations regarding the planning and management of residue stockpiles are set out in GN R 632 and GN R 633. The relevant sections are listed below:

- Regulation 3(2) of GN R 632 states that: "*The management of residue stockpiles and residue deposits must be in accordance with any conditions set out and any identified measures in the environmental authorisation issued in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998), an environmental management programme and a waste management licence issued in terms of the Ac*t."; and
- Regulation 4 of GN R 633 states that: "*An environmental management programme or plan approved in terms of the Mineral and Petroleum Resources Development Act, 2002 shall be deemed to have been approved and issued in terms of this Act*."

3.1.2. MINERAL AND PETROLEUM RESOURCES DEVELOPMENT ACT, 2002 (ACT N0. 28 OF 2002)

Requirements for the design, operation and closure of Mine Residue Disposal Facilities as contained in Government Notice 527 (23rd April 2004) published in terms of the Minerals and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002) have essentially been replaced by the provisions of Government Notice 632 (24th of July 2015) published in terms of the National Environmental Management: Waste Act, 2008 (Act 59 of 2008)

3.1.3. NATIONAL WATER ACT, 1998 (ACT 36 OF 1998)

Section 21(g) of the National Water Act (Act 36 of 1998) classifies the disposal of mine residues as water use. The objective of the National Water Act (NWA) in terms of the design of mine residue deposits is to reduce and prevent pollution and degradation of water resources, thereby protecting aquatic and associated ecosystems and their biological diversity.

Regulation 4 of GN 704 in terms of the NWA regulates the management of surface water on and around mining and related operations and requires that; *"No person in control of a mine or activity may locate or place any residue deposit, dam, reservoir, together with any associated structure or any other facility within the 1:100 year flood-line or within a horizontal distance of 100 metres from any watercourse or estuary, borehole or well, excluding boreholes or wells drilled specifically to monitor the pollution of groundwater, or on water-logged ground or ground likely to become waterlogged, undermined, unstable or cracked".* However, the Minister may in writing authorise an exemption from the requirements of regulations relating to restrictions in the locality on his or her own initiative or on application, subject to such conditions as the Minister may determine

The legislative requirements pertaining to the design of the Surface Water Management Measures are contained in Regulation 6 of GN 704 in terms of the National Water Act, 1998 (Act 36 of 1998), which stipulates that *"Every person in control of a mine or activity must:*

- Confine any unpolluted water to a clean water system, away from any dirty areas.
- Design, construct, maintain and operate any clean water system at the mine or activity so that it is not likely to spill into any dirty water system more than once in 50 years.
- Collect the water arising from any dirty area, including water seeping from mining operations, outcrops or any other activity, into a dirty water system.
- Design, construct, maintain and operate any dirty water system at the mine or activity so that it is not likely to spill into any clean water systems more than once in 50 years; and
- Design, construct and maintain all water systems in such a manner as to guarantee the serviceability of such conveyances for flows up to and including those arising as a result of the maximum flood with an average period of recurrence of once in 50 years".

3.2. CLIMATIC DATA

The average monthly rainfall and evaporation figures used for the design of the E OG WRD were obtained from the Buffelspoort II Agricultural Weather Station from 1938 to 2008 and is presented in Figure 3-1. This station was used as it was the closest station to the site situated approximately 2 km south-west of the site. From the station data, the average monthly rainfall depths were determined. The seasonal variances in rainfall depths were presumed to be the 10^{th} percentile (or 90% probability of exceedance) and the 99^{th} percentile (or 1% probability of exceedance) rainfall depths, which were determined to simulate the extreme "dry" and "wet" seasons respectively. Table 3-1 lists the discussed rainfall depths as well as the A-Pan evaporation depths.

Table 3-1: Rainfall and evaporation depths for the project area

Month	Average rainfall (mm)	Cumulative Average Rainfall (mm)	Evaporation (mm) A-Pan	Cumulative Average Evaporation (mm)	Nett Evaporation – Rainfall (mm)
January	126	126	195	195	69
February	97	223	165	360	68
March	85	308	158	518	73
April	46	349	125	643	84
May	14	366	107	750	90
June	8	374	87	837	79
July	4	379	97	934	92
August	6	385	128	1062	122
September	18	403	168	1230	150
October	60	460	193	1423	136
November	87	548	189	1612	101
December	117	667	199	1811	80
Total	**669**	**667**	**1811**	**1811**	**1144**

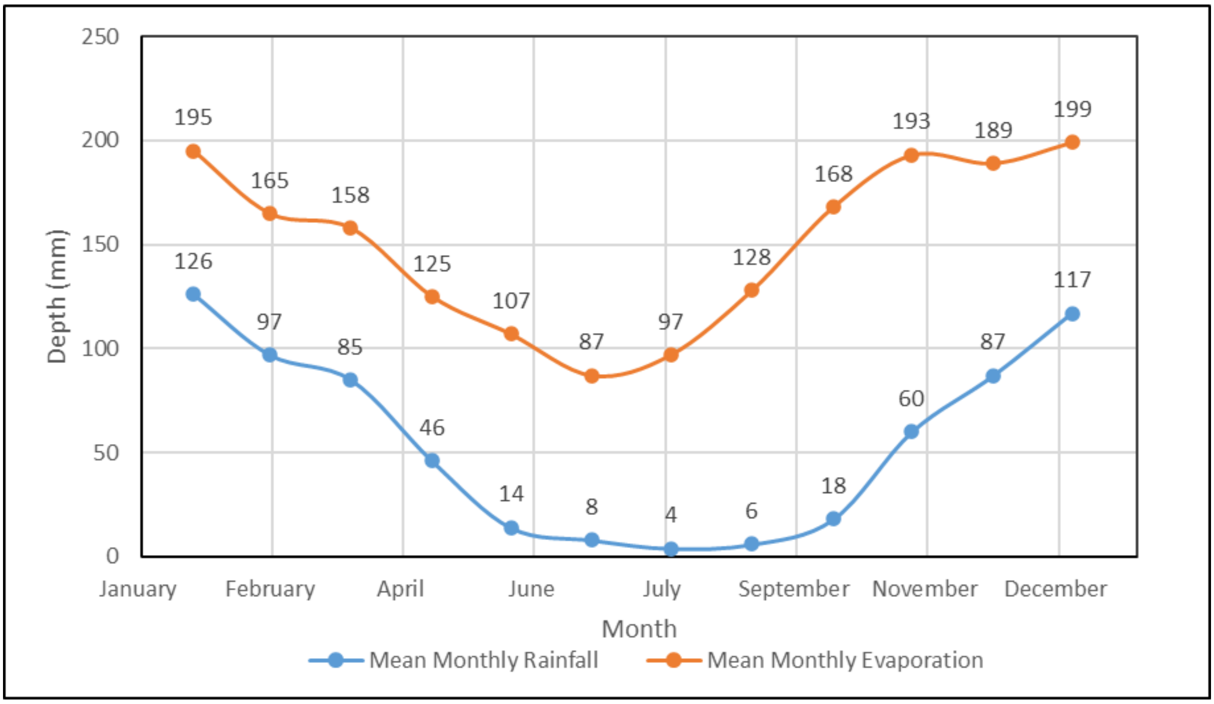

Figure 3-1: Daily rainfall depths as recorded from the Buffelspoort weather station

3.3. Design Storm Events

Adamson (1981) estimates the flood depth for recurrence intervals from 2 to 500 years based on empirical relationships developed from flood depth based on the daily rainfall and storm event recordings at over 2,400 sites across South Africa and Namibia. Table 3-2 lists the 1-day storm events based on the empirical relationship. Adamson (1981) states that a 24-hour event is approximated by increasing the equivalent 1-day event by a factor of 1.11, as listed in Table 3-2.

Table 3-2: Design floods depths based on Adamson (1981)

Duration	Rainfall Depth (mm) for each Recurrence Interval							
	2 Years	5 Years	10 Years	20 Years	50 Years	100 Years	200 Years	500 Years
1-day	70	87	99	110	126	139	152	170
24-hour	78	97	110	122	140	154	169	189

3.4. Site Geology

The Tharisa Minerals Mine is located along the south-western limb of the mineral rich main zone of the *Bushveld Igneous Complex,* as illustrated in Figure 3-2.

The mine extracts the Middle Group (*MG* and *UG*) Chromitite layers mine plan from an open pit with an expected life of 15-years. Expectations are for an additional further 40 years of underground mining life.

