THE MSA GROUP

Specialist Consultants to the Mining Industry

Bushveld Minerals Limited (BMN) and Bushveld Vametco Alloys (Pty) Ltd

Competent Persons' Report on the Vametco Vanadium Mine, North West Province, South Africa

Prepared By The MSA Group (Pty) Ltd for:
Bushveld Vametco Alloys (Pty) Ltd

Prepared By:

Mr Jeremy Charles Witley	Pr.Sci.Nat., FGSSA
Mr Trevor Rangasamy	MSAIMM
Mr Jonathan Hudson	Pr.Eng., FSAIMM
Mr John Derbyshire	Pr.Eng., FSAIMM
Mr Richard David Garner	Pr.Sci.Nat.
Mr André Johannes van der Merwe	Pr.Sci.Nat., FGSSA, MAusIMM

Report Date: 10 January 2020

Mineral Resource and Reserve Effective Date: 29 March 2019

MSA Project No.: J3798

This Competent Person's Report has been prepared in accordance with the Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves (The JORC Code) 2012 Edition.

IMPORTANT NOTICE

This report was prepared as a Competent Persons Report, prepared in accordance with the Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves (The JORC Code) 2012 Edition, for Bushveld Minerals Limited ("BMN") by The MSA Group (Pty) Ltd ("MSA"), South Africa. The quality of information, conclusions and estimates contained herein is consistent with the level of effort involved in MSA's services, based on: i) information available at the time of preparation, ii) data supplied by outside sources, and iii) the assumptions, conditions, and qualifications set forth in this report. This report is intended for use by BMN subject to the terms and conditions of its contract with MSA. Except for the purposes legislated under the United Kingdom Listing Authority in connection with the requirements of the London Stock Exchange, any other uses of this Report by any third party are at that party's sole risk.

EXECUTIVE SUMMARY

1.1 Introduction and Purpose

The MSA Group (Pty) Ltd ("MSA") was commissioned by Bushveld Minerals Limited ("BMN") and its subsidiary Bushveld Vametco Alloys (Pty) Ltd ("Vametco" or "the Company") to complete an Independent Competent Person's Technical Report ("CPR" or "the Report"), in accordance with the Australasian Code for Reporting of Exploration Results, Minerals Resources and Ore Reserves (the "JORC Code" or the "Code"), 2012 Edition, for the Vametco Vanadium Mine ("the Project"), located in the North West Province, South Africa.

Bushveld Minerals Limited (AIM:BMN), an integrated primary vanadium producer, is listed on the Alternative Investment Market ("AIM") of the London Stock Exchange ("LSE").

The Mineral Resources and Ore Reserves presented herein have an effective date of 29 March 2019. All further technical data used in the compilation of the CPR has an effective date of 26 June 2019. The Economic Evaluation was updated prior to the release of the CPR in January 2020 in accordance with the requirements of "Appendix 2 - CONTENT OF CPR of AIM Note for Mining, Oil and Gas Companies (LSE, June 2009)". The report, updated to the requirements of AIM and the London Stock Exchange ("LSE"), has a report date of 10 January 2020

The Competent Persons deem this summary to be a true and accurate reflection of the full CPR.

1.2 Project Outline

1.1.1 Property Description

The Vametco Mine is situated about 6.5 km northeast of the town of Madibeng (formerly known as Brits). The mine is an operational opencast vanadium mine, located in the Bojanala Platinum District within the North-West Province of the Republic of South Africa. The operations are near the Mmakau and Rankotea villages, which are approximately 500 m to the south and west of the operations respectively.

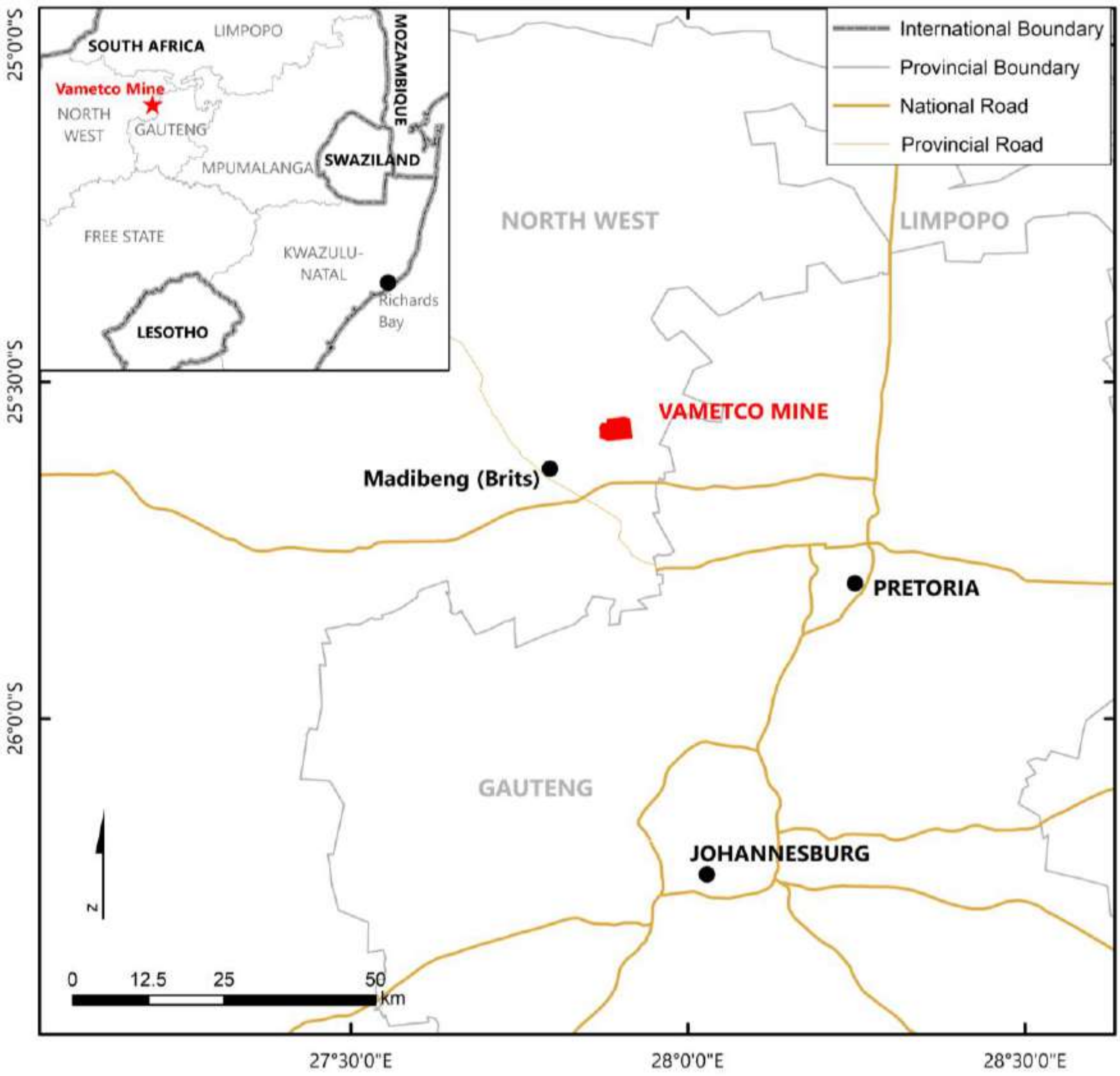
The Project comprises the Vametco Mining Right Area ("MRA") which covers an area of approximately 1,508 ha. The MRA comprises Portion 1 of the farm Krokodilkraal 426JQ and the Rest of Portion 1 of Uitvalgrond farm 431JQ.

A valid new order mining right (No: NW 30/5/1/2/2/08 MR) is held by Vametco Holdings (Pty) Ltd, for the vanadium operations. The mining right is valid for a period of 25 years and has an expiry date of 23 April 2038.

The Project comprises an open pit mine which supplies ore directly to the vanadium processing plant which is located on the same property. The open pit is approximately 3.5 km long, in an east-west direction. The vanadium is extracted from magnetite layers occurring near the basal contact of the Upper Zone of the Bushveld Igneous Completed. The mine has been in operation since 1967.

The location of the Vametco Mine is shown in Figure 1.

Figure 1
Location of the Vametco Mine



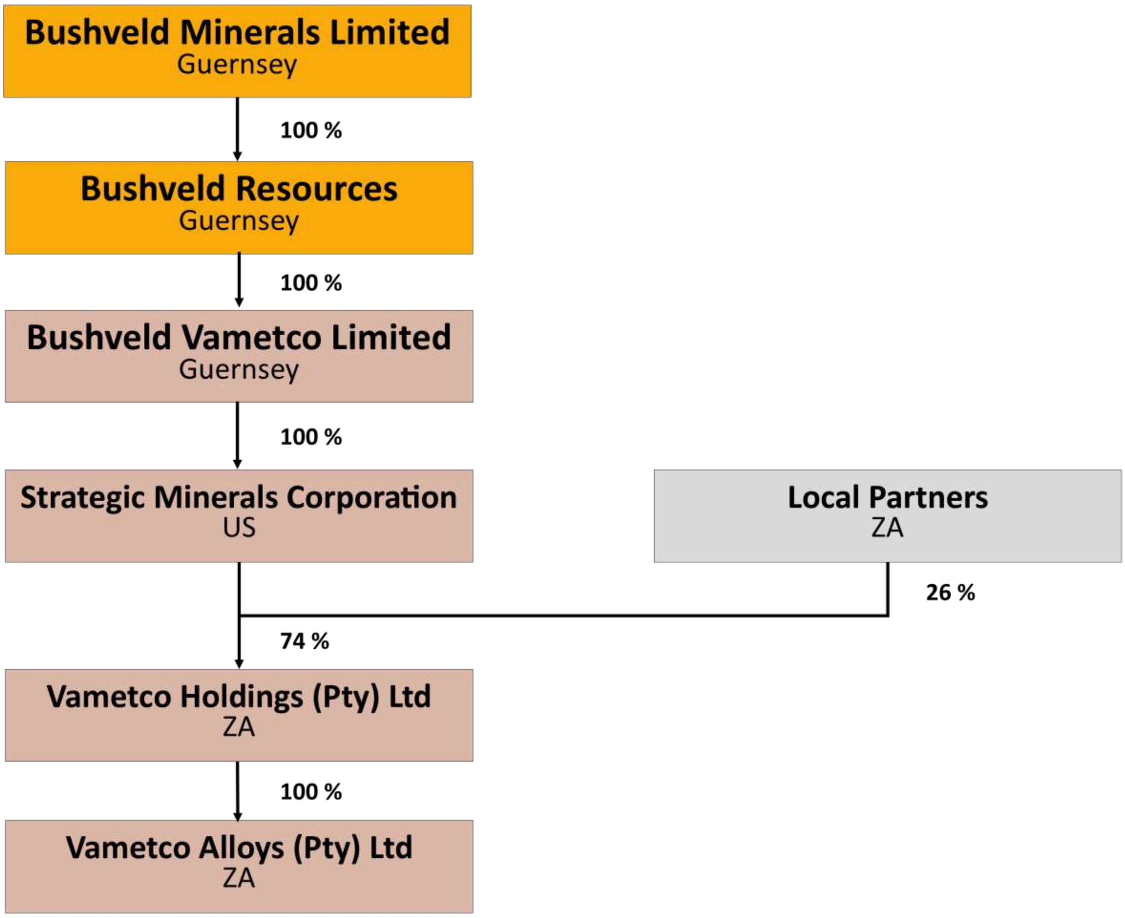
1.2.1 Ownership

A new order mining right is held by Vametco Holdings (Pty) Ltd, for the vanadium operations. The ownership structure is depicted in Figure 2.

As at 01 June 2019, the Broad based Black Economic Empowerment ("BBBEE") shareholding in Vametco Holdings (Pty) Ltd was 26 %.

Figure 2

The ownership structure for the Vametco Mine



Source: *Vametco (2019)*

1.3 Geological Setting, Deposit Type, Mineralisation

Vanadium mineralisation occurs in vanadium-bearing titaniferous magnetite-rich layers that occur within the Upper Zone of the Rustenburg Layered Suite of the Bushveld Complex. The magnetite-rich layers are part of the layered sequence and are concordant, continuous along strike and down-dip, although thickness variability occurs.

The Bushveld Complex intruded Pretoria Group meta-sedimentary rocks of the Transvaal Supergroup approximately 2,060 million years ago. The layered sequence of mafic rocks, known as the Rustenburg Layered Suite, comprises five distinct zones.

- the Marginal Zone,
- the Lower Zone,
- the Critical Zone,
- the Main Zone, and
- the Upper Zone.

Both the Main Zone and the Upper Zone of the Rustenburg Layered Suite occur in the Vametco Mining Right area. The Upper Zone is identified from the underlying Main Zone by the occurrence of cumulus magnetite. The Main Zone is comprised of gabbro-norite, pyroxenite and anorthosite layers. The lithologies in the Upper Zone include massive magnetite layers, magnetite–bearing gabbro, olivine-diorite and some anorthosite layers.

The layers are east-west striking with an average dip of 19° to the north.

At the Vametco Mine, groups of magnetite-rich layers are separated into three seams, namely the Upper, Intermediate and Lower seams, which dip to the north at approximately 19°. The seams occur above a distinct anorthosite layer near the contact of the Upper Zone with the underlying Main Zone. All three seams have been exposed by open pit mining on the Property.

1.4 Exploration and Drilling, Sampling Techniques and Data

Thirteen diamond drillholes were drilled by Bushveld Vametco in 2018 to verify the down-dip continuity of the magnetite-rich layers, validate historical drilling data and infill the historical drilling grid. The data from cores recovered from this drilling campaign, in addition to records of historical drilling, were used for the Mineral Resource Estimate.

Historical exploration activities are summarised in Table 1.

Table 1
Summary of historical drilling activities at Vametco Mine

Year	Drilling Method	No. of Holes	Purpose
Mid 1960's	Diamond Drilling	9	Assess the vanadium magnetite potential
1970	Diamond Drilling	6	Follow-up drilling to the earlier drilling campaign
1975-1976	Diamond Drilling	16	Outline the vanadium magnetite deposit and operational drilling for open pit mining
	Percussion Drilling	28	
1982	Diamond Drilling	16	Testing correlation between calcium and fracturing
2006	Diamond Drilling	6	Validate down dip extension of the deposit

No Quality Assurance Quality Control ("QAQC") was completed for the historical sample assaying outside of the QAQC protocols assumed to have been used routinely by the laboratory.

The 2018 drilling campaign was subjected to external QAQC protocols that included the insertion of blank and certified reference materials ("CRM"), and check assaying by a second laboratory.

Exploration expenditure (Table 2) for the Vametco Mine for 2018 was of the order of approximately ZAR 2,457,000. No exploration expenditure is currently planned for 2019-2020.

Table 2
Exploration expenditure (FY2018)

Description	Amount (ZAR)
Drilling	533,043.47
Sample Analysis	87,397.04
Mineral Resource Review	81,090.00
Davis Tube Testwork	96,423.88
Drillhole sample analysis	1,658,611.28
TOTAL	**2,456,565.67**

1.5 Mineral Resource Estimates

The Mineral Resources presented herein have an effective date of 29 March 2019. The Mineral Resource estimate incorporates drilling data from holes completed by Union Carbide Exploration from the mid 1960's until 1982, holes completed by Vametco in 2006, as well as from holes completed by BMN in 2018.

The Mineral Resource estimate was conducted using Datamine Studio RM software, together with Microsoft Excel, JMP and Snowden Supervisor for data analysis, and Leapfrog Geo for geological modelling. The Mineral Resource estimate was completed by Mrs Kaylan Bartlett, a Mineral Resource Consultant for MSA under the guidance and supervision of Mr Jeremy Charles Witley, Head of Mineral Resources for MSA.

Magnetite, contained in three magnetite-rich layers, is the source of vanadium within the deposit. The layers are stratiform and defined by the presence of significant magnetite content (>20 %). Three dimensional models of the magnetite-rich layers were constructed by defining the top and bottom contacts and then creating models of the surfaces using Leapfrog Geo software.

Of the 65 diamond drillholes in the database, a total of 36 intersections of the Upper Seam, 22 of the Intermediate Seam and 42 of the Lower Seam were used to estimate the grade of the Mineral Resource.