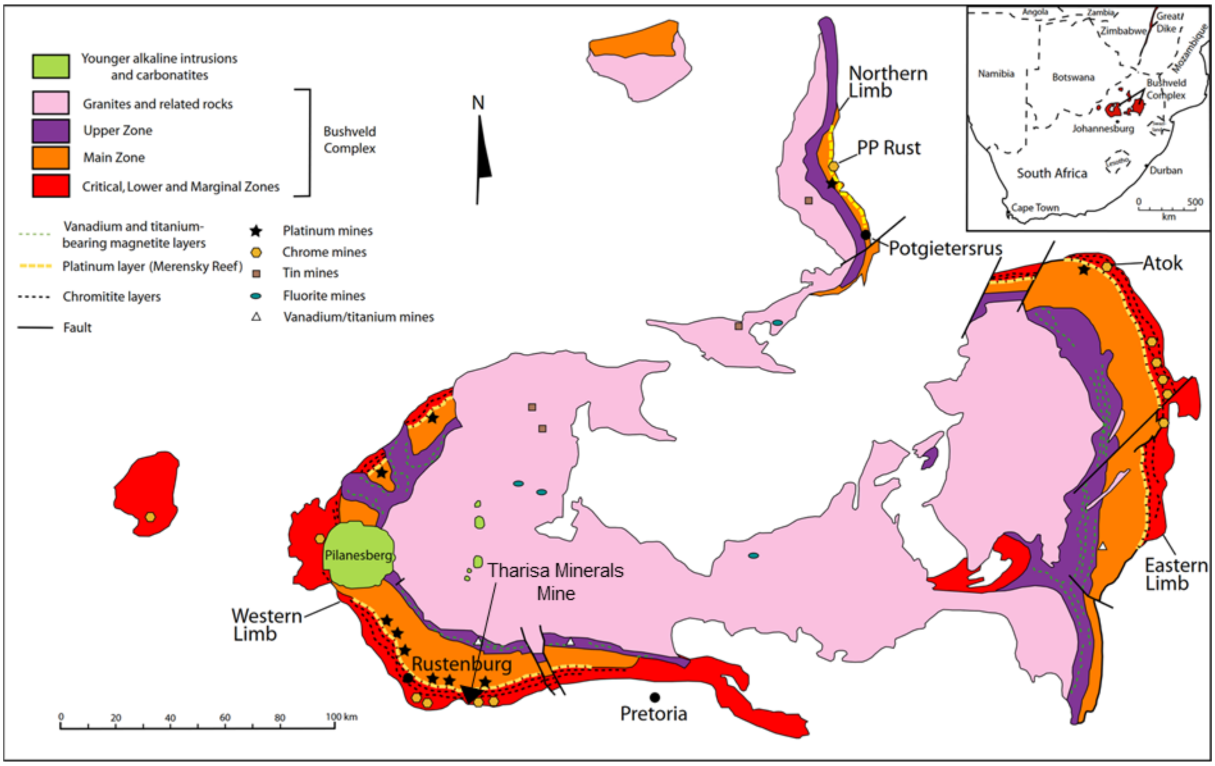

Figure 3-2: Project location on the geological map of South Africa

According to the geological map of South Africa obtained from the Council for Geoscience, illustrated in Figure 3-3, the mine is located over the following lithographic formations:

- Kroondal and Kologeng Norite (Rkk) formation to the west comprising of:
    - Norite; an
    - Quartz Norite.
- Vlakfontein subsuite (Rvl) to the east comprising of:
    - Pyroxene;
    - Harzburgite; and
    - Norite.
- Schilpadnest subsuite (Rsa) to the north, and the location of the mine open pits, comprising of:
    - Feldspathic pyroxene;
    - Leuconorite;
    - Anorthosite;
    - Pyroxenite; and
    - Chromitite.

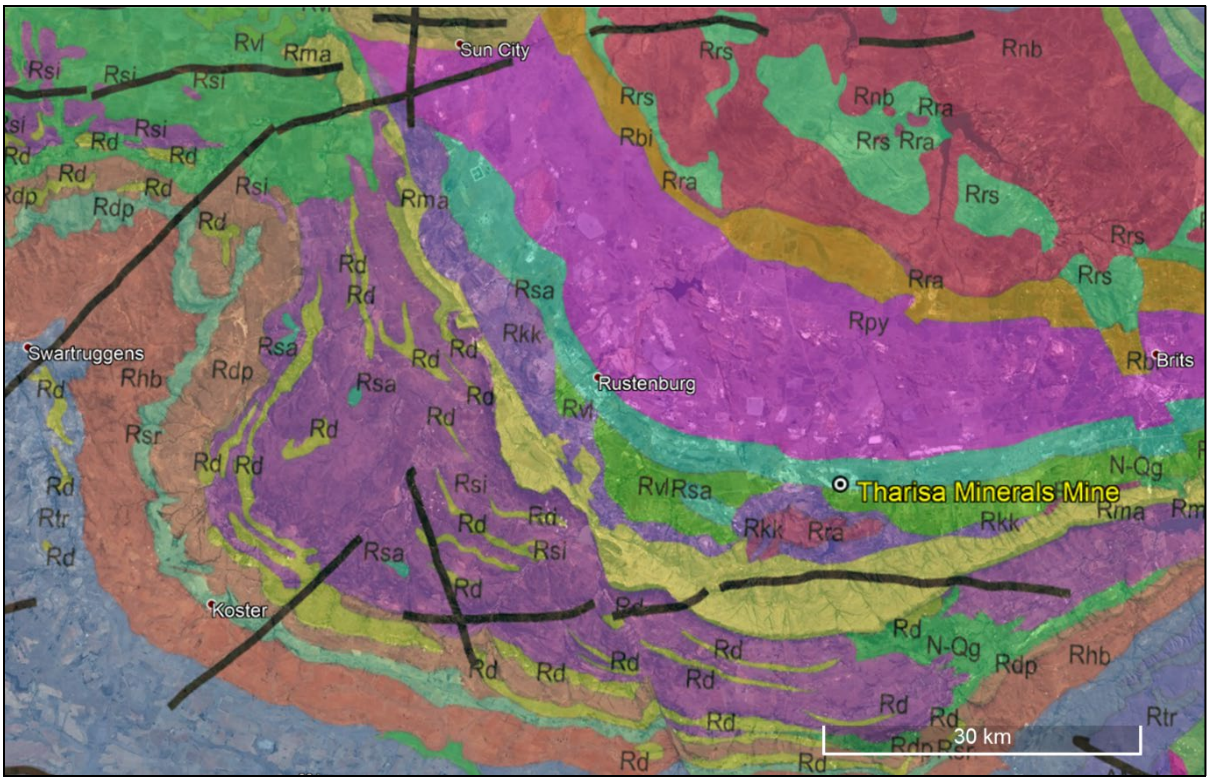

FIGURE 3-3: LITHOLOGY AT THE THARISA MINERALS MINE

3.5. Waste Classification

The waste classification, and assessment in terms of the requirements stipulated by the DWS was undertaken by SLR in 2019. Waste is classified according to a hazard classification threshold based on the following:

- Total Concentrate Threshold (*TCT*) which refers to the total existence of a substance present in the residue; and
- Leachable Concentration Threshold (*LCT*) which refers to the potential mobilisation of a substance within the residue.

3.5.1. Waste Assessment

The TCT and LCT are determined through geochemical testing by an accredited laboratory and categorised accordingly to the threshold limits. The three TCT and four LCT limit categories according to NEMWA are listed in Table 3-3 and Table 3-4 respectively, with the results of the waste assessment on the lithology samples completed by SLR.

The waste type is assessed to determine the potential liner requirements and Figure 3-4 illustrates the general processes to be followed based on the South African Waste Assessment Regulations (GN R.635 of 2013).

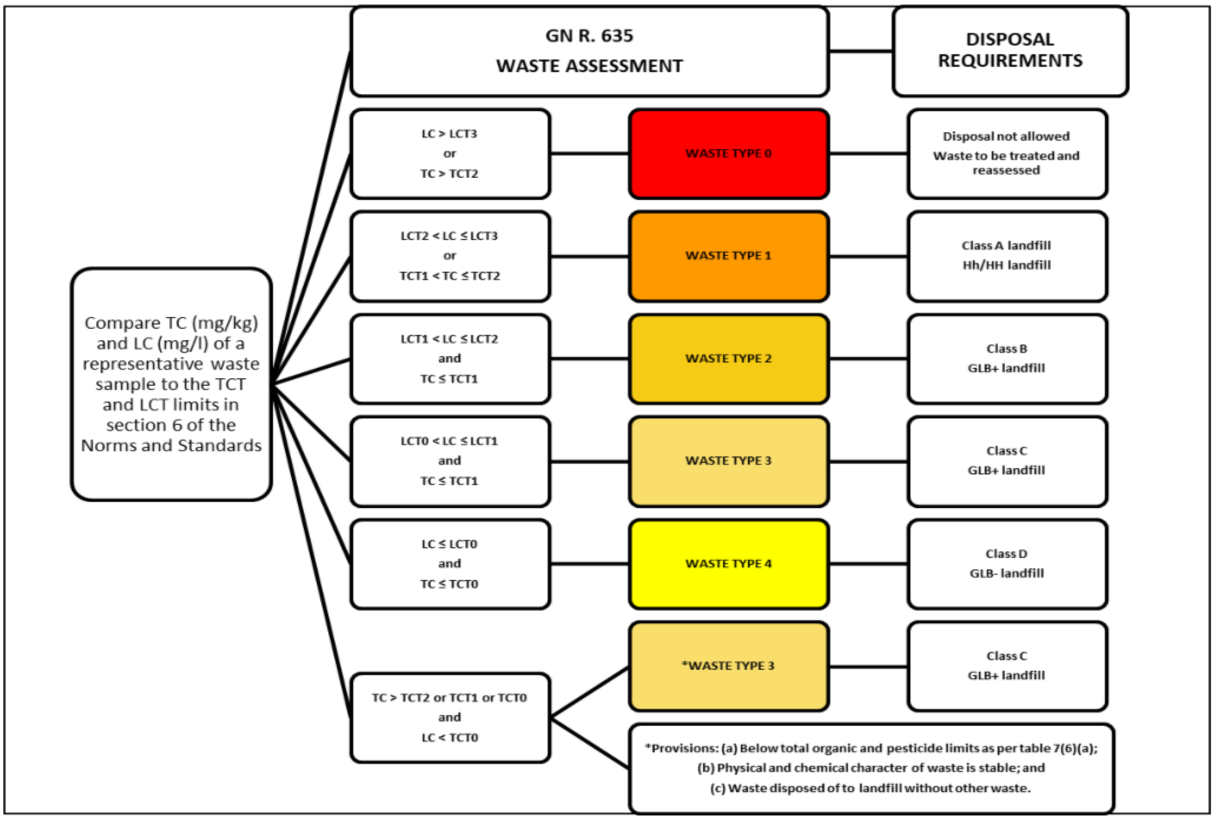

Figure 3-4: Flow Diagram for Assessing Waste in Terms of South African Waste Assessment Regulations (GN 635 of 2013)

TABLE 3-3: TOTAL CONCENTRATION THRESHOLD LIMITS AND LITHOLOGY SAMPLES RESULTS

ELEMENTS & CHEMICAL SUBSTANCES IN WASTE	TCT0	TCT1	TCT2	OBW-1	OBW-1 (D)	OBW-2	OBW-3	OBW-4	OBW-5	OBW-6	IBW-7	IB2-8	IBW-9	IBW-10
Metal Ions														
As Arsenic	5.8	500	2000	0.4	0.4	0.3	0.3	0.4	0.3	0.2	0.5	0.8	0.5	0.4
B, Boron	150	15000	60000	1	1	0.9	3.7	2	0.9	0.6	1.1	2.8	1.1	1
Ba, Barium	62.5	6250	25000	**136.9**	**133.1**	**113.2**	**116.1**	**121.8**	50.2	38.4	**66.7**	**102.3**	**134.8**	**142.3**
Cd, Cadmium	7.5	260	1040	0	0	0	0	0	0	0	0	0	0	0
Co, Cobalt	50	5000	20000	20.5	20.6	38.4	34.7	**54**	13.9	15	**70.6**	**72.4**	21.9	21.1
Cr (VI), Chromium (VI)	6.5	500	2000	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Cr Total (Chromium Total)	46000	800000	800000	163.1	158.7	416.8	361.5	615.6	1952.3	2832.4	1753.5	2540.4	256.1	181.3
Cu, Copper	16	19500	78000	**205.2**	**212.3**	**16.2**	**20.5**	**19.9**	12.1	13.5	**22.4**	**20.7**	**207.2**	**188.4**
Hg, Mercury	0.93	160	640	0	0	<0.01	0.5	0.2	0	0.4	0.1	1.8	0.1	0
Mn, Manganese	1000	25000	100000	491	484.6	829.8	642.7	1127.2	265.5	253.8	1896.9	1775.2	512.3	513.7
Mo, Molybdenum	40	1000	4000	0.2	0.2	2.4	1.3	1	1.1	2.2	1.1	2.4	0.2	0.2
Ni, Nickel	91	10600	42400	**107.7**	**111.7**	**170.8**	**152.9**	**268.8**	41.3	46.5	**362.4**	**349.6**	**126.1**	**106.3**
Pb, Lead	20	1900	7600	2.9	2.9	2.3	2.5	3.8	2.4	1.9	2.4	4.4	3.5	2.9
Sb, Antimony	10	75	300	0	0	0	0	0	0	0	0	0.1	0	0
Se, Selenium	10	50	200	0.2	0.2	0	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0
V, Vanadium	150	2680	10720	61	60.4	88.9	83.5	113.5	69.2	69.9	137.9	135.5	64.1	62.9
Zn, Zinc	240	160000	640000	26.9	26.7	44	39	54.4	24.9	26.7	76.3	72.6	30.1	27.6
Inorganic Anions														
F	100	10000	40000	**101.3**	96.8	87.8	87.9	80.1	**119.8**	78.3	74.8	**151.1**	**114.5**	**138.8**
CN(Total)	14	10500	42000	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

TABLE 3-4: TOTAL LEACHABLE CONCENTRATION THRESHOLDS AND LITHOLOGY SAMPLES RESULTS

ELEMENTS & CHEMICAL SUBSTANCES IN WASTE	LCT0	LCT1	LCT2	LCT3	OBW-1	OBW-1 (D)	OBW-2	OBW-3	OBW-4	OBW-5	IBW-6	IBW-7	IBW-8	IBW-9	IBW-10
pH	12	12	12	12	9.24	9.3	9.5	9.36	9.23	9.51	9.41	9.28	9.17	9.7	9.62
TDS	1000	12500	25000	100000	66	58	56	66	60	58	61	62	58	60	60
Chloride	300	15000	30000	120000	0.57	0.55	0.45	0.76	0.58	0.68	0.61	0.92	0.61	0.5	0.66
Sulphate	250	12500	25000	100000	4.58	3.51	4.13	4.09	3.14	3.33	3.14	2.76	2.88	2.76	3.47
Nitrate as (NO3)	11	550	1100	4400	0.18	0.17	0.16	0.28	0.19	0.29	0.24	0.23	0.19	0.21	0.24
F, Fluoride	1.5	75	150	600	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
CN-(total)	0.07	3.5	7	28	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
As, Arsenic	0.01	0.5	1	4	0.0025	0.0025	0.0018	0.0015	0.0017	0.0051	<0.001	0.0013	0.0045	0.0024	0.0026
B, Boron	0.5	25	50	200	0.017	0.021	0.018	0.016	0.018	0.021	0.018	0.023	0.023	0.03	0.029
Ba, Barium	0.7	35	70	280	0.117	0.114	0.132	0.106	0.097	0.134	0.112	0.121	0.141	0.196	0.199
Cd, Cadmium	0.003	0.15	0.3	1.2	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.001	<0.0001	<0.0001	<0.0001	<0.0001	<0.001
Co, Cobalt	0.5	25	50	200	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	0.001	0.001
Cr(VI), Chromium (VI)	0.05	2.5	5	20	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cr Total (ChromiumTotal)	0.1	5	10	40	0.009	0.009	0.016	0.016	0.02	0.043	0.027	0.019	0.021	0.035	0.033
Cu, Copper	2	100	200	800	0.0023	0.0022	0.0016	0.0027	0.002	0.0039	0.002	0.0027	0.0021	0.002	0.0021
Hg, Mercury	0.006	0.3	0.6	2.4	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Mn, Manganese	0.5	25	50	200	0.0155	0.0152	0.0134	0.0092	0.0134	0.043	0.0168	0.0087	0.0129	0.0427	0.0349
Mo, Molybdenum	0.07	3.5	7	28	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Ni, Nickel	0.07	3.5	7	28	0.0027	0.0029	0.0033	0.0045	0.0054	0.0065	0.006	<0.001	0.001	0.0076	0.007
Pb, Lead	0.01	0.5	1	4	<0.001	<0.001	<0.001	0.0018	<0.001	0.0011	<0.001	<0.001	<0.001	<0.001	0.0016
Sb, Antimony	0.02	1	2	8	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Se, Selenium	0.01	0.5	1	4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
V, Vanadium	0.2	10	20	80	0.0044	0.0047	0.0056	0.0068	0.0058	0.009	0.0051	0.0031	0.0028	0.0093	0.0105
Zn, Zinc	5	250	500	2000	0.0147	0.0125	0.0043	0.0041	0.008	0.0061	0.0093	0.0199	0.0093	0.008	0.0039

Based on the waste assessment completed by SLR, the total concentration limits for the TCT0 of the following elements were exceeded:

- Barium;
- Cobalt;
- Copper;
- Nickel; and
- Fluorine.

The LCT0 limit was not exceeded for any of the tested substances.

3.5.2. Waste Type and Prescribed Liner Requirement

The results from SLR's assessment indicate that the waste rock is to be classified as a Type 3 waste in terms of the total concentration of the elements exceeded as mentioned above and a Type 4 waste in terms of the leachable concentrations. Based on this conclusion Type 3 wastes require disposal to a facility with Class C lining.

The DWS accepted a proposal by the Chamber of Mines of South Africa to follow a risk-based approach on a case-by-case basis to allow for representations on alternative barrier systems for Mine Residue Deposits and Stockpiles based on a risk assessment. The risk assessment enabled an evaluation to prevent pollution. It is important to consider the potential water quality risk associated with the facility. In terms of the risk-based waste assessment undertaken by SLR, it has been motivated that Class-D liner system is required for storage of the waste rock material, based on the following reasons:

- The leachable concentrations of all the constituents are below the threshold limit which indicates a lack of mobilised leachate and a low risk of seepage;
- The placed waste material will be dry and not contain water; and
- SLR concluded from the geotechnical study that the waste rock material are not acid generating.