Attributes were estimated into the individual mineralised zones using the 2 m composite drillhole sample data for each seam. Inverse distance to the power of two was used to estimate the grades into 20 mE by 20 mN by 5 mZ parent cells. Density was determined through regression of the density data collected in the 2018 drilling campaign using the strong relationship between magnetite grade and density. A waste model was constructed around the magnetite layers for mine planning purposes, using the available drilling data.

A search of 200 mX by 200 mY by 10 mRL was used to select the sample composites for block estimation of the Upper, Intermediate and Lower Seams. A minimum number of six 2 m composites were required for a block to be estimated, up to a maximum of twelve 2 m composites. If a block was not estimated from the initial search ellipse, the ellipse size was doubled. Should a block still not be estimated, a larger search ellipse was used by expanding the search by ten times the original search ellipse extent.

The Mineral Resources were estimated and reported in accordance with the 2012 edition of the JORC Code and have an effective date of 29 March 2019 (Table 3 and Table 4). To the best of the Mineral Resource Competent Person's ("CP") knowledge there are currently no title, legal, taxation, marketing, permitting, socio-economic or other relevant issues that may materially affect the Mineral Resource described in this report.

Table 3

Vametco Mine Mineral Resource at a cut-off grade of 20 % magnetite, 29 March 2019 – Gross Basis

Class	Seam Name	Tonnes (millions)	V_2O_5 grade of whole rock (%)	Magnetite grade of whole rock (%)	V_2O_5 grade of magnetite concentrate (%)	Tonnes V_2O_5 in magnetite concentrate (thousands)	Tonnes V in magnetite concentrate (thousands)
Indicated	Upper	5.7	1.44	65.9	1.78	67.0	37.5
	Intermediate	28.7	0.68	32.7	1.91	179.2	100.4
	Lower	109.4	0.72	32.4	2.03	719.7	403.1
	Total	**143.8**	**0.74**	**33.8**	**2.00**	**965.9**	**541.1**
Inferred	Upper	10.5	1.46	63.5	1.75	116.3	65.1
	Intermediate	7.0	0.67	32.1	1.92	43.4	24.3
	Lower	25.4	0.74	31.3	2.00	158.5	88.8
	Total	**42.9**	**0.90**	**39.3**	**1.92**	**318.2**	**178.2**
Indicated and Inferred	Upper	16.2	1.45	64.3	1.76	183.3	102.7
	Intermediate	35.7	0.67	32.6	1.91	222.6	124.7
	Lower	134.8	0.72	32.1	2.03	878.2	491.9
	Total	**186.7**	**0.78**	**35.0**	**1.98**	**1,284.1**	**719.3**

Notes:

1. *All tabulated data have been rounded and as a result minor computational errors may occur.*
2. *Mineral Resources which are not Ore Reserves have no demonstrated economic viability.*
3. *Mineral Resources are inclusive of Ore Reserves (not indicated in the table).*
4. *Magnetite content (grade) is determined as the proportion of magnetite concentrate recovered using Davis Tube methodology.*
5. *Due to the magnetite grade being a recovered grade, differences will occur between whole rock V_2O_5 grades back-calculated from concentrate, versus those derived from whole rock assays.*
6. *Depleted as at 29 March 2019.*
7. *Reported on a Gross Basis. Bushveld Minerals shareholding in Vametco Alloys is 74%.*

Table 4

Vametco Mine Mineral Resource at a cut-off grade of 20 % magnetite, 29 March 2019 – Attributable Basis

Class	Seam Name	Tonnes (millions)	V_2O_5 grade of whole rock (%)	Magnetite grade of whole rock (%)	V_2O_5 grade of magnetite concentrate (%)	Tonnes V_2O_5 in magnetite concentrate (thousands)	Tonnes V in magnetite concentrate (thousands)
Indicated	Upper	4.2	1.44	65.9	1.78	49.6	27.8
	Intermediate	21.2	0.68	32.7	1.91	132.6	74.3
	Lower	81.0	0.72	32.4	2.03	532.6	298.3
	Total	**106.4**	**0.74**	**33.8**	**2.00**	**714.8**	**400.4**
Inferred	Upper	7.7	1.46	63.5	1.75	86.1	48.2
	Intermediate	5.2	0.67	32.1	1.92	32.1	18.0
	Lower	18.8	0.74	31.3	2.00	117.3	65.7
	Total	**31.7**	**0.90**	**39.3**	**1.92**	**235.4**	**131.9**
Indicated and Inferred	Upper	12.0	1.45	64.3	1.76	135.6	76.0
	Intermediate	26.4	0.67	32.6	1.91	164.7	92.3
	Lower	99.7	0.72	32.1	2.03	649.8	364.0
	Total	**138.1**	**0.78**	**35.0**	**1.98**	**950.2**	**532.3**

Notes:

1. *All tabulated data have been rounded and as a result minor computational errors may occur.*
2. *Mineral Resources which are not Ore Reserves have no demonstrated economic viability.*
3. *Mineral Resources are inclusive of Ore Reserves (not indicated in the table).*
4. *Magnetite content (grade) is determined as the proportion of magnetite concentrate recovered using Davis Tube methodology.*
5. *Due to the magnetite grade being a recovered grade, differences will occur between whole rock V_2O_5 grades back-calculated from concentrate, versus those derived from whole rock assays.*
6. *Depleted as at 29 March 2019.*
7. *Reported on a Gross Basis. Bushveld Minerals shareholding in Vametco Alloys is 74%.*

The Mineral Resource dips at approximately 19° to the northeast and strikes from northwest to southeast. The Upper Seam Mineral Resource extends for approximately 4,000 m along strike and approximately 230 m in the dip direction. The Intermediate Seam Mineral Resource extends for approximately 2,600 m along strike and approximately 290 m in the dip direction. The Lower Seam Mineral Resource extends for approximately 3,900 m along strike and approximately 230 m in the dip direction. The Mineral Resource estimate was limited to 150 m below surface. The mineralisation is open down-dip. The Upper Seam Mineral Resource is on average 2.6 m thick, the Intermediate Seam 11.8 m and the Lower Seam 33.8 m.

1.6 Technical Studies

1.6.1 Geotechnical

Stack angles for weathered and fresh material are 37.80 and 54.32 degrees, respectively. The overall slope angle should be planned at 56.95 degrees, which includes catch benches (Table 5).

Table 5
Slope angles suggested for the Vametco Mine

Material type	Bench heights	Berm widths	Stack height	Bench face angle	Stack angle	Maximum depth	Overall slope angle	Comments
Weathered	10	4.5	10	50	37.80	10	60.72	No catch benches
Fresh	10	4.5	90	75	54.32	60		
Catch bench (every 5th bench)	10	9	40	75	54.32	100	56.95	With a single catch bench

1.6.2 Mine Design

The current mining cycle for the Project is conventional drill, blast, load and haul with the opportunity of free-dig in some areas of weathered material. Due to the stratified nature of the deposit, Vametco uses a combination of strip mining and open pit mining.

Vametco uses a series of contractor to perform the mining.

A mining model was been prepared by regularising the Mineral Resource model using Datamine. The mining model was imported into GEOVIA's Whittle Four-X™ (Whittle). No prescribed cut-off grades were used in the pit optimisation. Whittle was used to formulate the optimal pit shell using the pit optimisation parameters.

Dilution was applied based on re-blocking to 10 mX x 10 mY x 5 mZ. This block size was determined after consideration of the size of the excavator bucket and expanded to mimic the mixing associated with blasting and loading.

Mining, processing and product cost and pricing estimates were coded into the model.

Only Indicated Mineral Resources were used in the base case pit optimisation. There was no Measured Mineral Resources in the Mineral Resource Statement. For the pit optimisation, in order to focus the pit design on the predominant Lower Seam ("LS"), the Intermediate Seam ("IS") and

Upper Seam ("US") were treated as waste for this exercise only. The final pit design includes all the seams as ore which were reported in the Ore Reserve Statement.

An exclusion area for the local Graveyard was coded into the model with an additional surrounding 100 m boundary pillar to protect this heritage area.

A build up to a process feed rate of 1.5 Mpta of run of mine to the plant was used by MSA. There is potential to increase the run of mine feed rate to the milling circuit. The key constraint in the process plant is the feed rate through the kiln. Vametco are investigating the potential to increase the kiln feed rate. Until this Pre-Feasibility / Feasibility level of study work has been proven and completed (Phase 3 plant expansion), MSA have the view that the current plant is able to build up to the targeted steady state production of 3,400 mtV p.a. of Nitrovan™ in 2021.

1.6.3 Metallurgical (Processing / Recovery)

The Vametco processing plant receives ore from the co-located open pit mine. The metallurgical process is well-tested in a steady state ongoing operation. No metallurgical testwork is required.

The processing plant has historically performed satisfactorily with a recent annual production history of around 2,600 mtV p.a. Nitrovan™. A study as to the current indicated sectional maximum throughputs indicates that some of the sections could become limiting at an annual tonnage throughput of 1.5 Mtpa for a production of around 3,400 mtV p.a. Nitrovan™.

Measures to increase the hourly throughput, improve thermal efficiencies and limit downtime in the kiln section are currently being considered.

A simplified plant mass balance for a run of mine feed of 1.5 Mtpa and targeted production of 3,400 mtV p.a. Nitrovan™ is shown in Table 6.

Table 6
Simplified vanadium mass balance for the plant

Section	Material	Monthly Feed (tpm)	Magnetite			Vanadium		
			Grade (%)	Tonnes per annum (tpa)	Recovery (%)	Grade (%)	Production (mtV p.a.)	Recovery (%)
Secondary crusher	RoM	1,500,000						
Tertiary crusher and screens	RoM	1,500,000						
Primary Mill	RoM	1,500,000	28.00	420,000		1.13	4,746	
Secondary Mill magseps	magnetite			413,448	98.44	1.13	4,672	98.44
Non-magnetic tailings	waste	1,086,552	0.60	6,552		0.007	74	
Kiln	magnetite			413,448		1.13	4,672	83.50
Leach Mill	calcine	413,448					3,901	
Leach Filter	residue	409,789					3,659	93.80
Precipitation Dryer	AMV						3,531	96.50
MVO Reactors	MVO						3,478	98.50
Nitrovan™ Reactors	NV						3,443	99.00
							Overall Recovery	**73.70**

Note: *The mass balance is calculated based on the 2018 annual recovery profile, and has been calculated for a RoM feed of 1.5 Mtpa and targeted production of 3,400 mtV p.a. Nitrovan™*

1.6.4 Infrastructure

Infrastructure for the Vametco Mine is well established, as the mine has been in operation since 1968.

There is a graveyard to the northwestern of the Vametco Mine open pit which is currently excluded from all Ore Reserve calculations. The largest current waste rock dumps ("WRD") are located to the south of the open pit and will not be a constraint to any of the mining activities going forward, as the orebody dips to the north and mining will continue in a northerly direction. There are some small WRD's to the north of the pit; these are very small and will not constrain future mining activities.

The positioning of major infrastructure on the mine does not constrain the open pit operation.

The supply of water and electricity is adequate and available to sustain the long term life of mine plan. The surface facilities (offices, security, maintenance, storage, laboratories, workshops, change houses, fire protection systems, etc.) are all in place and well maintained.

1.6.5 Environmental and Social

The Vametco Project (mine and plant) have been operational since the late 1960s. To date, there have been changes in ownership and several changes in legislation over the life of mine. The environmental compliance requirements have altered with the change in legislation. In assessing the currently applicable environmental legal compliance requirements, MSA have considered a set of authorisations and engagements with the regulatory authorities that stretches over the life of mine. Only those requirements still in effect have been considered. Some risks have been identified that could impact on the operations and these include:

- ground water contamination and the effectiveness of the containment initiatives underway;
- the required backfill strategy and the related mining and financial implications thereof;
- compliance with the Water Use Licence, Waste Management and Atmospheric Emissions authorisation conditions for monitoring and reporting;
- closure of the Department of Mineral Resources Section 93 Directive relating to the completion of the 2013-2018 Social and Labour Plan Action plan deliverables;
- confirmation of the Mine Closure Liability provisioning meeting the new 2018 assessment values; and
- confirmation of the scope of the possible Phase 3 expansion such that the new authorisations are applied for in good time before implementation and do not become a delay for the Project.

1.6.6 Market Outlook

The market outlook for Vanadium products (ferrovanadium and vanadium pentoxide) varies between different analysts, especially for the short to medium term. Long term forecasts vary from USD 33 to USD 50 /kg FeV, from which a consensus price of USD 40 /kg FeV is selected. Short to medium term forecasts may be as high as USD 54 to as low as USD 21 /kg FeV. MSA's consensus prices vary between USD 41.58 /kg FeV (2020) and USD 46.06 /kg FeV (2022).

Research by Roskill (2019) has shown that there is a very strong linear relationship between ferrovanadium and V_2O_5 prices, indicating that one product may be used as a proxy for the other when analysing price data.

From inspecting various production cost curves, it appears that Vametco is comfortably within the lower half of the cost curve and should be able to maintain or improve this position going forward.

1.6.7 Economic Evaluation

A detailed discounted cash flow model was constructed to evaluate in real money terms the economics of the Vametco Mine operations as a production entity. Taxes, royalties and capital expenditure redemption were evaluated in nominal terms to ensure better accuracy of these cost lines. Operating costs are based on actual achieved results.

The base case real Net Present Value ("NPV") of USD 371.0 million is based on a 10 % discount rate. Sensitivity analyses indicate that the operation is most sensitive to revenue, with a 15 % decrease in FeV prices causing the NPV to reduce by 30 %. The operation is moderately sensitive to operating costs, with a 15 % increase in costs triggering a 17 % drop in NPV. Sensitivity to exchange fluctuations is modest, with a 15 % strengthening of ZAR vs USD resulting in only a 14 % reduction in NPV.

This analysis implies that Vametco may be expected to weather adverse operating and trading conditions well.

1.6.8 Risk Analysis

Key risks identified are summarised in Table 7.

Table 7
Risk Summary

Risk Matrix - Summary					
Discipline	**Risk Description**	**Risk Probability**	**Description of Impact on Operations**	**Impact on Operations**	**Mitigation**
Mineral Resources	Mineral Resource risks relate to use of historical data; quantity of drilling data, geological features contributing to geological losses, grade variability and proximity to cultural features (graveyard)	Low	Minor	Low	Possible infill drilling to improve confidence in Mineral Resource classification
Mining	The plant is currently being restricted by the excessive SiO_2 which occurs in the Lower Seam (LS) ore.	Medium	Ultimately, reduced vanadium recovery in kiln	Medium	Install the second secondary crusher to improve comminution in the crushing section and optimise grind for Si liberation in the magnetite feed to magseps. And limit Si to kiln feed. To mitigate this risk further, optimisation work is recommended by MSA to investigate the proportion of SiO_2 in the long term plan and the availability of IS for blending.
Mining	Excessive dilution above plan would result in a reduction in the magnetite grade affecting vanadium production.	Medium	Reduced magnetite grade in RoM feed	Medium	It is suggested that a Reverse Circulation ("RC") drilling based grade control programme be considered, instead of the current blast hole sampling, in order to improve orebody understanding, mine planning and dilution control. A trade-off study comparing the costs and benefits of RC drilling with blast hole sampling is recommended for consideration