The prescribed lining requirements are depicted in Figure 3-5.Figure 3-5: Class D Prescribed Lining Requirement

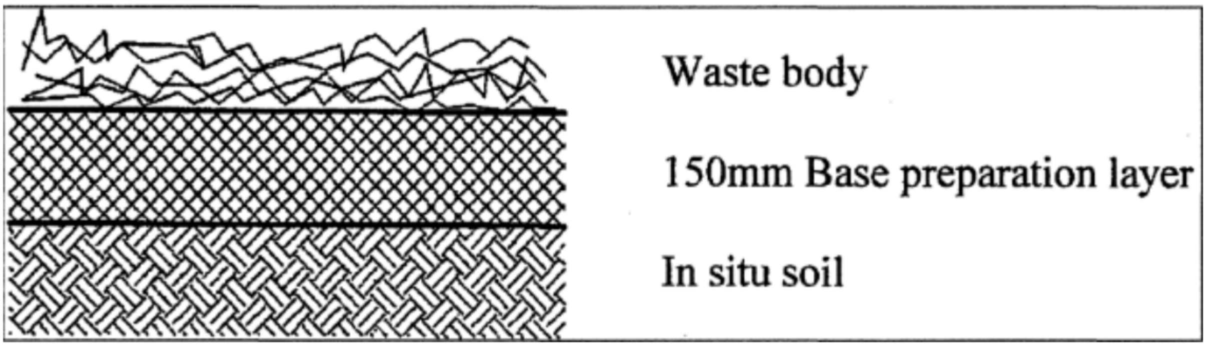

FIGURE 3-5: CLASS D PRESCRIBED LINING REQUIREMENT

The primary pollution consideration for the E OG WRD relates to the contaminated stormwater run-off that contains elevated levels of suspended solids, which will be mitigated by a dirty water containment system. Hence a Class D liner has been assumed for the FS phase of the project.

3.6. PHYSICAL CHARACTERISTICS

The manner in which waste rock is produced lends itself to a great degree of fluctuation in particle size, ranging from less than 1 mm to greater than 5 m in some cases. As such, predicting the particle size distribution of the waste rock will yield different results with each attempt. This fluctuation in particle size also results in variability in the bulk density of the placed rock, however, it has been noted that a bulk density of 2.2 tons/m^3 has been achieved at existing facilities on site.

4. DESIGN CRITERIA

The E OG WRD is to be designed to provide the maximum possible waste rock storage capacity within the available area. The Tharisa 2014 EIA Amendment provides the geometric constraints for the development of waste rock dumps at Tharisa Minerals Mine. The design criteria for the E OG WRD is summarised in Table 4-1.

TABLE 4-1: SUMMARY OF THE E OG WRD DESIGN CRITERIA

CRITERIA	VALUE	SOURCE	ADDITIONAL COMMENTARY
Maximum Height Above Ground Level	70 m	Tharisa 2014 EIA Amendment	-
Maximum Elevation	1,265 mamsl	Epoch	-
Maximum Bench Height	15 m	Tharisa 2014 EIA Amendment	-
Minimum Interim Bench Width	15 m	Tharisa 2014 EIA Amendment	-
Maximum Overall Slope	1V:3H	Tharisa 2014 EIA Amendment	-
Minimum Turning Radius	50 m	Epoch	Assumed

CRITERIA	VALUE	SOURCE	ADDITIONAL COMMENTARY
Maximum Interim Lift Slope	1V:2H (Slopes not to exceed 27°)	Epoch/SLR	Required to achieve final slope of 1V:3H with interim benches as per EIA. (SLR, 2014)
Waste Rock Production Rate	1 800 000 m^3/month	Epoch	Assumed
Waste Classification	Type-3 based on geochemistry Type-4 from Risk-Based approach	SLR 2019 Waste Assessment	-
Liner Requirement	Class-D (Motivated relaxation from Class-C)	SLR 2019 Waste Assessment	-
Maximum Topsoil Stockpile Height	30 m	Tharisa 2014 EIA Amendment	-

5. NEAR-SURFACE GEOTECHNICAL INVESTIGATION

The E OG WRD is positioned over the Tharisa Minerals Mine east open pit. The development of the pit involved the removal of soil horizons and bedrock in order to reach the ore body located within the area. The development of the east pit has progressed to such a depth that a geotechnical investigation of the near surface soil horizons of the E OG WRD footprint was not possible as these layers had already been removed. The majority of the facility will thus be founded on either competent undisturbed bedrock or waste rock from the pit backfilling campaign. Only a portion of the E OG WRD, along the southeastern toe, will be founded on an undisturbed soil horizon. Various geotechnical investigations across the Tharisa east mine, have shown that the near surface soils across this site are consistent in nature, comprising of black turf at the surface, underlain by a decomposed norite layer. Soil characteristics for the black turf and decomposed norite layer have been determined on numerous occasions over the years, with the latest study undertaken by Inroads Consulting (Inroads) in October of 2021 during the geotechnical investigation for the proposed Far West Waste Rock Dump 2 (FWWRD 2) which has subsequantly been remaned the West Above Ground (OG) Waste Rock Dump (W OG WRD), also located on the Tharisa east mine area. The report is included in Appendix 1 and it is recommended that the slope stability assessment, which is to be undertaken in the next phase of the project, incorporates strength parameters as identified in this report for the southeastern toe. Material properties of the waste rock should be sourced from Epoch's report, "Seepage and Slope Stability Assessment of the Tailings Storage Facility for Tharisa Minerals" September 2012.

6. SITE DEVELOPMENT STRATEGY

6.1. SITE SELECTION

A site selection study was not undertaken due to the limited space available for the development of WRD's both on and surrounding the Tharisa Minerals Mine. Instead, the current approach adopted by Tharisa Minerals Mine assesses the requirements for waste rock capacity and seeks to extend the available WRD's within the mines property boundary where possible or to find properties of suitable size adjacent to the current mine boundary for the development of waste rock storage facilities.

6.2. Sequence of Development

The proposed sequence of development of the facility is illustrated in Figure 6-1 through to Figure 6-5 and in a series of drawings attached as Appendix 2 to this document.

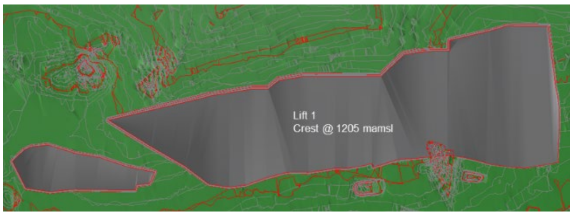

Figure 6-1 E OG WRD Lift 1

Figure 6-2 E OG WRD Lift 2

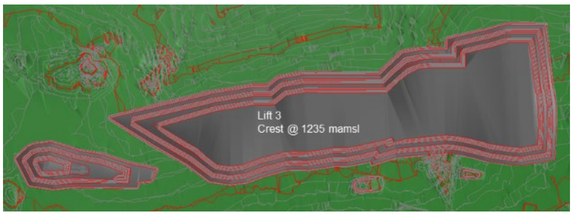

Figure 6-3 E OG WRD Lift 3

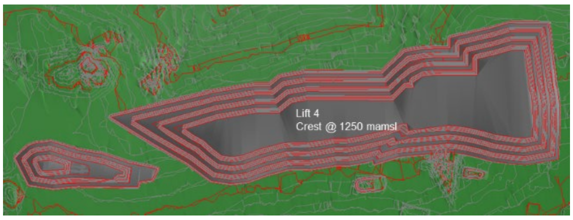

Figure 6-4 E OG WRD Lift 4

Figure 6-5 E OG WRD Lift 5

The following pertains to the waste dump development:

- The development of the waste dump will commence with the stripping of topsoil from areas of the waste dump not situated over the eastern pit, and the placement of a nominal bund of waste material to define the footprint to be developed;
- A 5 m wide structural key cut will be excavated beneath the toe of the dump in areas where the black clays are present. They will be removed down to norite and backfilled with waste rock. Representative soil strength parameters must be used in a slope stability assessment to confirm the requirement for a structural key cut;
- Topsoil and clay excavated during the preliminary construction works should be appropriately placed on designated stockpiles not exceeding 30 m in height;

- It is envisaged that the E OG WRD will be developed in a series of lifts not exceeding 15 m each, to a final elevation of 1265 mamsl;
- At each lift, the crest of the dump will be stepped in to allow for the creation of a 15 m wide stormwater control bench graded to drain towards the body of the waste dump. This, in combination with the intermediate slopes of 1V:2H, will form an overall side slope geometry of 1V:3H for the dump;
- The control of seepage from the toe of the waste dump as well as run-off from the slopes will be achieved by the construction of a series of toe paddocks and secondary toe paddock cross walls around the perimeter of the waste dump footprint, from where it will seep into the unsaturated soil or evaporate;
- A stormwater diversion trench is to be constructed adjacent to the south western toe of the facility to divert surface run-off from the surrounding area away from the facility and prevent contamination of clean water. and
- The facility will be rehabilitated for closure in line with the 2014 EIA, by placing topsoil in bowls excavated from the top surface and side slopes. The soil is to be vegetated and initially irrigated until no further artificial irrigation is needed for vegetation growth.

6.3. STAGE CAPACITY RELATIONSHIP

The E OG WRD will be developed in 5 successive lifts to provide a maximum waste rock storage capacity of 26.26 million m^3. This will provide approximately 14.6 months or 444 days of storage capacity based on a bulk waste rock production rate of 1 800 000 m^3 per month. A summary of the storage capacity per lift is listed in Table 6-1. Figure 6-6 illustrates the stage capacity relationship for the development of the waste rock dump. The construction drawings illustrating the development of the waste dump are included in Appendix 2.