Risk Matrix - Summary					
Discipline	**Risk Description**	**Risk Probability**	**Description of Impact on Operations**	**Impact on Operations**	**Mitigation**
Ore Reserves	The vanadium content in the magnetite of the Mineral Resources appears to be higher than the historical average performance. The result is that a relatively conservative production of 1.5 Mtpa RoM feed to the plant is required. Should the vanadium content be lower than expected, the annual Nitrovan^{TM} product production will be affected.	Medium	Lower than expected Nitrovan^{TM} production due to lower than expected vanadium content in magnetite	Medium	To mitigate this risk the RoM feed from mining could be increased to offset the product shortfall. The current milling circuit is able to handle additional tonnage. The risk in the processing plant is the kiln.
Metallurgy and processing	Kiln fails to meet hourly throughput requirement. The kiln has demonstrated ability to exceed the required tonnage throughput but gas emissions are limiting.	Medium	Failure to meet the 3,400 mtV p.a. Nitrovan^{TM} target output	Low	The plant is currently installing a kiln off gas system with commissioning planned for 2020.
Metallurgy and processing	Kiln fails to meet annualised availability requirement - excessive downtime due to planned and unplanned maintenance , breakdowns or power outages.	high	Failure to meet the 3,400 mtV p.a. Nitrovan^{TM} target output	Low	Improved extraction and scrubber leading to throughputs in excess of required with a resultant reduction in required availability. Improved shutdown and maintenance planning and execution through a focussed intervention.
Metallurgy and processing	Kiln fails to meet soluble vanadate requirement - Si scavenging of Na to sodium silicate thus making sub-optimal Na available for metavanadate conversion	Low	Low leach recoveries - failure to meet the 3,400 mtV p.a. Nitrovan^{TM} target output	Low	Install the second secondary crusher to improve comminution in the crushing section and optimise grind for Si liberation in the magnetite feed to magseps. And limit Si to kiln feed.
Metallurgy and processing	Salt Recovery Plant - both the dual stream crystallisers and the three boilers will be required to run at very high availability - any excessive downtime or the loss of one leg of the plant would not be recoverable due to a lack of catchup capacity.	high	In the event of major downtime and if the barren dam was full there would be production losses	Medium	Installation of a third crystallisation leg with waste salt crystalliser to reduce the Cl levels. The ongoing replacement of stainless equipment with fiberglass where possible. Increasing the boiler capacity.
Metallurgy and processing	Nitrovan^{TM} Plant fails to achieve required throughput.	Low	Failure to meet the 3,400 mtV p.a. Nitrovan^{TM} target output	Low	Install the available 5th Shaft furnace

Risk Matrix - Summary					
Discipline	**Risk Description**	**Risk Probability**	**Description of Impact on Operations**	**Impact on Operations**	**Mitigation**
Environmental & Social	Ground water contamination and the effectiveness of the containment initiatives underway.	High	Significant operational costs and increasing liability to the operation. As a licence condition could attract a more stringent and costly directive.	Medium	Ensure existing measures are maintained and fully operational / available. Consider the installation of additional scavenger boreholes. Focus on reducing ground water contamination around the plant with adequate bunding and pumping capacity.
Environmental & Social	Backfill of the pit and the resource. Mining and financial implications of the backfill strategy. Approval of the EMPr and new authorisations could be affected by this.	High	Authorisation to mine and mining licence implications. Safety and in-pit operational costs/constraints.	High	Improvements in the mine planning to ensure the backfill plan is optimised.
Environmental & Social	Relocation of the Gravesite ahead of mining on the western extent of the pit.	Medium	Sterilisation of mineral resources/reserves ahead of mining. Will be isolated once mining moves away from this area and backfill is done in this area. Safety and community exposure to community from blasting and mining operations.	Medium	Decision to re-locate or not before stranding of area from mining plans. Clear protocol to control access and reduce public exposure.
Environmental & Social	Compliance with the Water Use Licence ("WUL"), Waste Management and Atmospheric Emissions authorisation conditions for monitoring and reporting.	High	Risk of retraction of authorisation with operational stoppages, fine (cost) and increased compliance inspections or directives by the regulator with significant resource and financial cost implications.	Medium	Review all requirements for licences and authorisations. Establish a schedule of reporting. Ensure document control and records of submissions are kept.
Environmental & Social	Closure of the DMR Section 93 Directive relating to the completion of the 2013-2018 Social and Labour Plan ("SLP") Action plan deliverables.	Medium	Direct implications for Mining Right and licence to operate. Financial and administrative costs to business.	Low	Formalise approach and agreement on deliverables with implementation of mitigation. Clear and timely response to the DMR and ensure the operation get confirmation of retraction of the directive. Appointment of Transformation Manager at Bushveld

Risk Matrix - Summary					
Discipline	**Risk Description**	**Risk Probability**	**Description of Impact on Operations**	**Impact on Operations**	**Mitigation**
					Vametco with strategic direction from the Group Head Sustainability and Stakeholder Relations at Bushveld Minerals to ensure compliance.
Environmental & Social	Confirmation of the scope of the Phase 3 expansion changes such that the new authorisations are applied for in good time before implementation and do not become a delay for the Project.	High	A missed element in the new authorisations can have a significant delay and cost implication for the planned increase in production.	High	Follow Capital Management Process with stage gates, implementing the required engineering controls. Ensure that all alterations planned are itemised and reviewed against the regulations to ensure they are addressed and included in the current round of applications/updates in authorisation.

1.7 Estimation and Reporting of Ore Reserves

MSA has undertaken a mining study and mine plan for Vametco to convert the Mineral Resources to Ore Reserves (Table 8 and Table 9). The mine plan is deemed to be technically achievable and economically viable. The Ore Reserve estimation is derived from a combination of Geovia mine planning products including Whittle, Surpac and mine scheduling software. The Whittle Pit Optimisation software was used to determine the most preferable economically viable pit shell. The pit design was then completed in Surpac. The modifying factors and assumptions considered in the estimation of the Ore Reserves include:

- cost assumptions aligned with the Bushveld Vametco FY 2019 budget;
- geotechnical parameters for weathered rock (37.8 degrees) and fresh rock (56.95 degrees) types;
- a mining dilution applied based on re blocking the Mineral Resource model to an SMU size of 10.0 mX by 10.0 mY by 5.0 mZ;
- a mining loss of 15% applied based on historical performance at the Vametco Project. Ore Reserve Estimation was done using a combination of Geovia mine planning products including Whittle, Surpac and RPMGlobal mine scheduling software; and
- The average pit depth is kept less than 100 m below surface.

Table 8

Vametco Mine Ore Reserves, 29th March 2019 – Gross Basis

Class	Seam Name	Tonnes	V_2O_5 grade of whole rock	Magnetite grade of whole rock	V_2O_5 grade in magnetite	Tonnes V_2O_5 in magnetite	Tonnes V in magnetite
		(Millions)	%	%	%	(Thousands)	(Thousands)
Probable	Upper	0.96	0.58	27.3	1.78	4.6	2.6
	Intermediate	7.23	0.53	23.7	1.89	32.3	18.1
	Lower	40.23	0.63	29.4	2.05	242.1	135.6
	Total	**48.43**	**0.62**	**28.5**	**2.02**	**279.1**	**156.3**

Notes:

1. *All tabulated data have been rounded and as a result minor computational errors may occur.*
2. *Ore Reserve tonnes and grades reported on dry ROM (plant feed) basis after mining modifying factors have been applied but before beneficiation down-stream recoveries/losses have been applied.*
3. *Reporting was prepared on a Mineral Resource model developed by MSA.*
4. *Reported on a Gross Basis. Bushveld Minerals shareholding in Vametco Alloys is 74%.*
5. *Ore Reserve tonnes depleted as at 29 March 2019.*

Table 9

Vametco Mine Ore Reserves, 29 March 2019 - Attributable Basis

Class	Seam Name	Tonnes	V_2O_5 grade of whole rock	Magnetite grade of whole rock	V_2O_5 grade in magnetite	Tonnes V_2O_5 in magnetite	Tonnes V in magnetite
		(Millions)	%	%	%	(Thousands)	(Thousands)
Probable	Upper	0.7	0.58	27.3	1.78	3.4	1.9
	Intermediate	5.4	0.53	23.7	1.89	23.9	13.4
	Lower	29.8	0.63	29.4	2.05	179.2	100.3
	Total	**35.8**	**0.62**	**28.5**	**2.02**	**206.5**	**115.6**

Notes:

1. *All tabulated data have been rounded and as a result minor computational errors may occur.*
2. *Ore Reserve tonnes and grades reported on dry ROM (plant feed) basis after mining modifying factors have been applied but before beneficiation down-stream recoveries/losses have been applied*
3. *Reporting was prepared on a Mineral Resource model developed by MSA*
4. *Reported on an Attributable Basis. Bushveld Minerals shareholding in Vametco Alloys is 74%.*
5. *Ore Reserve tonnes depleted as at 29 March 2019.*

1.8 Conclusions

The Vametco Mine, comprising the integrate open pit vanadium mine and processing plant, has been in operation since 1967. This open pit mine is situated about 6.5 km northeast of the town of Madibeng (formerly known as Brits).

The Mineral Resource is considered to have low geological risk as the magnetite-rich layers are part of the layered sequence and are concordant and continuous along strike and down-dip, although thickness variability occurs. A combined indicated and inferred mineral resource of 186.7 Mt of 0.78 % V_2O_5 has been defined. The nature of the ore body means that minimal drilling would be required to bring a large percentage of the Inferred Mineral Resources into the Indicated Mineral Resources category.

Metallurgical risks are also considered low. The processing plant has historically performed satisfactorily with a recent annual production history of around 2,600 mtV p.a. Nitrovan^{TM}. The plant has some limitations in reaching the planned 3,400 mtV p.a. Nitrovan^{TM} production levels that are outlined as part of this Competent Persons Report and measures to improve the possible downtime have been implemented during 2019. The future plans to potentially increase production (Phase 3 plant expansion to >4,300 mtV p.a. Nitrovan^{TM}) are being investigated as part of a Pre-Feasibility / Feasibility level study. Other factors to be addressed include the need to expand the slimes dam post 2038 and ensuring that the SLP requirements are adhered to.

A detailed discounted cash flow model was constructed to evaluate in real money terms the economics of the Vametco Mine operations as a production entity. The base case real NPV of USD 371.0 million is based on a 10 % discount rate. Sensitivity analyses indicate that the operation is most sensitive to revenue, with a 15 % decrease in FeV prices causing the NPV to reduce by 30 %. The operation is moderately sensitive to operating costs and the effect of exchange fluctuations is not significant.

This analysis implies that Vametco may be expected to weather adverse operating and trading conditions well.

1.9 Recommendations

There is potential to deepen the open pit in excess of 100 m and extend the life of mine and Ore Reserves post additional geotechnical feasibility and scenario planning work. It is recommended that this geotechnical work be completed and additional pit design scenarios run to compare the economic impact of a deepened pit with the current mine plan.

It is suggested that a Reverse Circulation ("RC") drilling based grade control programme be considered, instead of the current blast hole sampling, in order to improve orebody understanding, mine planning and dilution control. A trade-off study comparing the costs and benefits of RC drilling with blast hole sampling is recommended for consideration.

Capacity bottlenecks in the plant have been identified on a section basis. Work is ongoing to determine where the process is likely to be constrained as increasing the plant vanadium output would imply increasing the magnetite tonnage to the mills, increasing the V grade in magnetite and/or increasing the vanadium recovery.

It has been noted that the leach recovery has shown a decline from 2017 to 2019. The cause of this is currently unknown and requires investigation. Although not approaching maximum availability, increasing the kiln availability from the current 69 % to 82 % is likely to be the major constraint to increasing the overall plant output. If kiln availability cannot be substantially increased, it may not be possible to increase the hourly throughput from the 66 tph envisioned in the mass balance. No engineered solutions to achieve this are currently in place; however Bushveld Vametco have indicated that availability could be increased using the same equipment at increased efficiencies or with relatively modest changes to the kiln setup, and that downstream plant bottlenecks would be engineered out as required. Bushveld Vametco have commissioned a process and mechanical audit of the salt roast kiln and cooler system in order to address the above.

Should Bushveld Vametco commence work on the planned plant expansion, the relevant environmental and related permitting will need to be in place before the expansion plans can be effected. It is critical that the timing of the environmental and related authorisations be considered in the expansion planning and scheduling.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 BACKGROUND

The Vametco Project comprises the Vametco Mining Right Area ("MRA") which covers an area of approximately 1,508 ha. The Vametco Project comprises an integrated mine and processing plant located approximately 6.5 km northeast of the town of Madibeng (formerly known as Brits).

1.1 Terms of Reference and Scope of Work

The MSA Group (Pty) Ltd ("MSA") was commissioned by Bushveld Minerals Limited ("BMN") and its subsidiary Bushveld Vametco Alloys (Pty) Ltd ("Bushveld Vametco" or "the Company") to complete an Independent Competent Person's Technical Report ("CPR" or "the Report"), in accordance with the Australasian Code for Reporting of Exploration Results, Minerals Resources and Ore Reserves (the "JORC Code" or the "Code"), 2012 Edition, for the Vametco Mine ("the Project"), located in the North West Province, South Africa. The Vametco Mine is an operational open pit mine.

Bushveld Minerals Limited (AIM:BMN), an integrated primary vanadium producer, is listed on the Alternative Investment Market ("AIM") of the London Stock Exchange ("LSE").

The Mineral Resources and Ore Reserve have an effective date of the 29 March 2019. All further technical data used in the compilation of the CPR has an effective date of 26 June 2019. The Economic Evaluation was updated prior to the release of the CPR in January 2020 in accordance with the requirements of "Appendix 2 - CONTENT OF CPR of AIM Note for Mining, Oil and Gas Companies (LSE, June 2009)". The report, updated to the requirements of AIM and the London Stock Exchange ("LSE"), has a report date of 10 January 2020.

1.2 Principal Sources of Information

MSA has based its review of the Vametco Mine on information provided by Bushveld Minerals Limited and its subsidiaries, Vametco Holdings (Pty) Ltd and Vametco Alloys (Pty) Ltd, along with technical reports by its contractors and associates and other relevant published data. A full list of all sources of information is provided in Section 14. Drafts of this CPR have been provided to BMN and its subsidiary companies, in order to identify and address any factual errors or omissions prior to finalisation. Any changes made as a result of these reviews did not involve any alteration to the conclusions made.

Principal sources of information for this CPR include:

- Botha, B. and Botes, W. (2016). Independent Competent Person's Report for Vametco Mine operated by EVRAZ Vametco in the North West Province, Republic of South Africa.
- Mostert, P. and Witley, J. (2017). Bushveld Minerals Limited. Vametco Mine and Associated Exploration Properties, North West & Gauteng Provinces, Republic of South Africa. Independent Competent Person's Report.
- JMA (2015). EVRAZ VAMETCO ENVIRONMENTAL IMPACT ASSESSMENT (EIA). Volume 1 of 3. 547pp.

1.3 Units and Currency

The International System of Units ("SI", abbreviated from the French Système international (d'unités)) are used throughout, and currency discussions are based on the South African Rand ("ZAR").

A table summarising the units of measurement, acronyms and abbreviations used in this CPR is included in APPENDIX 1.

It is noted that throughout the Report, columns and/or rows in tables may not add up due to rounding.

1.4 Site Inspection or Field Involvement of Competent Persons

MSA conducted independent site inspections of the Vametco Project in 2017, 2018 and 2019.

Mr Jeremy C. Witley (Competent Person ("CP") Geology and Mineral Resources), Ms Kaylan Bartlett (Contributing Author), Mr Jonathan Hudson (CP Mining and Ore Reserves), and Mr Richard Garner (CP Environmental) undertook a site inspection on the 28th May 2019. Mr Witley and Mrs Bartlett inspected the recent Vametco drillhole cores and the general site and infrastructure. In addition, the Vametco on-site laboratory was inspected. Mr Witley also undertook a site visit to the Vametco Project on 31 August 2017 during which time the mine workings and plant facilities were inspected. Mr Hudson and Mr Garner inspected the site infrastructure, surface workings and operations. The site visit substantiated the existence of BMN's and Bushveld Vametco's activities, infrastructure and operational context relating to the Ore Reserves which are supported by the exploration and production results. Mr Hudson also undertook a site visit to the Vametco Project on 14 March 2018 during which time the mine workings, plant facilities, stockpiles and tailings facilities were inspected, accompanied by Mrs Susan Frost-Killian (Contributing Author).

Mr John Derbyshire (CP Processing and Recoveries) undertook a site inspection on the 27th to 28th May 2019 during which he inspected the plant and related infrastructure and held conversations with the Vametco Mine personnel.

Due to the site inspections undertaken by the MSA technical experts, MSA considered a site inspection by Mr André van der Merwe (CP Economic Evaluation), would add little value and hence was not necessary.

1.5 Disclaimers and Reliance on Other Experts or Third-Party Information

1.5.1 Statement of Independence

This Competent Persons Report has been prepared by MSA, an independent advisory company. Its advisors have extensive technical experience in preparing, reviewing and evaluating assets for mining and exploration companies. MSA's advisors writing this report have, collectively, more than 100 years' experience in the mining sector. They are either registered as South African Council for Natural Scientific Professions (SACNASP) Professionals or Engineering Council of South Africa (ECSA) Professionals and are members in good standing of the appropriate Recognised Overseas Professional Organisations (ROPO).

Neither MSA, nor the authors of this report, has or has had previously, any material interest in Bushveld Minerals Limited or its subsidiaries. The relationship with Bushveld Minerals Limited is solely one of professional association between client and independent consultant. This report is prepared in return for professional fees based upon agreed commercial rates and the payment of these fees is in no way contingent on the results of this report. Neither MSA, nor any of the authors of this CPR, hold any share capital in Bushveld Minerals Limited or its subsidiaries.

Except for these fees, MSA have not received and will not receive any pecuniary or other benefit whether direct or indirect for or in connection with the preparation of this report.

1.5.2 Forward Looking Statements

This report contains forward-looking statements. These forward-looking statements are based on the opinions and estimates of MSA and BMN and its subsidiaries at the date the statements were made. The statements are subject to several known and unknown risks, uncertainties and other factors that may cause actual results to differ materially from those forward-looking statements anticipated by BMN and its subsidiaries. Factors that could cause such differences include changes in world coal markets, equity markets, costs and supply of materials, and regulatory changes. Although MSA believes the expectations reflected in the forward-looking statements to be reasonable, MSA does not guarantee future results, levels of activity, performance or achievements.

1.5.3 Reliance on Other Experts

This CPR is limited to an assessment of the Vametco Mine and the findings and conclusions presented herein represent the unbiased and independent opinion of MSA, based on the available source data as supplied by BMN and its subsidiaries. MSA's opinion, which is effective as of the 29 May 2019, is premised on data received from BMN and its subsidiaries as outlined above. MSA does not have any reason to believe that any material facts have been withheld.

MSA has relied on information provided by Bushveld Vametco personnel as follows:

- Mr Troth Saindi, Project Geologist at Bushveld Vametco" Mr Saindi supplied all data relating to the drilling (historical and 2018 exploration programme), in addition to other geological data in the form of mine works programmes ("MWPs"), geology including geological plans, exploration history, mineralisation, the drilling and sampling procedures, the sample analysis database, quality assurance quality control information and
- Mr William Steinberg, Chief Transformation Officer at Bushveld Vametco, supplied information and drawings pertaining to the plant (all sections), costing, metal balance, and production.
- Ms Tania Mostert, Chief Financial Officer at Bushveld Vametco, supplied operational budgets, and related information.
- Mr Ken Greve, Strategic Projects Head at BMN, provided the Discounted Cash Flow model for Vametco.
- Mr Dirk Venter, Production Manager (Mining) at Bushveld Vametco, provided information pertaining to mining, scheduling, and infrastructure.

- Mr Sam Mtileni, Works Manager (Mining and Concentrator) at Bushveld Vametco, provided information pertaining to environmental and social permitting and governance.

1.6 Qualifications, Experience and Independence

MSA is an exploration and resource consulting and contracting firm, which has been providing services and advice to the international mineral industry and financial institutions since 1983.

This report has been compiled by:

- Mr Jeremy Charles Witley, who is a Professional Geologist with more than 30 years' experience in Mineral Resource estimation, Exploration and Mine Geology. He has held several positions with consultancies and with mid-and large tier mining companies during his career. Jeremy has a strong background in orebody modelling, geostatistics, grade control and public reporting. Mr Witley is registered as a Professional Natural Scientist (Pr.Sci.Nat; Geological Science) with the South African Council for Natural Scientific Professions and is a Fellow of the Geological Society of South Africa and a member of the Geostatistical Association of Southern Africa.

  Mr Witley has the appropriate relevant qualifications, experience, competent and independence to act as a Competent Person as that term is defined in JORC Code (2012).
- Mr Jonathan Hudson, who is a Professional Mining Engineer with 30 years' experience in mine planning and Ore Reserves estimation, operations and change management, and project management. Mr Hudson is registered as a Professional Mining Engineer (Pr.Eng.) with the Engineering Council of South Africa (ECSA) and is a Fellow of the South African Institute of Mining and Metallurgy (SAIMM).

  Mr Hudson has the appropriate relevant qualifications, experience, competent and independence to act as a Competent Person as that term is defined in the JORC Code (2012).
- Mr Trevor Rangasamy, who is a Professional Rock Engineer with 28 years' experience, has professional experience in various rock engineering and geotechnical related projects.

  Mr Rangasamy is a member in good standing of the Southern African Institute of Mining and Metallurgy (SAIMM). Mr Rangasamy's specialist skills include consulting to the mining industry in the rock engineering, geotechnical and geological disciplines.

  Mr Rangasamy has the appropriate relevant qualifications, experience, competence and independence to act as a Competent Person as that term is defined in the JORC Code (2012).
- Mr John Derbyshire, who is a Professional Engineer with approximately 40 years' plant operational and project experience in senior positions in the South African mining industry. Over the last eight years he has consulted jointly and independently for a number of ongoing projects in the Platinum, Gold, Niobium, Graphite and Rare Earth sectors. Mr Derbyshire is registered as a Professional Engineer (Pr.Eng.) with ECSA, is a Fellow of SAIMM and is an Ordinary member of Mine Metallurgical Managers Association.

  Mr Derbyshire has the appropriate relevant qualifications, experience, competence and independence to act as a Competent Person as that term is defined in the JORC Code (2012).
- Mr Richard David Garner, who is a professional Environmental Consultant with 20 years' experience, the majority of which has involved environmental management, regulatory compliance and water strategies at coal mines, primarily within South Africa, but also extending to other geographic regions and commodities. As such, his experience extends into

international work for multiple commodities across Australia, South America and Africa and various sectors such as Water Efficiency training for the Association Energy Engineers (AEE). He is the Head of Department – Environmental Studies with MSA.

Mr Garner is a Member in good standing of the South African Council for Natural Scientific Professions (SACNASP; No. 116205) as well as a Member and Lead of the Water Institute of Southern Africa Mine Water Division (WISA), the Grassland Society of Southern Africa (GSSA) and the Association of Energy Engineers (AEE) where he is one of the only certified Water Efficiency Practitioner (CWEP) Trainers outside of the United States and is a certified Measurement and Verification Practitioner in training (CMVP-IT). He has 20 years' direct experience in the sub-Saharan Coal and Minerals industries, holds a MSc from the University of the Witwatersrand (South Africa), and has authored a number of published and unpublished academic articles ranging from ecology, impact assessment of exotic alien vegetation to the implementation of ISO14001 management systems and setting water efficiency targets in the mining sector. He regularly presents at several industry forums and conferences, is a reference group member for the Water Research Commission (WRC) and an advisor to the South African Minerals Council (SAMC) on Water Conservation and Demand Management in the Mining Sector. Mr Garner has marked several MSc thesis for the University of Johannesburg in the area of environmental management.

Mr Garner has the appropriate relevant qualifications, experience, competence and independence to act as a "Competent Person" as that term is defined in the JORC Code (2012).

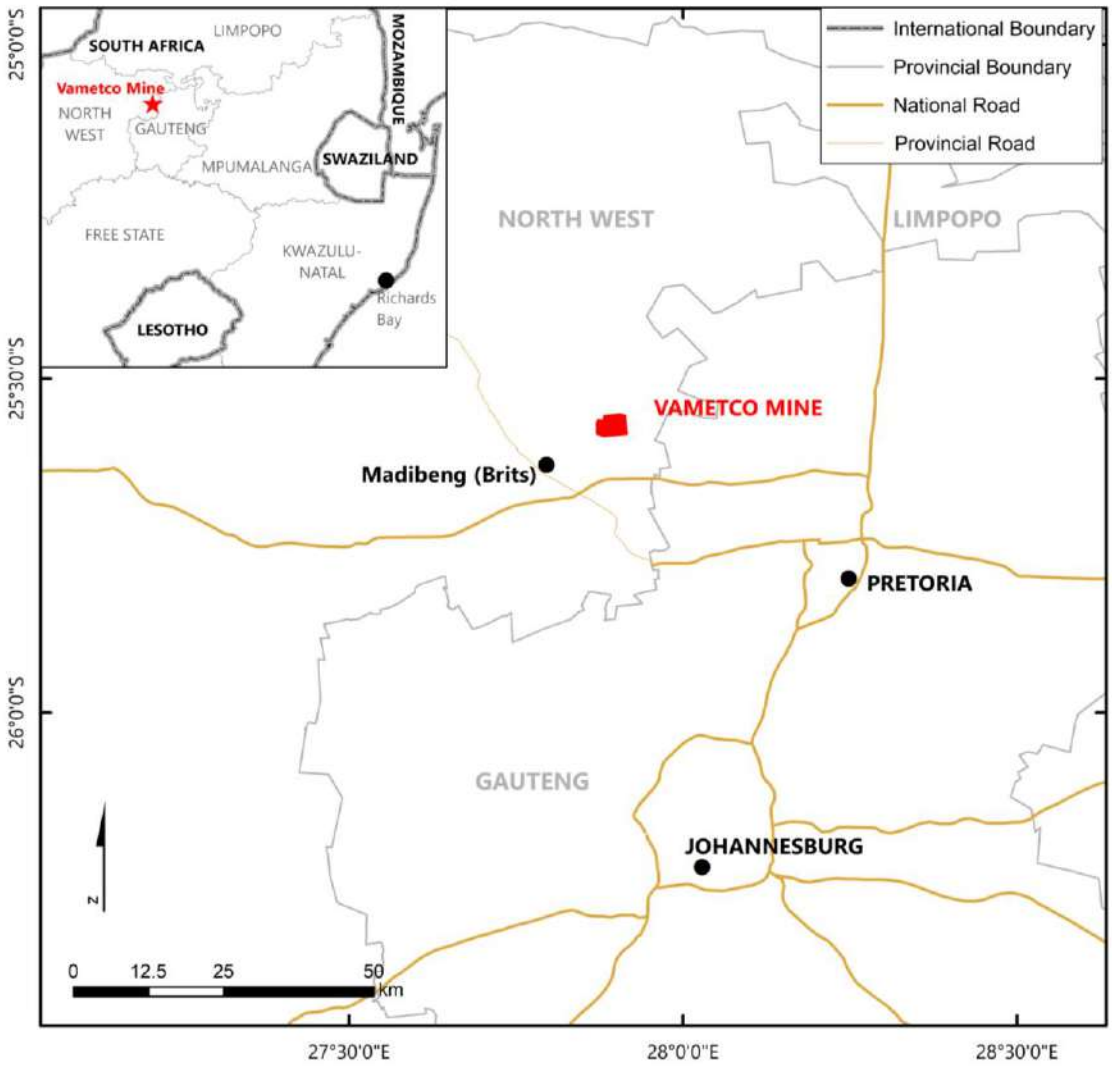
- Mr André Johannes van der Merwe, who is a Professional Geologist with more than 30 years' experience in exploration, mining, project development, due diligence reviews and valuations of mineral assets. Mr van der Merwe has been Technical Consultant/Advisor to several successful listings on FTSE, AIM, TSX, ASX and JSE, as well as private fundraisings. Mr van der Merwe is registered as a Professional Natural Scientist (Geological Science) (SACNASP No 400329/04) and is a Fellow of the GSSA and a member in good standing of the Australasian Institute of Mining and Metallurgy (AusIMM) and the Society of Economic Geology (Member). Mr van der Merwe has the appropriate relevant qualifications, experience, competence and independence to act as a "Competent Person" as that term is defined in the JORC Code (2012).

2 PROJECT OUTLINE

2.1 Property Description

The Vametco Mine is situated about 6.5 km northeast of the town of Madibeng (formerly known as Brits). The mine is an operational opencast vanadium mine, located in the Bojanala Platinum District within the North-West Province of the Republic of South Africa. The regional location of the Project is shown in Figure 2-1.

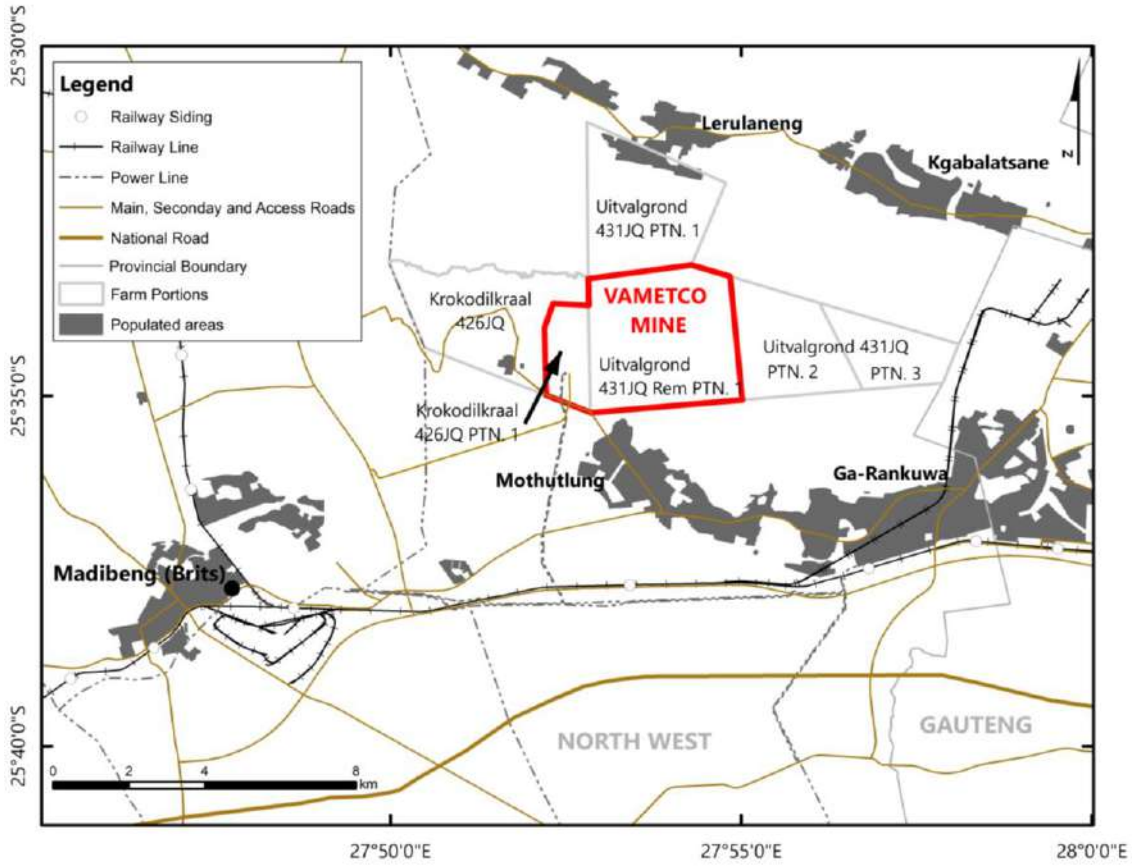
Figure 2-1
Regional location of the Vametco Mine



Source: *Modified from Vametco (2019)*

The Vametco Mine comprises the Vametco Mining Right Area ("MRA") which covers an area of approximately 1,508 ha. The MRA comprises Portion 1 of the farm Krokodilkraal 426JQ and the Remaining Extent of Portion 1 of Uitvalgrond farm 431JQ, as shown in Figure 2-2.

Figure 2-2
Vametco Mine Location



Note: *Background information sourced from the digital 1:50 000 topographic map sheet 2527DB, Projection WGS84 LO27 (Surveys and Mapping, South Africa)*

The Project comprises an open pit mine which supplies ore directly to the vanadium processing plant which is located on the same property. The open pit is approximately 3.5 km long, in an east-west direction. The vanadium is extracted from magnetite layers occurring near the basal contact of the Upper Zone of the Bushveld Igneous Completed. The mine has been in operation since 1967.

The mining right is valid until 23 April 2038. The MRA stretches for some 4.7 km from west to east and 3.9 km from north to south. The surface elevation ranges from 1,185 metres above mean sea level ("mamsl") in the southwest perimeter to 1,140 mamsl on the northwest perimeter of the site. The ground surface is gently sloping toward the Rosespruit in the north. Vametco is located in the upper region of the Rosespruit catchment (drainage region A21J, as defined in WRC Report No. 298), a minor tributary (97.2 km^2) of the Crocodile River. The confluence of these two rivers is approximately 12 km downstream from Vametco. The Vametco MRA covers approximately 11 % of the catchment.

The corner co-ordinates of the Vametco MRA are listed in Table 2-1.