TABLE 6-1: WASTE ROCK STORAGE CAPACITIES PER LIFT

LIFT FINAL ELEVATION (MAMSL)	MAXIMUM LIFT HEIGHT (M)	LIFT CAPACITY (M3)	LIFE OF LIFT (MONTHS)
1205	15	5 410 192	3.01 (~ 91 days)
1220	15	8 495 892	4.72 (~ 144 days)
1235	15	5 970 114	3.32 (~ 101 days)
1250	15	4 041 075	2.25 (~ 68 days)
1265	15	2 344 689	1.30 (~ 40 days)
Total:	**75**	**26 261 962**	**14.59 (~ 444 days)**

6.4. OPERATIONAL PHILOSOPHY

6.4.1. PLACEMENT OF WASTE ROCK

The placement of waste rock as per the proposed development plan for the facility is essential to minimise the extent of reshaping required at closure and to ensure that the stormwater management and rehabilitation plans for the facility can be adhered to. The contractor responsible for the disposal of waste to the dump will be required to ensure that:

- The toe line, outer slope, intermediate and final levels associated with each phase of the development of the dump should be set out by a properly qualified surveyor prior to the commencement of waste rock placement in the area;
- The setting out beacons and poles are protected from damage and repaired or reinstated should such damage occur to ensure continued control over the placement of waste;
- Waste is placed and levelled in layer thicknesses appropriate to the equipment in use for transporting and handling of the rock; and
- Large rocks are wherever possible dozed away from the outer slopes of the dump to facilitate the final shaping of the dump profile and its rehabilitation.

6.4.2. TOPSOIL MANAGEMENT PLAN

The placement of topsoil to facilitate the establishment of vegetation on designated areas of the waste dump will be one of the biggest costs associated with the rehabilitation and closure of the dump. It is essential that a plan is developed to ensure that topsoil is stripped from the dump footprint for use in the rehabilitation process. The plan should ensure that the stripping, stockpiling and placement of soil is planned to avoid double handling wherever possible. Topsoil should be stripped to a depth of 500 mm as prescribed by the 2014 EIA Amendment from the footprint of the WRD and appropriately placed on stockpiles not exceeding 30 m in height. The footprint area for the E OG WRD will not require any stripping of topsoil.

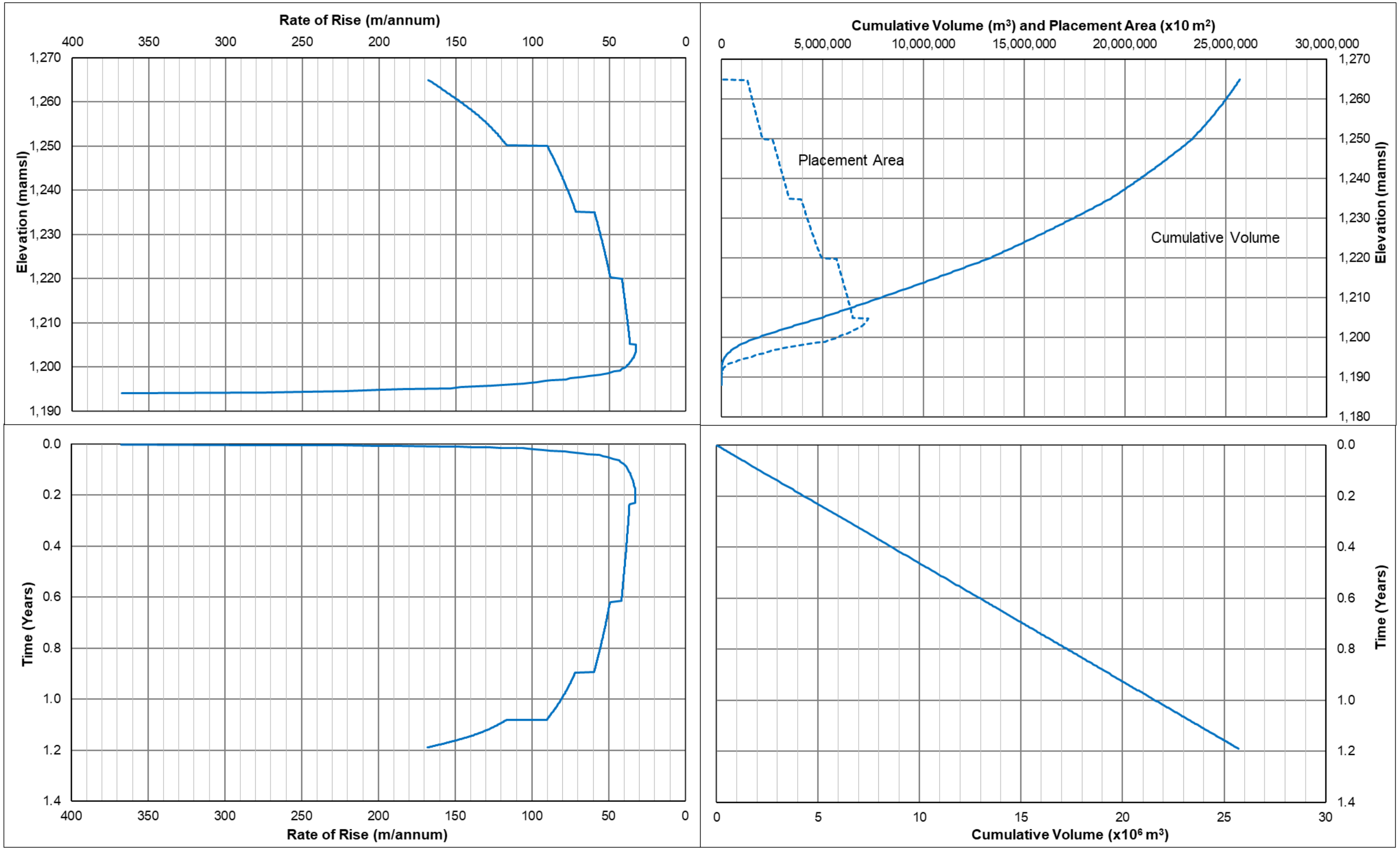

FIGURE 6-6: STAGE CAPACITY RELATIONSHIP OF THE E OG WRD

The 2014 EIA undertaken by SLR requires that the WRD be rehabilitated by placing topsoil in bowls excavated from the top surface and side slopes at closure such that the facility is sufficiently vegetated with a combination of indigenous trees, shrubs, grasses and aloe species etc.

A shortfall of material for the capping of the WRD should not be expected based on a stripping depth of 500 mm as prescribed by the EIA. However, should the 500 mm deep stripping not be achieved, additional material will have to be sourced from other stockpiles. The suitability of the topsoil and the in-situ material for the capping of the WRD and the establishment of vegetation must be assessed during the appropriate closure and rehabilitation design phase. Given the height of the soil stockpile, a vegetation specialist should be consulted to determine the nutrient status of the soil at various depths and to advise on the need for active seeding and fertilisation.

The contractor responsible for the development of the waste dump should carry overall responsibility for the management of the available topsoil to facilitate the rehabilitation and closure process. This is expected to include:

- Stripping of topsoil to the specified depths and in the prescribed manner;
- Placement of soil directly to areas to be rehabilitated wherever possible;
- Stockpiling of soil, that cannot be placed directly to rehabilitation areas, to designated topsoil stockpiles;
- Loading, hauling, placing and spreading of topsoil as required to areas ready for vegetation establishment;
- The maintenance of an up to date survey drawing providing:
  - Areas from which topsoil has been stripped;
  - The remaining areas from where topsoil is to be stripped;
  - The location of all topsoil and clay stockpiles and their volumes;
  - Areas of the E OG WRD that have been rehabilitated with a soil capping layer in preparation for vegetation establishment;
  - Areas where vegetation establishment has commenced;
  - The dates on which topsoil is moved; and
  - The dates on which vegetation establishment to the various areas commences.
- The compilation of annual reports on the management of topsoil and clay at the waste dump as well as on the progress in the rehabilitation of the final surfaces of the waste dump.

6.4.3. SURVEY CONTROL OF WASTE DUMP LEVELS AND CONFIGURATION

The control of the placement of waste rock is essential to ensure the cost-effective operation and closure of the waste dump. It is essential that the facility is constructed to the footprint extents and outer slope configuration in order to avoid the need for reshaping of the facility at closure and to ensure that the expected waste rock disposal capacity is achieved. It is expected that the necessary survey staff and equipment are available to ensure that:

- The deposition of waste rock takes place in accordance with the proposed development strategy;
- The site layout plan is kept up to date;
- The rate of advance of the various lifts is monitored;
- The benches, toe paddocks and other stormwater management features are built as specified and are shown on the layout plan;
- The stripping and stockpiling of topsoil are carried out as specified;
- The use of topsoil in rehabilitation works is carried out as specified;
- Areas of environmental or heritage sensitivity are identified, mapped and relocated as necessary; and
- Volumes and tonnages of rock placed are recorded and correlated to enable verification of the estimated in-situ density upon which the capacity of the dump has been estimated.