Table 2-1
Vametco Mine Property Coordinates (WGS84 LO27)

ID	Y-Coordinates	X-Coordinates
A	-88,500.35	+2,827,573.16
B	-90,954.98	+2,827,243.69
C	-91,839.74	+2,827,530.57
D	-92,117.33	+2,830,810.63
E	-88,518.93	+2,831,115.17
H	-87,464.74	+2,830,653.22
I	-87,455.21	+2,828,822.81
J	-87,675.54	+2,828,211.86
K	-88,503.96	+2,828,262.36
Back to A	-88,500.35	+2,827,573.16

2.2 Property Location

The Vametco Mine is situated about 6.5 km northeast of the town of Madibeng (formerly known as Brits), 1 km north of Mothutlung, 5 km northwest of Ga-Rankuwa and 4 km south of Lerulaneng. The mine is an operational opencast vanadium mine, located in the Bojanala Platinum District within the North-West Province of the Republic of South Africa. The operations are near the Mmakau and Rankotea villages, which are approximately 500 m to the south and west of the operations respectively (Figure 2-2).

The parent farms shown in the figure are located on Government 1:50,000 topo-cadastral sheets (2527, 2528, 2627 and 2628) which are published by the Chief Directorate, Surveys and Mapping (Private Bag X10, Mowbray 7705, South Africa, Phone: +27 21 658 4300, Fax: +27 21 689 1351 or e-mail: cdsm@sli.wcape.gov.za). The Vametco MRA was surveyed as part of the requirements for the conversion of the Old Order Mining Right to the New Order Mining Right in 2013 (see Section 2.4.3).

2.3 Country Profile

South Africa has a mixed economy, the second largest in Africa after Nigeria (IMF 2019). The country is a middle-income emerging market with an abundant supply of natural resources; well-developed financial, legal, communications, energy, and transport sectors; and a stock exchange that is Africa's largest and among the top 20 in the world (CIA Factbook, 2019). Economic growth has decelerated, with unemployment, poverty and inequality among the highest in the world.

The current key economic indicators for South Africa are given in Table 2-1

Table 2-1
Economic indicators for South Africa (March 2019)

Interest Rate	GDP Growth Rate (YoY)	Unemployment Rate	Core Inflation Rate
6.75 %	1.1 %	27.6 %	4.4 %

Source: *www.tradingeconomics.com*

South Africa has a mature minerals industry and is the world's largest producer of platinum, chrome and vanadium. South Africa ranks highly in the production of diamonds, coal, iron ore and base metals (PwC, 2018).

Challenges and risks associated with the minerals and mining industry in South Africa in 2018 included (PwC, 2018):

- Macro-economic fluctuations
- cost pressures with risk being driven by:
    - labour relations and wage negotiations
    - maintenance and loss of critical skills
    - reliance on third party infrastructure with availability and costs of water and electricity highlighted as a concern; and
- geopolitical and regulatory risk
- safety, health and environmental
- public perception on licence to operate (socio-economic environment surrounding mines is of concern).

2.4 Legal Aspects and Permitting

The legislative framework, and nature of the issuer's rights and the right to use the surface of the properties to which the Vametco MRA relates are described below. The farm boundaries are clearly defined by existing fencing and other boundary markers.

2.4.1 Legislative Framework

The South African Government has an extensive legal framework within which mining, environmental and social aspects are managed. Inclusive within the framework are international treaties and protocols, and national acts, regulations, standards, and guidelines which address international, national, provincial and local management areas.

The Department of Mineral Resources ("DMR"), with a head office in Pretoria and regional offices in each of the nine provinces of South Africa, administers the mining industry of South Africa.

South African statutory legislation and requirements relevant to the Project and considered as part of this CPR include:

- Mineral and Petroleum Resources Development Act (Act 28 of 2002) ("MPRDA");
- Mineral and Petroleum Resources Development Amendment Act 49 of 2008;
- National Environmental Management Act (Act 107 of 1998) ("NEMA");
- National Water Act (Act 36 of 1998) ("NWA"):
- National Environmental Management: Air Quality Act (Act 39 of 2004) ("NEM:AQA"); and
- National Environmental Management: Waste Act (Act 59 of 2008) ("NEM:WA").

The most important of these, applicable to Vametco, are summarised in the subsections to follow. Bushveld's compliance in regard to the specific pieces of legislation are detailed in Table 2-3.

2.4.1.1 Mineral and Petroleum Resources Development Act (Act 28 of 2002) - MPRDA

The types of rights and permits applicable to the mining industry in South Africa are defined in the MPRDA and subsequent amendments. In addition, in terms of the MPRDA, mining and exploration companies have to comply with additional responsibilities relating to environmental management and to environmental damage, degradation or pollution resulting from their prospecting or exploration activities.

Section 37 of the MPRDA establishes the framework for the inclusion of environmental management principles. Section 39 defines the environmental management programme ("EMP") and EMP requirements. Requirements for the contents of exploration, scoping, Environmental Impact Assessment ("EIA"), EMPs and EMP reports are provided in Government Notice Regulations ("GNR"s) 49, 50, 51 and 52.

Sections 41 to 47 of the MPRDA address legislative closure requirements. Some of this has now been repealed and moved to under NEMA, however as most of the provisioning for the Arnot MRA was previously done under this act, it still has reference. GNR 527 of the MPRDA addresses the financial provision for mine rehabilitation and closure and requires that the quantum of financial provision, to be approved by the Minister, must be based on the requirements of the approved EMP and include a detailed itemisation of all actual costs required for:

- premature closure regarding:
    - the rehabilitation of the surface of the area;
    - the prevention and management of pollution of the atmosphere;
    - the prevention and management of pollution of water and the soil; and
    - the prevention of leakage of water and minerals between subsurface formations and the surface;
- decommissioning and final closure of the operation; and
- post closure management of residual and latent environmental impacts.

Recently published draft NEMA regulations (GNR 667) are out for comment; this new proposed regulation will both replace and repeal the existing regulations in place since 2015. Implications of these new regulations are still being assessed.

GNR527 defines the requirements for the social and labour plan ("SLP"). This amongst other aims, is how the MPRDA strives to transform the mining and production industries. The Act requires the submission of the SLP as a prerequisite for the granting of mining or production rights. The SLP requires applicants for mining and production rights to develop and implement comprehensive Human Resources Development Programmes including Employment Equity Plans, Local Economic Development Programmes and processes to protect jobs and manage downscaling and/or closure.

2.4.1.2 Mineral and Petroleum Resources Development Amendment Act 49 of 2008

In 2008, an Amendment Bill proposed to make significant changes to the MPRDA. The Bill was signed by the President in 2009 but did not come into force at that time (Webber Wentzel, 2009).

While not an exhaustive list, the Amendment Act is noteworthy because it addresses the following issues pertinent to the environmental and social aspects of mining:

- it requires the prior written consent for disposal in various forms of a prospecting or mining right or an interest in such a right;
- it allows the Minister to impose further conditions on an applicant for mining rights to include participation by the community;
- it allows for the cancelation or suspension of mineral rights if there is non-compliance with the MPRDA; and
- it has various forward-looking environmental provisions that were to come into effect 18 months after the promulgation of the Act. These include:
    - making the Minister of Mineral Resources responsible for environmental matters that relate to mining (now under the NEMA);
    - requiring the simultaneous application for environmental authorisation with mineral tenure applications (Now managed under the "One Environmental System"); and
    - requiring a report on compliance with environmental authorisation with renewal applications known as an "EMPr Performance Assessment Report" (Legalbrief Today, 2013; Webber Wentzel, 2013).

2.4.1.3 National Environmental Management Act (Act No. 107 of 1998) - NEMA

NEMA was promulgated in 1998 to replace the Environmental Conservation Act 1989 ("ECA"), Act No. 73, as the overarching national environmental legislative framework. NEMA was promulgated to give effect to the Environmental Management Policy (published in 2007), and has been subsequently amended, including the National Environmental Management Amendment Act of 2003, and the National Environmental Management Second Amendment Act, No. 8 of 2004.

As per the EIA Regulations, an application for environmental authorisation for certain listed activities must be submitted to the provincial environmental authority, the national authority, depending on the types of activities being applied for or, when mining and mineral processing activities are involved, the Department of Mineral Resources ("DMR").

The current EIA regulations, GN R.982, GN R.983, GN R.984 and GN R.985, promulgated in terms of Sections 24(5), 24M and 44 of the NEMA and subsequent amendments, commenced on 8 December 2014. In summary, the amendments have the following repercussions:

- NEMA will regulate all environmental related aspects;
- all environmental aspects have been repealed from the MPRDA;
- the Mineral Resources Minister will be responsible for the issuance of Environmental Authorisation ("EA") in terms of NEMA;
- the Mineral Resources Minister will implement the provisions of NEMA and the subordinate legislation;
- the ministries (Department of Mineral Resources ("DME") and Department of Environmental Affairs ("DEA")) now undertake an integrated environmental authorisation under the "one Environmental System" as per the National Environmental Management Laws Amendment Act, Act No.25 of 2014 of NEMA. This gives powers to the Minister of Mineral Resources

and Energy as the competent authority in terms of NEMA listed activities within mining or related extraction and primary processing of mineral activities; and

- the issuing of mining related licences and permits by the DMRE will adhere to a defined time frame of a maximum of 300 days as per the regulation.

GN R.983 lists those activities for which a Basic Assessment is required, GN R.984 lists the activities requiring a full EIA (Scoping and Impact Assessment phases) and GN R.985 lists certain activities and competent authorities in specific identified geographical areas. GN R.982 defines the EIA processes that must be undertaken to apply for Environmental Authorisation.

2.4.1.4 National Water Act (Act No. 36 of 1998) - NWA

The NWA was promulgated in 1998 to replace the Water Act of 1956. There were several critical changes within the NWA that changed the water landscape. Water was in the custody of the state and access to water required a process of registration and subsequently the Licensing of the water uses (either as an existing water use or new water use). The types of water uses were clearly defined in Section 21 of the Act.

The Water Use Licence ("WUL") Application processes took the form of an EIA for water and the motivation for access included detailed understanding of the water resource being accessed. Integrated WULs are encouraged and in most cases an integrated licence will authorise several water uses of the same and/or different types. Any WUL issued to a legal entity includes several conditions relating to that particular water use.

Under the NWA and often stipulated within the WUL conditions are the requirements for the following (non-inclusive list):

- the development of an Integrated Waste and Water Management Plan;
- the establishment and maintenance of a monitoring programme with regular report submission to the regulatory authorities;
- a water conservation and water demand management plan; and
- the annual auditing of the water licence and its associated conditions.

In addition, and of particular pertinence to the mining sector are the regulations under GN. 704. GG20119 (4 June 1999) which repealed the regulations published as GN287 of 1976. This set of regulations defines the requirements on the use of water from mining and related activities and is aimed at the protection of water resources. Sections 6 and 7 of GN704 provide clear guidance on the capacity requirements of clean and dirty water systems and the protection of water resources.

2.4.1.5 National Environmental Management: Waste Act (Act 59 of 2008) - NEM:WA

The National Environmental Management: Waste Amendment Act 26 of 2014 (Waste Amendment Act) came into effect on 2 June 2014.

"Waste" is defined as:

a) any substance, material or object, that is unwanted, rejected, abandoned, discarded or disposed of, or that is intended or required to be 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; or

b) any other substance, material or object that is not included in Schedule 3 that may be defined as a waste by the Minister by notice in the Gazette, but any waste or portion of waste, referred to in paragraphs (a) and (b), ceases to be a waste:

   i. once an application for its re-use, recycling or recovery has been approved or, after such approval, once it is, or has been re-used, recycled or recovered:

   ii. where approval is not required, once a waste is, or has been re-used, recycled or recovered; or

   iii. where the Minister has, in terms of section 74, exempted any waste or a portion of waste generated by a particular process from the definition of waste.

The regulations for residue deposits and residue stockpiles have also been included within the scope of the new Act (this was previously regulated in terms of the Mineral and Petroleum Resources Development Act 28 of 2002).

According to the new amended Act of 2014, "residue deposits" means any residue stockpile remaining at the termination, cancellation or expiry of a prospecting right, mining right, mining permit, exploration right or production right, and "residue stockpile" means any debris, discard, tailings, slimes, screening, slurry, waste rock, foundry sand, mineral processing plant waste, ash or any other product derived from or incidental to a mining operation and which is stockpiled, stored or accumulated within the mining area for potential re-use, or which is disposed of, by the holder of a mining right, mining permit or, production right or an old order right, including historic mines and dumps created before the implementation of this Act.

Residue deposits and residue stockpiles include:

- wastes resulting from exploration, mining, quarrying, and physical and chemical treatment of minerals;
- wastes from mineral excavation;
- wastes from physical and chemical processing of metalliferous minerals;
- wastes from physical and chemical processing of non-metalliferous minerals; and
- wastes from drilling muds and other drilling operations.

"Hazardous waste'' is now classified to include any waste that contains organic or inorganic elements or compounds that may, owing to the inherent physical, chemical or toxicological characteristics of that waste, have a detrimental impact on health and the environment and includes hazardous substances, materials or objects within business waste, residue deposits and residue stockpiles.

2.4.1.6 National Environmental Management: Air Quality Act (Act 39 of 2004) -NEM:AQA

The National Environmental Management: Air Quality Act (NEM:AQA, Act 39 of 2004) results from the promulgation of the NEMA. The Act serves as the dominant legislative tool for the management of air pollution and related activities, and defines listed emission activities which require licensing.

The overall objectives of the Act are to protect the environment by providing reasonable measures for:

- protection and enhancement of the quality of air in the Republic;
- prevention of air pollution and ecological degradation;
- securing ecologically sustainable development while promoting justifiable economic and social development; and
- giving effect to Section 24(b) of the constitution to enhance the quality of ambient air for the sake of securing an environment that is not harmful to the health and wellbeing of people.

The South African government established the National Ambient Air Quality Standards in Government Notice 1210. The standard provides for various emission limits, inclusive of particulate matter (PM10), ozone (O_3), carbon monoxide (CO), sulphur dioxide (SO_2), and nitrogen dioxide (NO_2).

2.4.2 Corporate Structure

A new order mining right is held by Bushveld Vametco Holdings (Pty) Ltd, which holds 100 % of the operating company Bushveld Vametco Alloys (Pty) Ltd.