6.4.4. Maintenance Works

It is anticipated that a range of maintenance and sundry works will be required from time to time to facilitate the operation of the facility and to maintain the site in an acceptable condition. These works and activities would be carried out from time to time as instructed by the engineer's representative on site and are described as follows:

- Clearance of accumulated silt and debris from the toe paddocks and benches for disposal to the dump.
- Clearance of vegetation and obstructions to flow from trenches and surface water control works. The stormwater diversion, containment trenches, associated energy dissipaters and control structures are to be kept free of vegetation which may cause obstructions to flow and / or impede their inspection or the monitoring of seepage flows;
- It is intended that the establishment of vegetation on the outer slopes of the dump would be undertaken as their final shaping is completed. The contractor should carry out the establishment of vegetation in accordance with approved performance-based method statements.

7. WATER MANAGEMENT

As per the requirements of the National Water Act, clean water from run-off or released from a clean water source, must not be contaminated with dirty water emanating from a mine residue. Spillage of dirty water into a clean water system must be prevented from occurring more than once in a 50-year period (2% probability of annual occurrence). Similarly for a clean water system into a dirty water system.

The clean water systems at the project location include:

- Rainfall run-off around the footprint of the WRD;

Dirty water systems include:

- Rainfall water infiltrating into the waste rock deposit;
- Rainfall run-off from the crest and side slopes of the WRD benches (Classified as “dirty” water before the rehabilitation of the side slopes);

7.1. SURFACE WATER MANAGEMENT

It is a legislative requirement that potentially contaminated surface water runoff from the waste dump is prevented from leaving the site and that uncontaminated water from the surrounding areas is diverted around the dump and associated infrastructure by means of appropriately sized Storm Water Diversion berms and trenches.

The design and layout of the E OG WRD incorporate several features designed to ensure that surface water run-off from the waste rock dump is not released into the surrounding environment. These measures include:

- Taking advantage of the previous nature of fragmented waste rock to encourage the infiltration of rainfall into the waste body, and limit the volumes of run-off water;
- Any infiltrated water that may seep from the WRD toe, are to be collected in the toe paddocks from where it may evaporate or seep into the unsaturated soil; and
- Stormwater diversion situated next to the southern perimeter of the facility to prevent clean water run-off from the surrounding area from being contaminated by the WRD.

7.2. INFILTRATION WATER MANAGEMENT

Understanding how rainfall infiltrates is stored within, and is transported through a rock dump is essential to predicting the release of mineral weathering constituents from the waste body to the environment. Rates of water flow through a waste rock body are difficult to predict as they are dependent upon the climate, the method of dump construction, the resulting dump structure, and the physical and chemical characteristics of the rock (Williams D.J. & Rohde T.K., 2008).

Williams and Rohde (2008) undertook research studies regarding the rainfall infiltration into and seepage from waste rock dumps. The findings from their review is discussed in the section below.

The water balance of a WRD includes rainfall run-off, rainfall infiltration and evaporation. Run-off can be managed and evaporation either occurs from surface ponding or storage in near surface layers of the dump. Mechanisms of infiltration are required for rainfall water to enter and flow through the waste rock deposit. These mechanisms of rainfall infiltration may include preferential flow paths and the progressive large-scale saturation of the dump. Initially, any base seepage will occur through “pipes” or preferred flow paths in the dump which is triggered by heavy rainfall events or the cumulative storage of rainfall infiltration over time. In the early life of the dump, base seepage may be relatively high at the local “pipes” but the total amount of seepage over the area of the dump is likely to be small. Cumulative rainfall infiltration will cause saturation of the waste rock dump over time, but the rate of saturation depends largely on the climate. The net infiltration will be retained in storage, especially in the fine-grained layers of the dump. Depending on the climate and nature of the rock, an uncovered dump may eventually saturate to such an extent that continuous water pathways may form through the dump. Under such conditions, any rainfall infiltration will be matched by base seepage, which could result in a continuum breakthrough and thus a greater probability of contaminant transport to the environment

Based on the results of measurements carried out on a 15 m high waste dump at the Cadia Hill Gold Mine in New South Wales, Australia (Williams D.J. & Rohde T.K., 2008) in an area with mean annual precipitation (MAP) of approximately 750 mm, it was determined that:

- The average infiltration into the dump was approximately 50% of the cumulative rainfall over the period of measurement;
- Base seepage beneath the angle of repose slopes of the dump is approximately 50% higher than that beneath the flat top (crest) due to the reduced storage capacity;
- Flows reporting to the base of the dump beneath the crest of the dump varied over five orders of magnitude, recording between 0.0001% and 20% of cumulative rainfall. Cumulative flows to the base of the dump were measured at approximately 2.5% with the majority of rainfall (~94%) being stored within the dump; and
- Flows reporting to the base of the dump beneath the angle of repose slopes of the dump varied over five orders of magnitude, recording between 0.0003% and 9% of cumulative rainfall. Cumulative flows to the base of the dump were measured at between 3.2% and 5.5% of cumulative rainfall with the majority of rainfall (~93%) being stored within the dump.

While the measurements were carried out over a relatively short period of time they do indicate that, in an area with a MAP greater than 670 mm as in the North-West Province, the rates of seepage flows reporting to the base of the dump were low (< 5% of cumulative rainfall), with significant volumes of infiltrated water being stored within the dump.

Based on the results of the study described above and the description of the mechanisms by which water may accumulate in, and potentially flow through waste rock dumps, the following measures have been identified which would reduce the potential for the development of a continuum breakthrough and seepage if implemented:

- Waste should be mixed on placement to prevent the formation of zones of coarse material or "pipes" associated with the end tipping of material;
- Ponding of water on the top crest of the dump should be minimised by ensuring that the top surface of the dump is graded to encourage surface water flow to the edges of the dump crest and run-off for collection in the toe paddocks;
- Where possible, the crest of the dump should be compacted to reduce infiltration and encourage run-off;
- The use of benches on the slopes of the dump should be minimised to prevent the accumulation of run-off and associated seepage into the slope areas, which are more likely to reach saturation than the dump itself, which has a greater capacity to store water due to its height;
- The slopes and interim benches of the dump should be rehabilitated to promote the increased evapotranspiration of water associated with the establishment of vegetation through top-soiling and seeding; and
- Excess run-off from the dump should be contained within the toe paddocks.

The implementation of these measures will be considered in the configuration of the interim and final dump arrangements as well as in the rehabilitation and closure planning.

7.3. INTEGRATED WATER BALANCE

Containment of any run-off occurring from the E OG WRD side slopes and toe seepage due to rainfall infiltration should be contained and prevented from spilling into the environment as per the Water Act. This may be achieved by the construction of toe paddocks that will provide temporal storage of water emanating from the E OG WRD. Water temporarily stored in the toe paddocks will dissipate through seepage into the unsaturated ground or evaporate from exposure.

An integrated monthly water balance was conducted by means of a deterministic numerical analysis of the progressive development of the E OG WRD to assess the storage requirements to contain contaminated run-off from the E OG WRD side-slopes as well as infiltrated seepage water. The aim of the assessment was to determine the appropriate size of the E OG WRD toe paddocks to prevent the spillage of dirty water into the environment. Storage capacity with enough freeboard/depth is required to prevent overtopping from the paddock and spillage into the environment.

7.3.1. MODEL SETUP

The water balance model took into consideration the following dirty water inflows:

- Average monthly rainfall run-off from the slopes and the catchment area of the paddock itself; and
- Toe seepage as a result of rainfall infiltration.

Outflows from the toe paddock took cognisance of:

- Evaporation of stored water; and
- Seepage from the base of the toe paddock into the in-situ soils. Permeability of the in-situ soils was assumed to be 2.3 x $10^{\wedge -9}$, which is representative of the permeability of residual black turf which is located within the footprint of E OG WRD.

The following assumptions were made to support the model:

- That rehabilitation of the waste rock dump will reduce the volume of rainfall infiltration and conversely increase the volume of rainfall run-off;
- That 5% of the cumulative rainfall over the footprint of the WRD would reach the toe of the facility, based on the literature discussed in Section 6.2 of this report;

7.3.2. RESULTS OF ANALYSIS

An estimation of the potential toe seepage was conducted by means of a numerical analysis of the progressive development of the WRD. Figure 7-1 presents the variation of seepage potential over the life of the facility and the peak toe seepage rates from the WRD may be approximated between the ranges of:

- 4.6 m^3/month/m with a 1% probability of exceedance;
- 1.5 m^3/month/m with a 50% probability of exceedance; and
- 0.6 m^3/month/m with a 90% probability of exceedance.

Results from the life-cycle analysis of the storage depth within the toe paddocks over the operational life and up to five years post closure, is illustrated in Figure 7-2. The solid areas represent the total volume of paddock water inflow and outflow. The dotted line, representing the average storage depth within the paddocks, indicates that 15 m wide and 1 m high paddocks, with 0.75 m high paddock cross walls, will provide adequate capacity and freeboard to contain dirty water emanating from the E OG WRD.