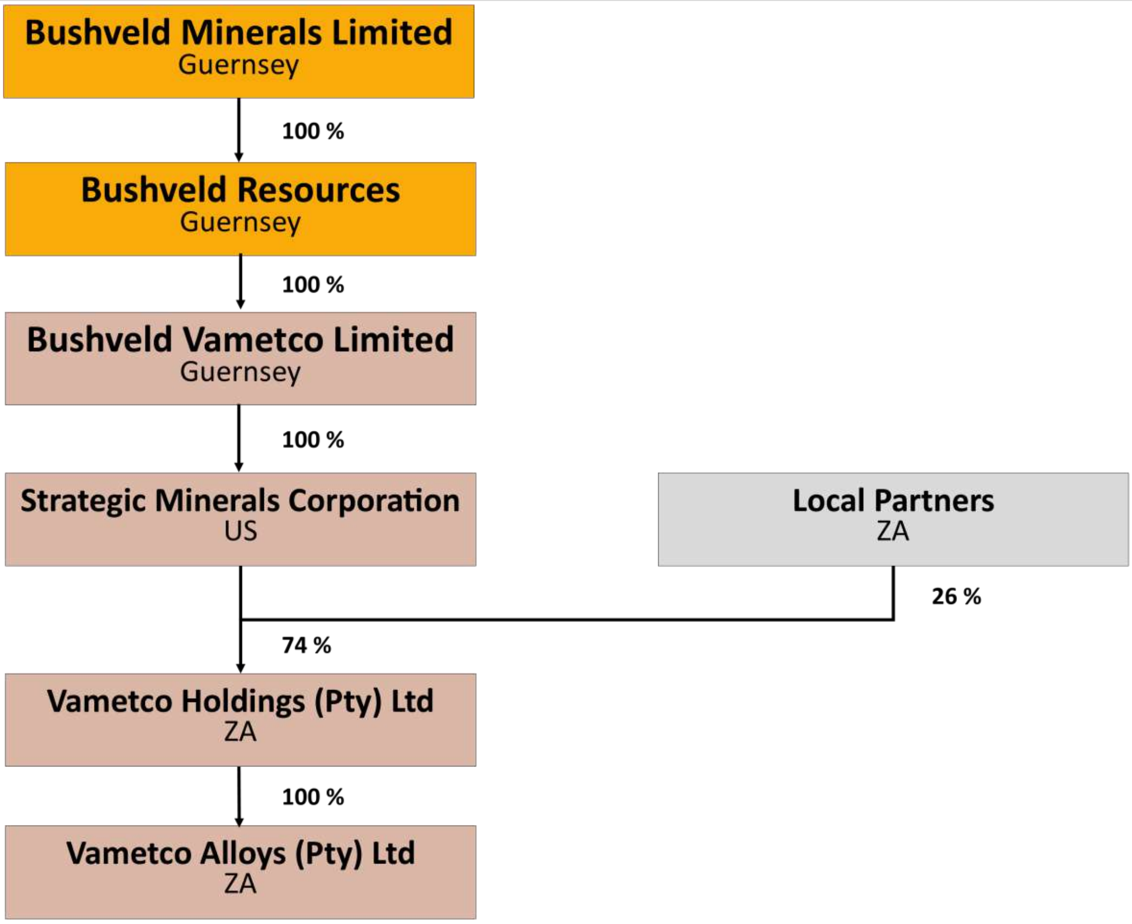
On 6 April 2017, Bushveld Minerals Limited ("BMN"), in partnership with Yellow Dragon Strategic Minerals Corporation ("SMC") who, at the time, held a 75 % shareholding in Vametco Holdings (Pty) Ltd and Vametco Alloys (Pty) Ltd. On 21 December 2017, BMN completed the acquisition of 55 % of Bushveld Vametco Limited from Yellow Dragon, effectively increasing BMN's shareholding from 26.6 to 59.1 %. On 13 September 2018, BMN completed the acquisition of a 21.22 % interest in SMC from Sojitz. As a result, BMN's effective shareholding increased to 75 %. On 27 September 2018, BMN sold 1 % equity interest in Vametco Holdings (Pty) Ltd to its two Broad Based Black Economic Empowerment ("BBBEE") shareholders, i.e. Business Ventures Investments No. 1833 (Proprietary) Limited and Business Ventures Investments No. 973 (Proprietary) Limited, decreasing the BMN shareholding to 74 %, the maximum equity ownership amount permitted under the South African Mining Charter (BMN, 2018).

The ownership structure is depicted in Figure 2-3.

As at 01 June 2019, the Broad based Black Economic Empowerment ("BBBEE") shareholding in Bushveld Vametco Holdings (Pty) Ltd was 26 %.

Figure 2-3

The ownership structure for the Vametco Mine



Source: *Modified from BMN, 2019*

2.4.3 Mining Rights

MSA is not qualified to give opinion on the legal tenure of the Vametco Mining Right.

All mining and prospecting rights in the Republic of South Africa are issued by the DMR in accordance with MPRDA.

A new order mining right (No: NW 30/5/1/2/2/08 MR) is held by Vametco Holdings (Pty) Ltd, for the vanadium operations. The converted mining right replaced the old order mining right which was held by Strategic Minerals Corporation (75 %), Business Venture Investment Group no 973 (15 %) and Business Venture Investment Group no 1833 (10 %), with the latter two representing community based trusts and co-operations.

The mining right is valid for a period of 25 years and has an expiry date of 23 April 2038. The current ownership structure discussed in Section 2.4.2 and depicted in Figure 2-3.

Table 2-1
Vametco's Mining Right Status

Type	DMR Reference	Interest (%)	Official Area (ha)	Licence Expiry Date	Holder	Status
Mining Right	NW 30/5/1/2/2/08 MR	100	1549	23/04/2038	Vametco Holdings (Pty) Ltd[1]	Operating

Note: *[1] BMN has a 74 % net attributable interest in Vametco Holdings (Pty) Limited.*

2.4.4 Surface Rights

Current operations are on parts of the farms "Krokodilkraal" and "Uitvalgrond". These farms are owned by Historically Disadvantaged South Africans ("HDSA"s) and have been since 1912. Vametco Holdings had long-term lease agreements in place with the registered landowners and co-owners listed in Table 2-4 until the conversion of the Old Order Mining Right to the New Order Mining Right was executed during April 2013. The parties are currently in negotiations to secure surface lease agreements which will be retrospectively implemented to April 2013.

Table 2-4
Registered Landowners of the Properties

Property	Area (ha)	Registered Landowners and Co-owners
Krokodilkraal (462JQ)	272.1358	Co-Owners: c/o Fabricius & Engelbrecht Attorneys 102 Amos Street Colbyn Pretoria
Uitvalgrond (431JQ)	1235.6069	Co-Owners: c/o Sixabela Incorporated P.O. Box 12520 Hatfield 0028

2.4.5 Servitude Rights

Vametco Holdings holds servitude rights over the water line that leads to the plant. Eskom has servitude rights for the power line, which crosses the Property.

2.4.6 Environmental and Social Compliance

Various environmental authorisations are required from governmental departments for Vametco Holdings to operate lawfully. These include: -

- a conversion of the Old Order Mineral Rights to New Order Mineral rights;
- a Record of Decision ("ROD") from the DMR in terms of the MPRDA;
- an Environmental Authorisation from the North-West Department of Economic Development, Environment and Tourism ("NWDEDET") in terms of NEMA;
- an approved Integrated Water Use Licence ("IWUL") from the Department of Water and Sanitation ("DWS") in terms of Section 40 of the NWA; and
- an approved Waste Management Licence from the Department of Environmental Affairs.

The environmental and social compliance status in relation to the South African legislative requirements for the Vametco Project are summarised in Table 2-3.

Table 2-3
Vametco Project Environmental Authorisations

Environmental Authorisations						
NO.	**ENVIRONMENTAL AUTHORISATION**	**PROPERTIES**	**DATE ISSUED**	**EXPIRY DATE**	**STATUS**	**COMMENTS**
1.	As per NWA 36 of 1998 - Consolidated Water Use Licence (WUL) Ref. 04/A21J/ABCFGIJ/4669	• Krokodilkraal 426 JQ (Portion 1) • Uitvalgrond 431 JQ (Portion 1)	31st May 2017	2037 (20 years) and next review 2022	Active	The WUL covers all planned activities at the operation.
2.	As per Minerals Act (50 of 1991) - Environmental Management Plan (EMP) - 1998	• Krokodilkraal 426 JQ (Portion 1) • Uitvalgrond 431 JQ (Portion 1)	1998			Was undertaken in 1997/8 by Walmsley Environmental Consultants (Pty) Ltd and addresses mining and processing activities on the forms Krokodilkraal 426 JQ (Portion 1) and Uitvalgrond 431 JQ (Portion 1).
3.	As per MPRDA, 2002 (Act 28 of 2002) - Environmental Management Plan (EMP) - 2015	Covers both Krokodilkraal and Uitvalgrond properties where all current activities are situated within the Mineral Resource Area.	No ROD.		Application for addendum submitted in 2015 was not approved but does not affect the original authorisation	Refusal of the addendum to the mining was primarily based on the failure to provide for backfill of the pit as part of the mitigatory factors. Ongoing engagement on this issue has been done with a partial backfill strategy having been devised. Engagements are currently underway with DMR to resolve this issue.
4.	As per MPRDA, 2002 (Act 28 of 2002) - Environmental Management Plan (EMP) - 2018	• Krokodilkraal 426 JQ (Portion 1) • Uitvalgrond 431 JQ (Portion 1)	In progress		In progress	Project initiated in 2018 with scoping meeting held in May 2019.
5	As per NEMA:WA 59 of 2008 – Waste Management Licence (Ref. 12/9/11/L44253/7)	Class A waste disposal facility and recovery of hazardous materials	9th March 2016	2026 (10 years) and next review 2021	Active	Covers specific activities on Ptn 1 of Krokodilkraal 426 JQ and the remaining extent of Ptn 1of Uitvalgrond 431 JQ
6	As per NEMA:AQA 39 of 2004 – Atmospheric Emissions Licence (Ref. NWPG/VAMETCO/AEL4.18/FEB13)	Addresses the stack emissions from the Boiler 1&2 stack , Boiler 3 stack, Kiln stack, MVO stack. Nitrovan™ furnace 4 stack and the Precipitation stack	01st April 2015	01st April 2020	Active	Bi-annual monitoring done on the stack emissions have shown historical non-conformance of the facility. Upgrades to the kiln and filter system as part of the "Phase 3 project" are scheduled and should address this.

2.4.6.1 Magnetite dump and slimes dam facilities

Waste disposed of magnetite at the Vametco mine is done under a Class A Categorisation and Waste Management Licence (Table 2-3). This authorisation is valid to 2026, but will be subject to review in 2021.

The magnetite dump is currently nearing capacity and is being expanded to accommodate a further five years of disposal capacity. The extension is being done to the southeast of the existing dump footprint. The existing dump slopes are being rehabilitated with grasses and require regular irrigation with clean water. The success of the vegetation establishment approach is variable and the sustainability of maintaining this vegetation with artificial wind protection and irrigation is difficult to assess. The new magnetite dump extension will be tied into the existing facility with an impermeable liner and designed drainage being installed. The construction is nearing completion with some minor alterations being made.

Key to note in the conditions of the licence and the magnetite dump construction:

- access control and security:
  - the proximity of communities to the mine make this condition critical in ensuring public exposure is restricted and is a clear and specific stipulation for the facility that needs to be met;
- establishment of a Waste Monitoring Committee, appointment of a Management Control Officer and a Professional Civil Engineer are all governance requirements established in the Waste Management Licence:
  - the formal appointment of the Engineer for the waste facility could not be confirmed, however MSA did see copies of communication to this effect. No clarity could be obtained on the other required appointments; if these appointments have not been made, this would constitute a breach of the licence conditions;
- it could not be confirmed whether the change in ownership from EVRAZ to BMN was ever formally done to the relevant authorities as is required;
- the overlay of the actual footprint of the facility and the licenced delineation of the approval could not be ascertained at the time of reporting. This will become critically important should a future plan to increase production (Phase 3 planning) come to fruition;
- it was not clear if the additional 5-year capacity gained by extending the magnetite dump is for the current production rate or whether it can accommodate a possible future increase in production (proposed Phase 3 plant upgrade). This needs to be verified as further extensions to the magnetite dump will be required and adequate time provisions must be allowed for to accommodate this and any alterations to authorisations and reviews. Should scheduling and planning of future extensions to the magnetite dump and the related permitting required be incorrect, it could result in bottlenecking of production and possible compliance issues.

2.4.6.2 Water Uses and Infrastructure

Water consumption at Vametco is done under an approved Integrated Water Use Licence ("IWUL") (Table 2-3). The main source of water used by the mine is from the Hartbeespoort Water Scheme, from which the mine receives an allocation.

The amendment to the IWUL has been initiated through an integrated EIA, Waste and Water Use Licence Application process that was initiated in May 2019 with the statutory required Scoping Meeting held with the relevant authorities. This is a critical path item for any proposed alterations to infrastructure and resource access as environmental regulatory approval needs to be granted before any implementation or construction may commence. The timing of this authorisation process (i.e. statutory 300 days for administrative processing) does not take into account any additional baseline studies that could be required. Some of these could take up to a year of data collection (i.e. one hydrological cycle for water) before being sufficient for inclusion in the application.

Water supply is currently only sourced from the Hartbeespoort Besproeiingsraad / Water Scheme. Raw water is pumped to the raw water UCAR Reservoir before being treated to potable water standards and distributed to the mine and plant.

Not all conditions as set out in the existing WUL have been complied with, for example, the IWWMP has not been updated since 2011 when the licence was issued.

The ground water amelioration work/program that is in place is not delivering the performance required to ameliorate the water impacts of seepage from the mine and/or plant. Ground water qualities are therefore non-compliant with the National Water Act. As a consequence, the operation runs the risk of receiving a directive relating to this activity. This will be mitigated if the application of the program is implemented consistently and effectively and the operation can show clear intent to comply.

2.4.6.3 Atmospheric Air Emissions

Atmospheric Air Emissions from the boiler 1 and 2 stack, boiler 3 stack, kiln stack, modified vanadium oxide ("MVO") stack, Nitrovan^{TM} furnace 4 stack and the precipitation stack are licensed as per the NEMA:AWA (Table 2-3). This Air Emissions Licence will expire in April 2020 and should be updated well before this occurs.

It is noted from the information available that there are periodic exceedances of the air quality emissions. Monitoring undertaken does not include interpretation of the air quality results or any long-term trends, nor is there any documentation on the corrective actions raised from the exceedances. The risk of non-compliance to the emission standards includes possible fines, directives or revoking the licence.

2.4.6.4 Other Legal Issues

Bushveld Vametco have confirmed to MSA that there are no land claims on any of the portions of land within the Mining Right Area. These include the farms Krokodilkraal 426 JQ and Uitvalgrond 431 JQ.

The long outstanding private landowner and mine agreement (initiated upon the implementation of the new order mineral rights) has not been finalised. This document is essential in protecting both parties' rights and needs to be concluded. In the interim, Bushveld Vametco continue to make surface lease payments.

The commitments made in the 2013-2018 Social and Labour Plan ("SLP") were not completed within the stipulated time frame. The DMR requested a Plan of Action to address these issues which was subsequently provided by Vametco. On subsequent review of the implementation of this plan, the DMR issued a Section 93 directive against Vametco for not meeting one of the requirements relating to the installation of high mast lighting structures. Addressing this change has been delayed due to ongoing negotiations within the community. A SLP is a statutory requirement for a Mineral rights holder. The new SLP for Vametco (2018 to 2022) is under final review and is expected to be submitted to the DMR in July 2019.

2.4.7 Environmental Liability

2.4.7.1 Operational Environmental Liability and Costs

Vametco has provided for a total estimated operational environmental management cost of ZAR 7 million in 2019 for the operations. Similarly, there is a provision for ZAR 23 million for Social Management in the budget.

The environmental operational costs noted above exclude any capital costs scheduled for 2019 such as:

- the slimes dam drain (ZAR 1.5 million);
- the shafts feed dust collector (ZAR 4.85 million);
- the water treatment mcc (ZAR 4.5 million); and
- the plant bund wall repairs (ZAR 0.85 million).

The longer term (2020 to 2028) capital budget is also in place for the environmental aspects of the operation and includes:

- ground sealing and other environmental projects (ZAR 3.75 million p.a.);
- return water dam construction (ZAR 12.5 million in 2022); and
- calcine dump expansion scheduled for 2028 (ZAR 80 million).

Some clarity on the future changes, which may be required for the possible Phase 3 operational production increases, relating to ground water treatment, increasing rate of closure provisioning, inclusion of the agreed backfill and rehabilitation costs of the pit and the increased rate of waste disposal facility expansions is needed.

The costs for the authorisation of the proposed plant expansion are included in the financial model, however considering the authorisation updates which will be required and which include an update to the Mine Works Programme, the EIA/EMPr update, the Water Use Licence update, the Integrated Waste and Water Management Plan update and any required amendments to the Air Emissions and Waste Management Licences, the provision seems to be too low (ZAR 670,000).

MSA are not aware of any cost to compliance fees (i.e. fines or penalties) incurred by Vametco for the environmental permits, authorisations and licences.

2.4.7.2 *Reclamation and Closure Liability Provision*

The Vametco mine closure cost provision was recalculated in November 2018 by JMA Consulting (Report JMA/30035 Prj6170) in line with the DMR Guideline (Guideline for the Evaluation of the Quantum of Closure-related Financial Provision provided by a mine). The quantum calculated was ZAR 113,747,992.53 excl. VAT or ZAR 129,672,711.48 incl. VAT (at 14 %).

Collectively the finance provided for by Vametco in their financial model for closure is referred to as "Rehabilitation Provisions" is ZAR 97.12 million excl. VAT for 2019. However, revision of the Financial Provisioning mechanisms used by Vametco indicated that the financial provisioning is covered through two mechanisms a rehabilitation trust and financial guarantees:

- Evraz Vametco Rehabilitation Trust Account (1100541231451) holds ZAR 91,320.78 as at May 2019;
- Evraz Vametco Rehabilitation Trust Fixed Deposit Account (1100541231450) holds ZAR 40,420,563.87 as at May 2019; and
- Guardrisk Guarantees (6) amounting to ZAR 90,731,000 as at May 2019 (including the recent guarantee top-up of ZAR 9,286,804.16 signed on the 25th February 2019).