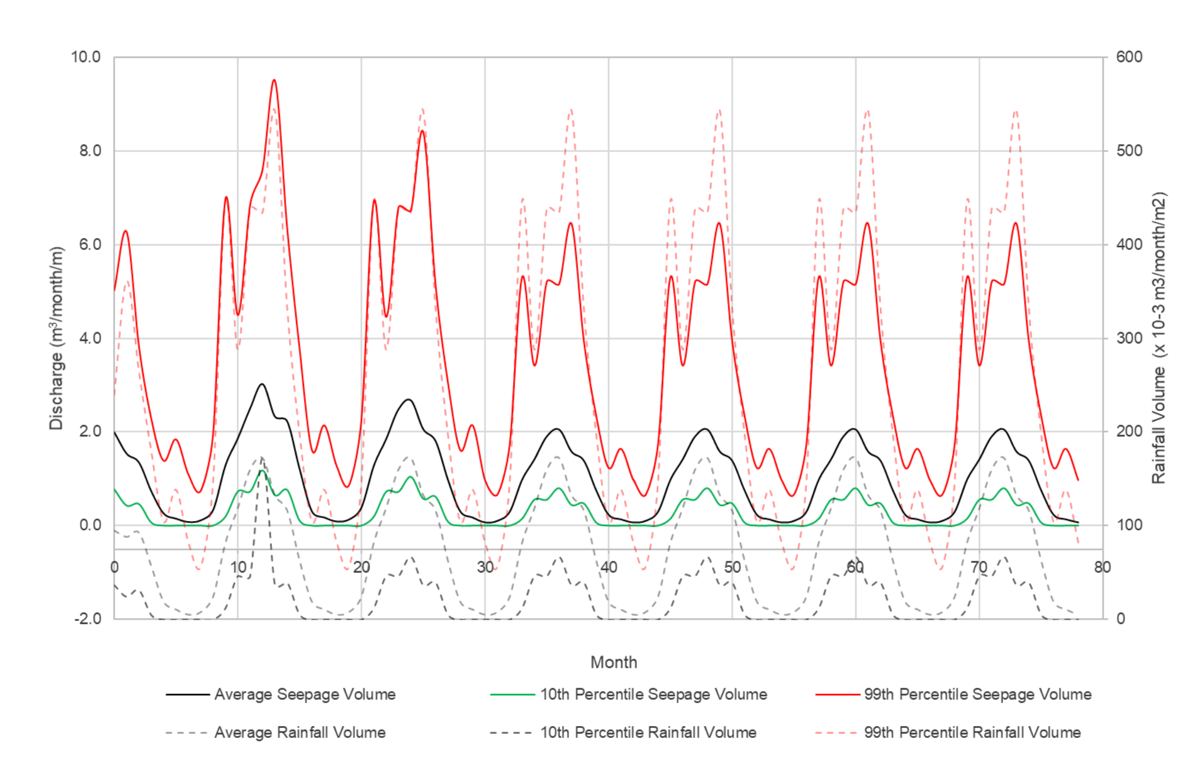

FIGURE 7-1: VARIANCE IN POTENTIAL DISCHARGE WATER AS A RESULT OF RAINFALL INFILTRATION

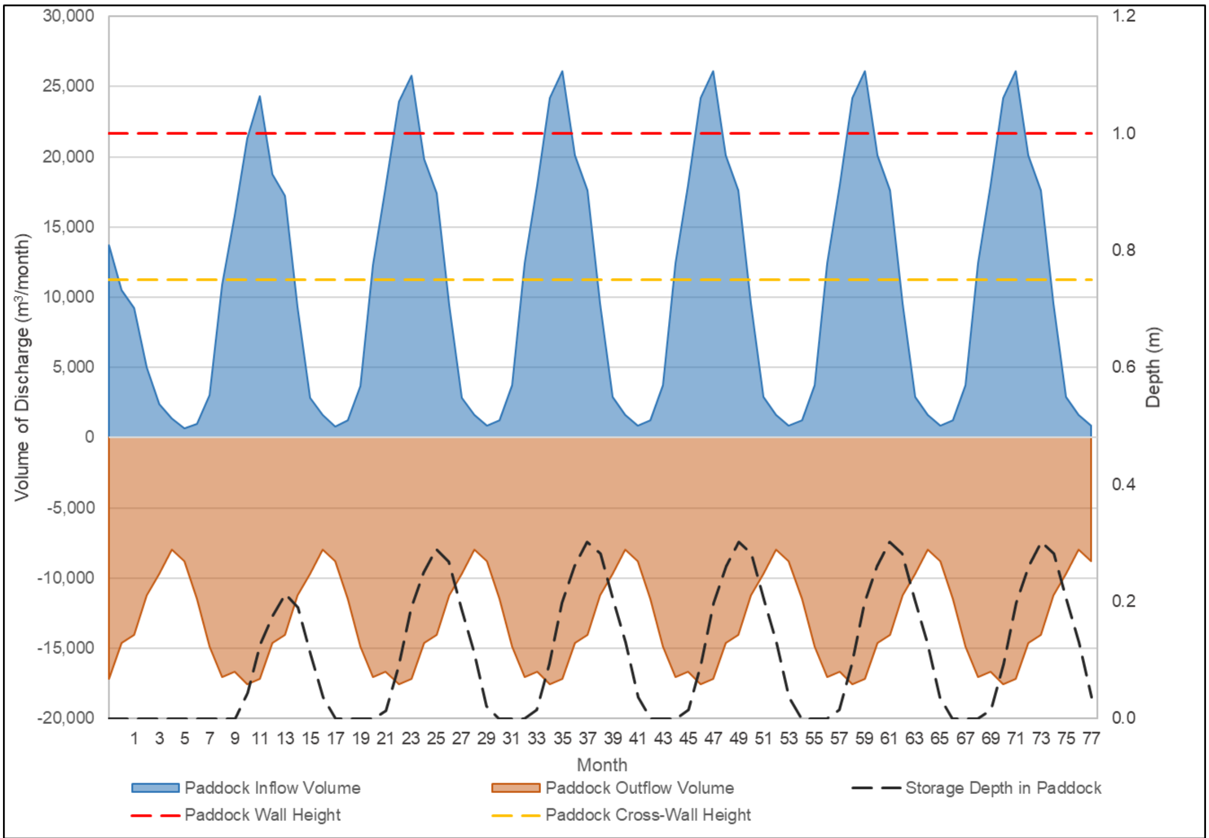

FIGURE 7-2: INFILTRATION AND RUN-OFF WATER CONTAINED IN TOE PADDOCKS WITH A MINIMUM WIDTH OF 15 M

8. HAZARD CLASSIFICATION

The safety classification of the E OG WRD has been carried out in accordance with the requirements of *SANS 10286:1998: Code of Practice for Mine Residue* (formerly SABS 0286). The safety classification system serves to provide a consistent means of differentiating between low, medium, and high hazard facilities based on their potential to cause harm to human life, property, and/or the environment. The classification system furthermore provides a basis for the implementation of safety management practices for specified stages of the life cycle of the WRD. The code prescribes the aims, principles and, minimum requirements that apply to the classification procedure and the classification, in turn, gives rise to minimum requirements for investigation, design, construction, operation and decommissioning.

8.1. ZONE OF INFLUENCE AND SAFETY CLASSIFICATION

The classification system is based on the determination of a zone of influence for the facility corresponding to the area considered most likely to be affected by a failure of a side slope. Waste rock material to be stored is not considered liquefiable and therefore assumed to not be capable of causing a flow slide in the event of a slope failure. The zone of influence for the E OG WRD, illustrated in Figure 8-1, is accordingly determined as twice the height from the finished ground level to the final crest elevation, from each respective toe point on the perimeter of the facility.

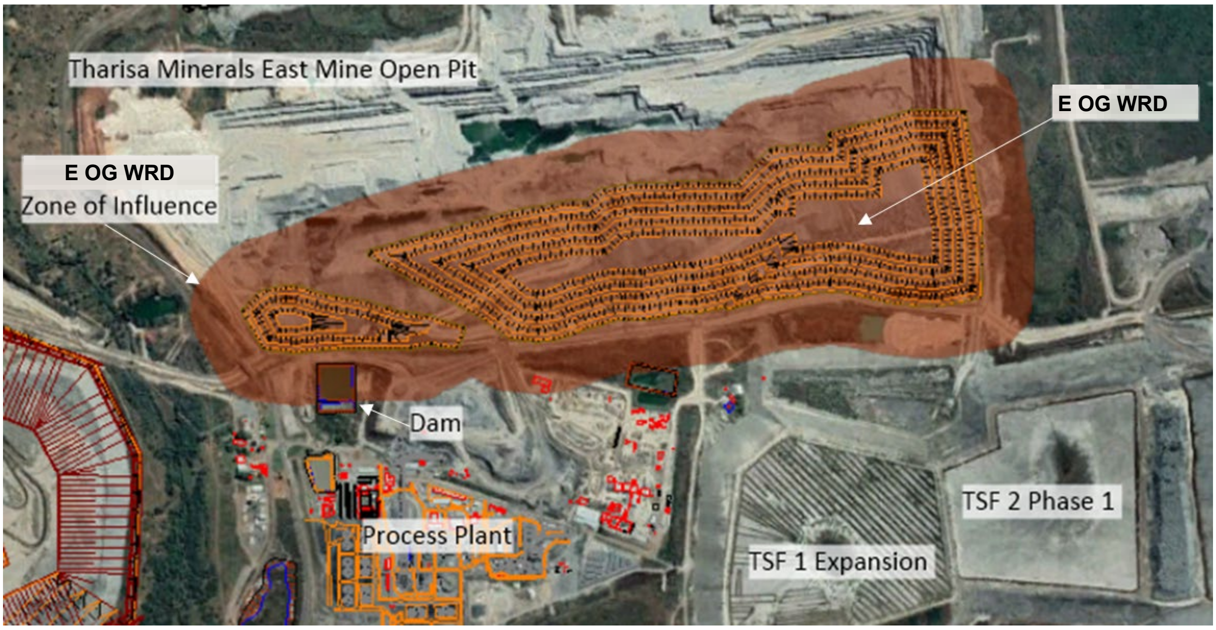

FIGURE 8-1: SANS 10286 E OG WRD ZONE OF INFLUENCE

SANS 10286 stipulates that the following be taken cognisance of when determining the safety classification of the WRD:

- The number of private residents residing within the zone of influence;
- The number of personnel employed by the mine within the zone of influence;

- The value of third-party property within the zone of influence; and
- The depth to underground workings within the zone of influence.