The sum of Financial provisioning using both these financial tools is ZAR 131,242,885 which adequately covers the mine closure liability assessed by JMA Consulting.

The Mine Closure assessment report done by JMA Consulting (Pty) Ltd has still to be submitted to the DMR. The following items should be noted:

- due to the postponement of the financial provisioning regulations 2015 compliance period due date, Bushveld Vametco Alloys has updated their 2018 financial provision using the DMR 2005 Guideline rates which have been adjusted annually by the consumer price index excluding mortgage costs ("CPIX") rate of the previous year. The Financial Provisioning Regulations (including the current 2019 draft regulations) all now require the use of actual contractor rates. As such, the rates in the JMA report are likely to be under provisioned;
- the closure cost estimate undertaken by JMA Consulting in December 2018 proactively included the partial backfill of the pit with restrictions and the integration of the original EMPr and 2015 draft EMPr which was pending approval by the DMR; and
- the mine closure water management allocation is ZAR 4,736,738.62 for the site. This allocation may not be adequate considering the extent of the ground water contamination identified on site and the residual long-term high impacts.

2.4.7.3 *Reclamation and Closure Methodology*

JMA Consulting was appointed by BMN to undertake an annual independent assessment of the closure and rehabilitation liability quantum at Vametco in November 2018. The Regulation GN1147 was applied to the mine closure assessment, plan and costing for Vametco.

Given the above, the approach followed included:

- a number of site visits to assess the current situation, collect and evaluate information and/or data and confirm the nature of all infrastructure;
- verify and update the bill of quantities;
- determine and confirm the applicable unit rates for the costing; and
- compile costing spreadsheets for all relevant aspects of the mine final rehabilitation, decommissioning and closure plan for:
  - infrastructure areas;
  - mining areas;
  - general surface rehabilitation;
  - water/runoff management;
  - post-closure (latent and residual) aspects; and
  - additional allowances.

JMA Consulting has assumed that all infrastructure will be demolished and no allowance has been made for the handover of any facilities (for post closure use). Several inclusions and exclusions need to be noted:

- other than contractual rehabilitation, decommissioning and closure no other staff, support services or retrenchment packages for staff have been included;
- costs associated with environmental authorisations and permitting as well as detailed engineering designs have not been included;
- contingencies of 10 % have been included and P&Gs of 12 % have been included for all areas;
- provisioning for social aspects which are not inherent in the SLP have been excluded; and
- no latent risk calculation has been provided for as this assessment was done against the 2015 regulation.

Allowances for the initial monitoring, maintenance and aftercare for the mine have been included and allow for three years of monitoring, care and maintenance of rehabilitation.

2.5 Royalties and Liabilities

2.5.1 Government Royalty – Mineral and Petroleum Resources Royalty Act (2008)

Royalties are payable for the duration of the mining right, as per Section 25 (2) (g) of the MPRDA.

The Mineral and Petroleum Resources Royalty Act (2008) ("Royalty Act") requires a royalty fee be paid to the National Revenue Fund in respect to the transfer of mineral resources extracted from within the Republic. According to Schedule 2 of the Royalty Act, vanadium >1 % V_2O_5 equivalent and <2 % calcium ("CaO") and silica ("SiO_2") bearing gangue minerals is classified as an unrefined mineral resource.

The royalty payable for an unrefined mineral resource is calculated as follows:

- 0.5 + [earnings before interest and taxes / (gross sales in respect of unrefined mineral resource x 9)] x 100.

The royalty is required bi-annually with the deficit between forecast sales and actual sales payable in a third payment.

2.5.2 Rehabilitation Guarantees

In terms of Regulation 54(2) of the MPRDA, Vametco must make financial provision for the interim and final rehabilitation activities on the site. The provision must be reviewed annually for adequacy and amended to compensate for new activities and/or inflation.

The reader is referred to Section 2.4.7.2 above.

3 ACCESSIBILITY, PHYSIOGRAPHY, CLIMATE, LOCAL RESOURCES AND INFRASTRUCTURE

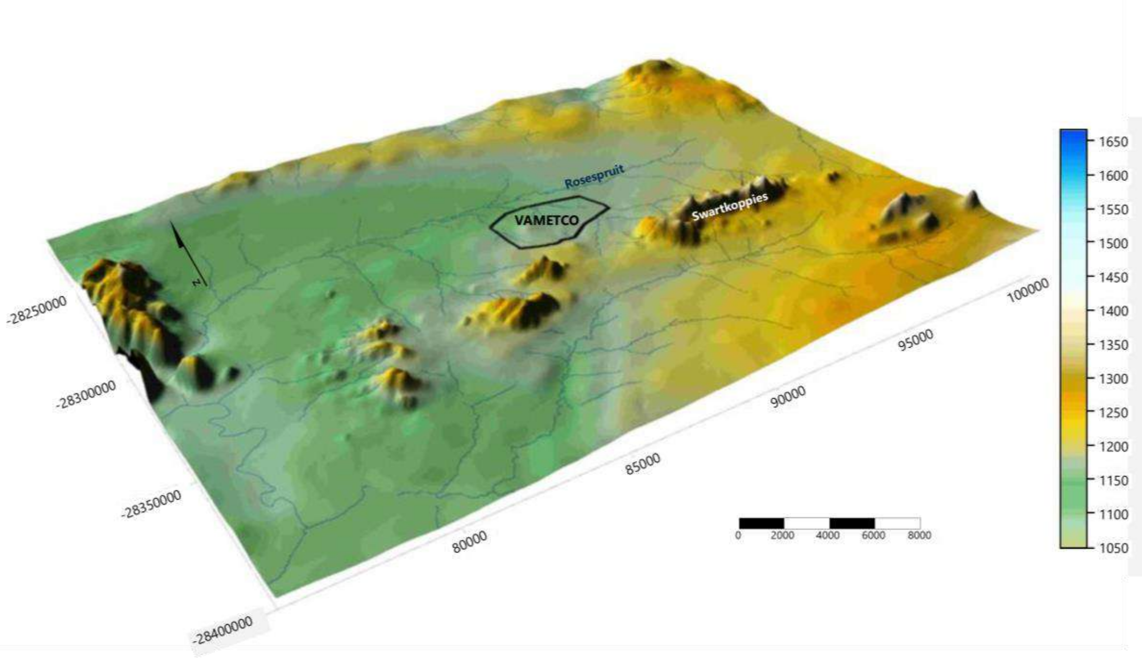
3.1 Topography, Elevation, Drainage, Flora and Fauna

3.1.1 Topography and Elevation

The topography of the Vametco MRA and surrounds is characterised by slightly undulating plains as well as hills and lowlands. The Magaliesberg mountain range is situated just south of Madibeng (formerly known as Brits) and Rustenburg.

The surface elevation of the Vametco MRA ranges from 1,185 mamsl in the southwest to 1,140 mamsl in the northwest of the licence area. The ground surface slopes gently to the north towards the Rosespruit River, with a gradient of 1:100. The Rosespruit River flows from east to west. The Swartkoppies hills are prominent to the south of the operations and reach elevations of 1,405 mamsl. A smaller range of hills, with elevations up to 1,234 mamsl, is present to the north of the Vametco MRA. Figure 3 1 indicates the regional topography.

Figure 3-1
Topography of the area around the Vametco MRA, based on 20 m contour data



Source: *Modified from JMA, 2015*

3.1.2 Drainage

The Vametco Mine is located in quaternary sub-catchment A21J, and drains via the Rosespruit, which is located due north of the site, into the Crocodile River Catchment. The downstream receiving water body is the Roodekoppies Dam. The Rosespruit catchment area, up to the point at which Vametco Mine water discharges into the river, is about 97.4 km^2. The Vametco MRA covers approximately 11% of this catchment area.

The baseline studies undertaken as part of the EMPr by Walmsley Environmental Consultants (Pty) Ltd clearly indicate no significant wetlands or wetland systems or pans within the Mining Right or closely associated with future mining areas on the farms Krokodilkraal 426 JQ and Uitvalgrond 431 JQ.

3.1.3 Flora and Fauna

The vegetation of the Project area falls within the Mixed Woodland vegetation area which comprises grassland, tree and mountainous vegetation areas. This vegetation classification forms part of the savannah biome (Rutherford and Westfall, 1994) and is situated within the Central Bushveld Bioregion (Mucina and Rutherford, 2006). The vegetation present in the Project area falls within the Marikana Thornveld vegetation type (Mucina and Rutherford, 2006), and is characterised by the presence of relatively short trees, including Acacia and broad-leaved species.

Much of the Project area and surround has previously been cleared to make way for mixed farming or modified by overgrazing with cattle resulting in bush encroachment and dense thickets of Acacia species. No Red Data List ("RDL") floral species occur in the Project area; one protected tree species (Adansonia digitate (Baobab)) occurs within the office (landscaped) area of the Vametco mine property.

Wetlands are associated directly with the riverine areas to the north and northwest of the current mining operations and will not be directly affected by Vametco operations.

A security fence installed surrounding the Vametco mining facility is a physical barrier restricting movement of terrestrial fauna. Small mammal species can however negotiate this barrier with ease. Fauna reported from the Project area include Black-Backed Jackal (*Canis mesomelas*), Scrub Hare (*Lepus saxatilis*), Common Duiker (*Sylvicapra grimmia*), Steenbok (*Raphicerus campestris*), Yellow Mongoose (*Cynictis penicillate*), Rock Hyrax (*Procavia capensis*) and the Cape clawless Otter (*Aonyx capensis*), all mainly from the northern most region of the Project area (JMA, 2015). No RDL mammals occur in the Project area.

Several bird species and some reptile species are present; no RDL birds or reptiles have been noted in the Project area.

3.2 Climate

The climatic conditions for the Project area are generally temperate, with cold winter temperatures.

Summer (mid-October to mid-February) is characterised by hot sunny weather, often with afternoon thunderstorms of short duration. The average annual temperatures for nearby Madibeng (Brits) range from a summer maximum of 31°C (daytime) to a winter minimum of 1°C (night). Day time temperatures in spring and summer range from 25°C to 30°C. During the winter months (May to July), much cooler temperatures occur, ranging between 15°C and 24°C during the day.

Precipitation records for the Project area record an average annual rainfall rate of 637 mm, with most rainfall occurring during summer, usually in the form of thunderstorms between November and February. There is a distinct seasonal variation in rainfall and the evaporation follows the same seasonal trend (JMA, 2015). Recent rainfall data from the rainfall weather stations near the Project area is available; however, rainfall is also recorded at the mine. The highest rainfall averages in a year are between October and March (approximately 91 %), while about 9 % of rainfall is recorded from April to September. Table 3-1 shows the monthly distribution of rainfall for the Project area.

Table 3-1
Average Monthly Rainfall for the Vametco Area

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
%	21.7	14.3	14.7	2.8	1.5	2.05	-	0.95	1.2	7.9	17	15.8	100
Mean	138	91	93.7	18.7	9.63	13.1	-	6.04	7.8	50	109	100	637

The Mean Annual Evaporation ("MAE" (S-Pan)) is adopted from the Hartebeespoort Dam and the Rustenburg gauges and is calculated as 1,665 mm. The Mean Annual Runoff ("MAR") is 23 mm, with the total virgin MAR of the Rosespruit catchment area upstream of the point where the affected water course discharges into Rosespruit, being 2,241 x 106 m^3. Activities are expected to only alter this by a reduction of ~4%.

Mining operations in the region continue throughout the year and climatic conditions are not a major hindrance to operations, although delays due to rain and thunderstorms may occur due to exposure of opencast mining operations.

3.3 Access

The Project is located near urban developments of variable size. The roads are predominantly tarred and undergo regular maintenance. The mine can be accessed by gravel road from Madibeng(Brits)/Lethlabile or via the road leading out of Mothutlung-Krokodilkraal, which passes the southwestern corner of the Property.

From the capital city Tshwane (previously Pretoria), the N4 national road runs to the west past Madibeng (Brits). The R511 tarred provincial road splits off from the N4 and continues into Madibeng. A provincial road runs from the eastern side of Madibeng to the intersection where the Vametco road gives access to the mine. The mine can also be reached via a gravel road from Madibeng/Lethlabile tarred road. The major access routes to the Project area are shown in Figure 3-1 and described in more detail in Table 3-2.

Figure 3-1
Access routes to Vametco Mine

Source: *Background imagery from ESRI World Imagery (sourced from Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community)*

Table 3-2
Access roads leading to the Vametco Mine

Road	Jurisdiction	Road Function	Road Surfacing	Typical Width of Road
K16	North West Dept. of Transport, Roads and Community Safety	Provincial class 3 road with collector-distributor function. Connects Lethlabile with Madibeng (Brits) and Rosslyn. The K16 is oriented in a north-south direction.	Tarred	Single carriageway
Vametco Road	Madibeng Local Municipality	Municipal road that provides mine access. The Vametco road is oriented in an east-west direction. Connects Rankotea village with Madibeng and carries very low traffic volumes (approximately 60 - 150 vehicles per hour)	Tarred for 170 m (K16) before turning taking the Vametco Road turnoff – from this point the road to the mine is a gravel road	Single carriageway

Road	Jurisdiction	Road Function	Road Surfacing	Typical Width of Road
Mothutlung Road	Madibeng Local Municipality	Municipal road that connects Rankotea village and Mothutlung. The Mothutlung road runs in a north-south direction and carries relatively low traffic volumes (approximately 100 – 150 vehicles per hour)	Tarred	Single carriageway

3.4 Proximity to Population Centres and Nature of Transport

The closest populated area to the Vametco operation is about 500 m from the boundary of the Property and falls within in the Madibeng Local Municipality, which in turn, falls under the administrative jurisdiction of the Bojanala Platinum District Municipality in South Africa's North West Province. It also falls under the Brits ("Madibeng") Magisterial District, which comprises part of the greater North West Magisterial Districts.

The closest urban area is Madibeng (Brits), approximately 6.5 km from the Vametco Mine. Other villages within a 5 km radius are listed below:

- Mothutlung;
- Krokodilkraal / Rankotea;
- Uitvalgrond / Rabokala;
- Damonsville;
- Mothutlung-A;
- Moumong;
- Ramolapong;
- Tshwara;
- Lerulaneng; and
- Ga-Rankuwa.

The co-owners of Krokodilkraal and Uitvalgrond are the legal landowners of the respective farms and are considered as primary Affected Stakeholders as well as Focus Groups in the Public Participation Programme. The other communities are also recognised as Interested and Affected Parties and were all engaged during the Public Participation Programme.

Access to road transport is readily available.

3.5 General Infrastructure

The mine has been operational since the late 1960s. As a result, the infrastructure in the area and on site is well established (Figure 3-1):

- the administrative offices, change houses, plant and workshops are all located to the south-western part of the Property, close to the mine entrance;

- electricity is provided by a 22 kV power line that crosses the Property on the southern side. This power line supplies enough electricity required to sustain the daily operations of the mine;
- the plant on the mine and other facilities are supplied water that is sourced from six boreholes and a canal; and
- an agricultural aqueduct from Hartebeestpoort Dam passes 500 m from the north-western corner of the Property.

The current power and water supply to operations is deemed to be sufficient for continued production at the current rates. The Project infrastructure is discussed in further detail in section 8.4.