The extent of considerations for the safety classification in terms of low, medium, and high hazard facilities are listed in Table 8-1. Based on the zone of influence in accordance with the requirements from SANS 10286, the following findings are presented to substantiate a low hazard facility classification:

- The number of people employed by the mine within the zone of influence at any given time should not exceed ten;
- A rockslide is unlikely to affect the major national route to the south of the facility. The value of adjacent 3rd party property within the zone of influence is expected to be less than ZAR 2 m;
- Tharisa minerals is an opencast mining operation with no current underground mine workings.

TABLE 8-1: SAFETY CLASSIFICATION (SOURCE: SANS 10286:1998, TABLE 2 – SAFETY CLASSIFICATION CRITERIA)

NO. OF RESIDENTS IN ZONE OF INFLUENCE	NO. OF WORKERS IN ZONE OF INFLUENCE	VALUE OF 3RD PARTY PROPERTY IN ZONE OF INFLUENCE	DEPTH TO UNDERGROUND MINE WORKINGS	CLASSIFICATION
0	< 10	0 – ZAR 2 m	> 200 m	Low Hazard
1 – 10	11 – 100	ZAR 2 m – ZAR 20 m	50 m – 200 m	Medium Hazard
> 10	> 100	> ZAR 20 m	< 50 m	High Hazard

Note:
(1) Not including workers employed solely for the purpose of operating the deposit.
(2) The value of third-party property should be in the replacement value in 1996 terms.
(3) The potential for collapse of the residue deposit into the underground workings effectively extends the zone of influence to below ground.

8.2. ENVIRONMENTAL CLASSIFICATION

The environmental impacts associated with the development, operation, and closure of a WRD relates to its:

- Potential to contaminate surface water resources due to uncontrolled runoff of water from its side slopes or releases of water from the surface water management system;
- Potential to contaminate groundwater due to seepage;
- Potential to cause loss or contamination of soils;
- Change in land use associated with the development of the facility;
- Potential to generate dust; and
- Aesthetic impact on their surroundings.

The impacts listed above are potentially applicable to the E OG WRD and must be considered to have the ability to impact the environment adversely. These risks are discussed below, with specific reference to the mitigation measures required to ameliorate those risks.

Surface Water

The facility has the capacity to impact the local surface water quality and will be isolated from its surroundings by means of a stormwater diversion trench along the upstream perimeter and toe paddocks intended to minimise the impact on the surface water environment.

Ground Water

The infiltration of water through the facility to the underlying groundwater table may result in a deterioration of groundwater quality which should be investigated through a geohydrological study. The establishment of vegetative covers to the facility will reduce the potential impacts by increasing the storage and evapotranspiration of rainwater.

Land Use

The development of the facility will result in a change in the land use of the immediate area upon which it is established. It is possible however that the facility could be rehabilitated in such a way as to enable it to complement the intended future land use for the area.

Soil Conservation

The topsoil on the footprint area to be covered by the construction of the facility will be stripped and used for the rehabilitation of the facility for closure.

Atmospheric Pollution

The facility will have the potential to generate windblown dust. The relatively coarse nature of the waste rock is likely to mitigate this impact to an extent. On-going rehabilitation of the completed areas of the facility should further mitigate this impact.

The generation of dust from the hauling and placement of the waste rock is expected to be managed by the watering of haul roads.

Aesthetic Impacts

The facility will have an impact on the aesthetics of the area for as long as it is in operation. Upon completion of operations, the aesthetic impacts on the area can be significantly reduced, through appropriate rehabilitation. The limitations on the final height of the facility as well as the construction to the outer slopes such that top soiling and vegetation is possible are expected to mitigate the aesthetic impact.

9. CONCLUSIONS

The following conclusions are made with regards to the detailed design of the E OG WRD:

- The available footprint for the development of the WRD is confined between:
  - The EWRD 1 situated to the north; and
  - The process plant to the south; and
  - WWRD 1 to the west.
- The design of the WRD adheres to the requirements of the 2014 EIA amendment;
- The WRD has been designed to maximise the storage volume on the available footprint, resulting in a total waste rock storage capacity of 26,261,962 m^3;
- The WRD is to be constructed in five lifts, not exceeding 15 m in height, with 15 m wide benches between each subsequent lift;
- 5 m wide keys (if required) will be excavated along the perimeter of the WRD with the clays (if present) removed to the depth of the residual weathered norite as a minimum;
- Run-off from the slopes of the facility and any potential toe seepage is to be contained within 15 m wide toe paddocks on the perimeter of the facility;
- Run-off from the upstream catchment to the south of the facility is to be diverted around the facility by means of a stormwater diversion trench;
- The E OG WRD should be classified as a low-risk facility as its zone of influence does not pose a significant risk to the surrounding environment, private residences and property, nor the mine infrastructure and personnel; and
- The potential environmental impacts associated with the facility can be effectively mitigated by:
  - Ensuring that it is constructed in such a way to facilitate its rehabilitation; and
  - Ensuring that potentially contaminated surface water run-off from the facility is effectively contained within toe and bench paddocks.

10. RECOMMENDATIONS

Based on the evaluation of the available information and an assessment of the pollution potential of the proposed E OG WRD, it is recommended that:

- The development of the dump be carried out to encourage collection, containment and retention of run-off from the facilities, to limit the potential of infiltration and groundwater contamination;
- The post closure configuration of the dump be confirmed with the authorities to comprise:

- ➢ The shaping of the dump as necessary;
- ➢ The establishment of a vegetative or rock cladding cover to control erosion from the side slopes; and
- ➢ The configuration of the height and slopes of the dumps to limit its erosion potential.

- A program of sampling and testing to monitor the environmental impacts of the dump be agreed upon with the authorities to include:
  - ➢ Sampling and testing of groundwater samples;
  - ➢ Dust monitoring;
  - ➢ Periodic confirmation of the waste materials geochemistry and waste classification; and
  - ➢ Monitoring that ensures maintenance and repairs to the surface water control works takes place.
- The dump be constructed strictly in accordance with the guidelines for its development as described;
- The requirements for the construction, operation and closure of the dump be incorporated into contractually binding agreements with the contractors responsible for each lift of its development;
- A management structure is implemented for the dump whereby the performance of the contractor against the specified performance criteria is reviewed at regular intervals.

DocuSigned by: Tinette Brümmer 1DAA160A752B4DE...	DocuSigned by: Andrew Savvas A6EB058A8DF8474...	DocuSigned by: Guy Wiid C712C6A7A2D848A...
Report Author	**Project Manager**	**Reviewer**
T Brümmer	**A Savvas**	**GJ Wiid (PrEng)**

epoch resources (pty) ltd

11. REFERENCES

Department of Mineral Reources. (n.d.). Mineral and Petroleum Resources Development Act, 2002. *Act 28 of 2002*.

Department of Water Affairs and Forestry. (1998, August 20). National Water Act, 1998. *Act No.36 of 1998*.

Inroads Consulting. (August 2011). *Report on a Geotechnical Investigation for the Tharisa Tailings Storage Facility in Rustenburg.* Johannesburg.

Metago. (May 2008). *Conceptual Design and Management of Surface Water and Waste Facilities For The Proposed Tharisa Project.*

SANRAL. (2007). *Drainage Manual.* Pretoria.

SLR Consulting (Africa) (Pty) Ltd. (2014). *Environmental impact assessment and management and management programme report for changes to the pit, tailings dam and waste rock facilities; a chrome sand drying plant and other operational and surface infrastructure changes.* Johannesburg: SLR Consulting (Africa) (Pty) Ltd.

SLR Consulting (Africa) (Pty) Ltd. (2019). *Tharisa mine waste rock assessment report.* Johannesburg: SLR Consulting (Africa) (Pty) Ltd.

SLR Consulting (Africa) (Pty) Ltd. (December 2012). *Conceptual Design of the Waste Rock Dumps for Tharisa.* Johannesburg: SLR Consulting (Africa) (Pty) Ltd.

South African Bureau of Standards. (September 1998). *SABS 0286:1998.* Pretoria: South African Bureau of Standards.

The Department of Agricultural Technical Services Republic of South Africa. (1977). *Soil Classification A Binomial System for South Africa.* Potchefstroom: The Department of Agricultural Technical Services Republic of South Africa.

Williams D.J. & Rohde T.K. (2008). Rainfall Infiltration Into and Seepage from Rock Dumps - A Review. *First International Seminar on the Management of Rock Dumps, Stockpiles and Heap Leach Pads* (pp. 79 - 89). Perth, Australia: Australian Centre for Geomechanics.