The Vametco operation uses a combination of strip and open pit mining techniques for ore extraction. The following key infrastructure is present (Figure 3-1):

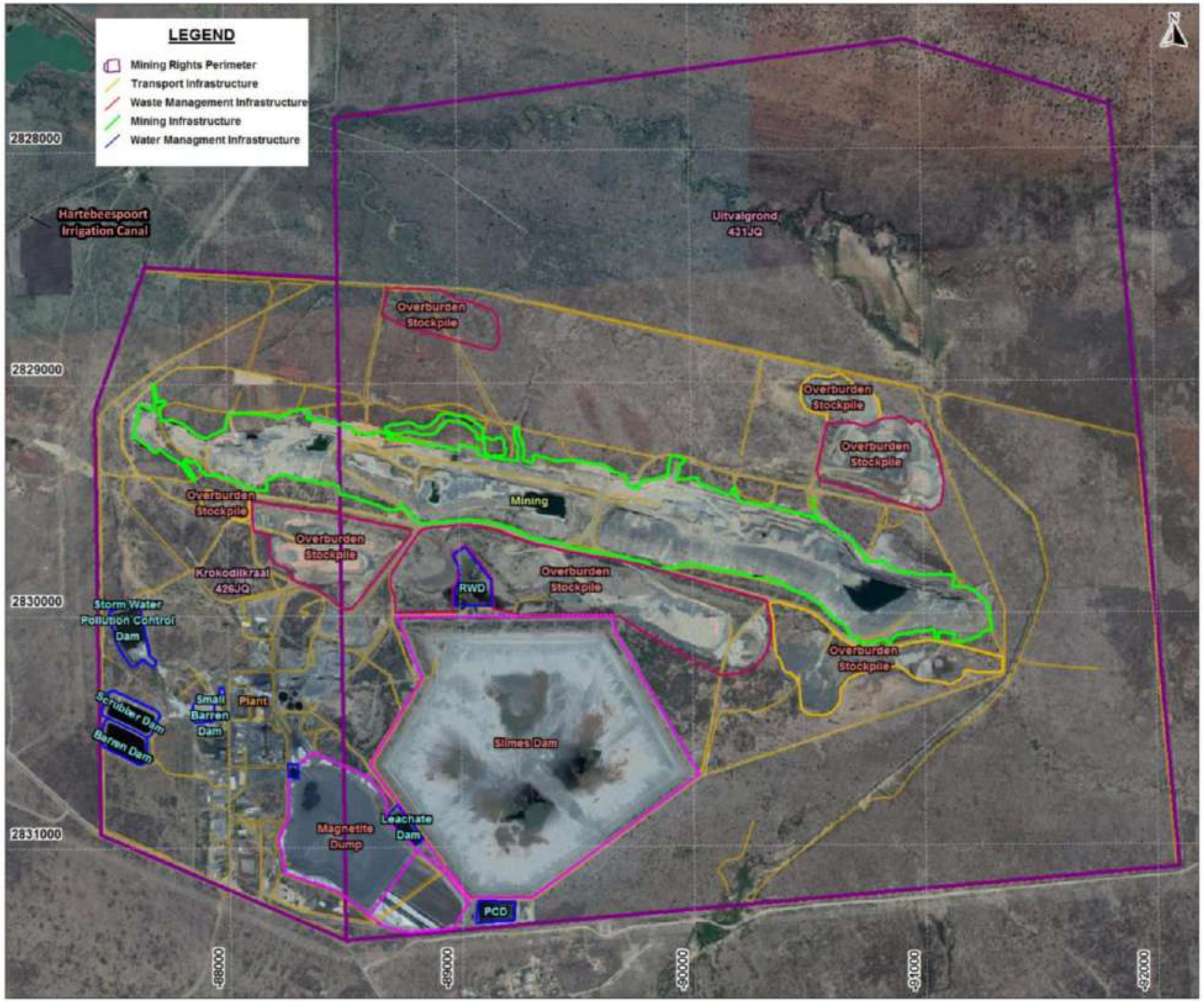
- production haul roads (in pit as well as connecting the mining pits to the beneficiation facilities);
- beneficiation plant;
- workshops, fuel storage, stores and office buildings;
- high tension power distribution;
- waste dumps and ore stockpile facilities;
- process water dams and slimes deposition facilities; and
- security.

3.5.1 Roads and Rail

Access to the mine is facilitated by a well-developed road network with both tarred and gravel roads connecting the Project area to Madibeng (Brits) and the surrounding villages and settlements. No provincial roads pass through the Vametco MRA. The road infrastructure in the area is in fair condition and is well maintained.

The Madibeng (Brits) east-west railway line is located to the south of the Vametco MRA (Figure 2-2).

Figure 3-1
General Infrastructure



Source: *JMA (2018)*

4 PROJECT HISTORY

4.1 Previous Ownership

In 1967, vanadium mining operations commenced on Portion 1 of the farm Krokodilkraal 426JQ and the Remaining Extent of Portion 1 of Uitvalgrond farm 431JQ. The mine was owned and operated by Union Carbide (USA).

The farms were leased from the legal landowners, a group of Historically Disadvantaged South Africans ("HDSAs"), with whom formal lease agreements were entered into in 1988, valid for a period of 25 years, until 2013.

In April 2013, the Old Order Mining Right was converted to the New Order Mining Right. The private landowner and mine agreement (which was re-initiated upon the implementation of the new order mineral rights) has not been finalised. This agreement will finalise the royalty payments from Vametco to the private landowners amongst other items. The landowners and Vametco are currently in negotiations to secure surface lease agreements which will be retrospectively implemented to April 2013.

In 1984, the company name changed to Vametco Minerals Corporation ("VMC"). Union Carbide was acquired by Strategic Minerals Corporation ("SMC") in 1986. In 1994 mining and concentration operations were temporarily suspended due to a global oversupply of vanadium. The feed material to the extraction plant became vanadium-bearing slag (spinel) which was supplied to Highveld Steel. In 1996, the mining and concentration operations recommenced due to an increased demand for vanadium and good vanadium prices (JMA, 2018).

Vametco Minerals Corporation was a fully owned American subsidiary of SMC until November 2006, when it was converted to a South African Company under the name Vametco Holdings (Pty) Ltd.

SMC owned 75% of Vametco Holdings (Pty) Ltd, with the remaining 25 % owned by two Business Venture Investment Groups: 15 % by number 973 and 10 % by number 1833. These Groups represent a BEE Strategic Partner and co-owner interests (VBKom, 2016). Vametco Alloys (Pty) Ltd is a fully owned subsidiary of Vametco Holdings (Pty) Ltd.

In 2007 EVRAZ plc acquired a controlling shareholding in SMC and the name was officially changed to EVRAZ Vametco Holdings (Pty) Ltd and EVRAZ Vametco Alloys (Pty) Ltd in 2011.

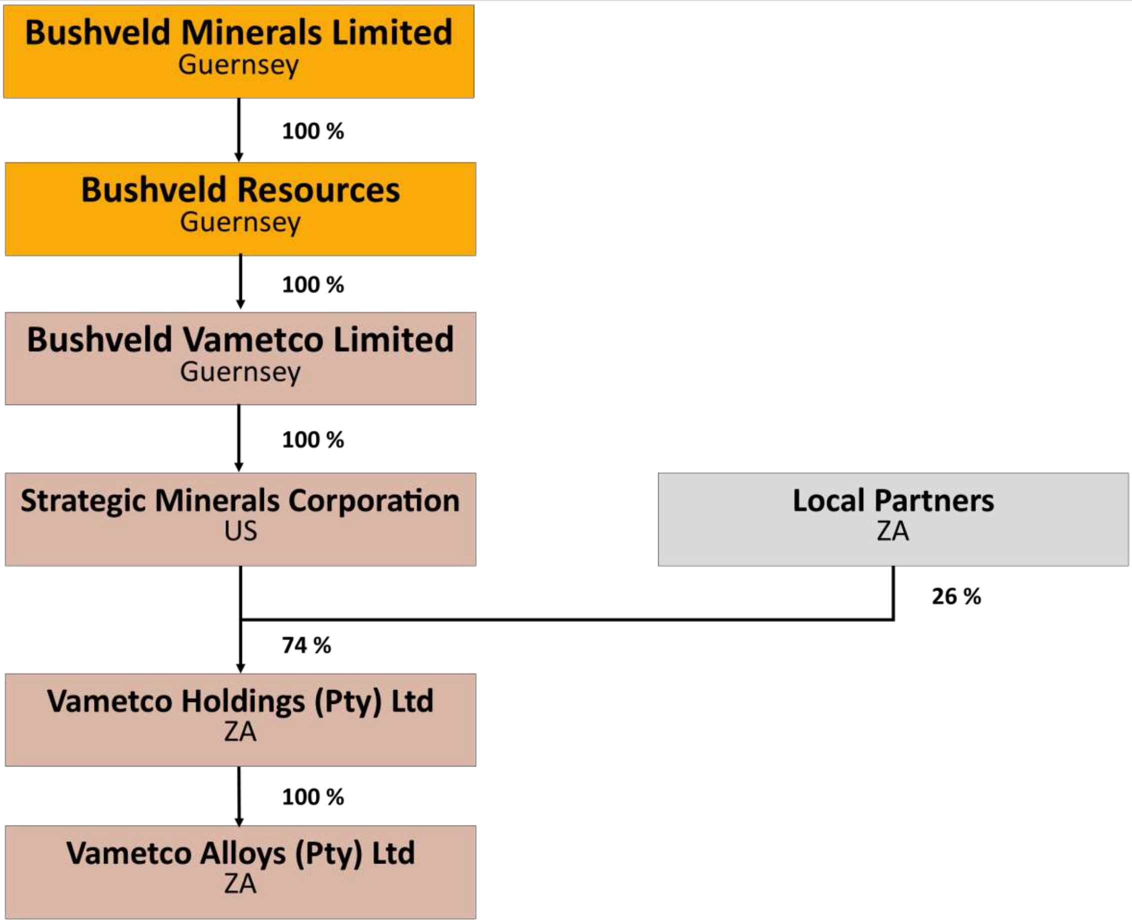
On 6 April 2017, Bushveld Minerals Limited ("BMN"), in partnership with Yellow Dragon SMC (the then holding company of Vametco Alloys (Pty) Ltd) from the Evraz Group S.A. and renamed EVRAZ Vametco Holdings to Bushveld Vametco Holdings (Pty) Ltd.

On 21 December 2017, BMN completed the acquisition of 55 % of Bushveld Vametco Limited from Yellow Dragon, effectively increasing BMN's shareholding in Vametco Holdings (Pty) Ltd from 26.6 % to 59.1 %. On 13 September 2018, BMN completed the acquisition of a 21.22 % interest in SMC from Sojitz. As a result, BMN's effective shareholding in Vametco Holdings (Pty) Ltd increased to 75 %.

On 27 September 2018, BMN sold 1 % equity interest in Vametco Holdings (Pty) Ltd to its two Broad Based Black Economic Empowerment ("BBBEE") shareholders, i.e. Business Ventures Investments No. 1833 (Proprietary) Limited and Business Ventures Investments No. 973 (Proprietary) Limited, decreasing the BMN shareholding to 74 %, the maximum equity ownership amount permitted under the South African Mining Charter (BMN, 2018).

The ownership structure is depicted in Figure 4-1. As at 01 June 2019, the Broad based Black Economic Empowerment ("BBBEE") shareholding in Vametco Holdings (Pty) Ltd was 26 %.

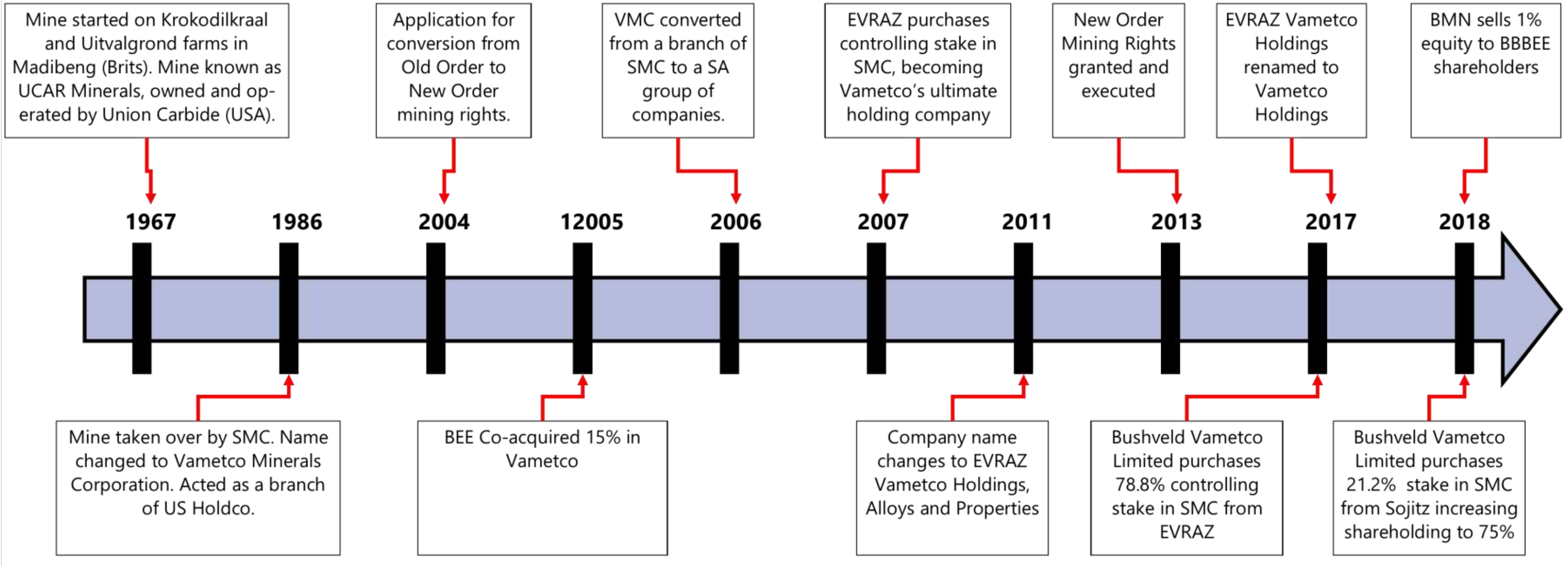
Figure 4-1
The ownership structure for the Vametco Mine



Source: *Modified from BMN (2019)*

A summary of the Vametco Mine history is shown in Figure 4-2.

Figure 4-2
Vametco Mine history



Source: *Modified from VBKom (2016)*

4.2 Previous Exploration and/or Mine Development

Exploration was undertaken by Union Carbide from the mid-1960s to1982. In 2006, six diamond drillholes were drilled by Vametco. Botha and Botes (2016) reported on the different drilling campaigns, drilling methods and the purpose of the drilling under Union Carbide and Vametco Holdings Limited (Pty) Ltd. (Table 4-1).

Table 4-1
Summary of Exploration Activities

Year	Drilling Method	No. of Holes	Purpose
Mid 1960s	Diamond	9	Assess the vanadium magnetite potential
1970	Diamond	6	Follow-up drilling to the earlier drilling campaign
1975-1976	Diamond	16	Outline the vanadium magnetite deposit and operational drilling for Open Pit Mining
	Percussion	28	
1982	Diamond	16	Testing correlation between calcium and fracturing
2006	Diamond	6	Verify seam down-dip continuity of the magnetite rich layers

Note: *This information is presented for historical context only. MSA was unable to verify that all of these holes have been completed*

Source: *Botha and Botes (2016)*

A thorough review of the historical drillhole data was undertaken by MSA in 2018 and 2019. For the purpose of Mineral Resource estimation some drillholes were excluded from the historical data due to incomplete records and/or loss of legibility of the original hardcopies (see Section 8.11). The available historical drillhole records contained in the historical drillhole database, as received by MSA, are summarised in Table 4-2.

Table 4-2
Historical drillhole information made available to MSA

Year	Drilling Method	No. of Holes	Drillhole ID's
Mid 1960s to 1976	Diamond	23	UI01-UI02; UI05-UI10; UI13-UI18; UI20-24; KR1, KR7-KR9
	Percussion	23	UI25; UI27-UI33; UI35-UI46; KR10-KR12
2006	Diamond	6	VA1 - VA6

The MSA Mineral Resource estimates considered all diamond core and percussion drilling results. Quality assurance/quality control ("QAQC") outside of the laboratory internal controls was not completed for the historical drilling. Considering that information from mining operations, which took place from the 1970's, indicate actual mined vanadium values are similar to those determined from drilling and that the recent drilling results are similar to the historical results, the historical data were accepted to use in Mineral Resource estimation. The assay data from two historical drillholes were excluded from the Mineral Resource estimate based on the data not being verifiable during a validation process of comparing original scanned copies of drillhole logs and the captured database in excel (drillholes UI25 and UI26 drilled by Union Carbide). All other data passed validation and were used in the estimation.

4.3 Previous Mineral Resource Estimates

Previous Mineral Resource Estimates ("MRE") were completed by Geologix in April 2006, VBKom in December 2015 (Botha and Botes, 2016) and MSA in 2017 (Mostert and Witley, 2017). The estimate by Geologix dated 6 April 2006 was not reported in accordance with any reporting code and excluded the Upper Seam.

The results of the previous Mineral Resource estimates by VBKom and MSA are summarised in Table 4-3 and Table 4-4 respectively.

VBKom did not undertake a comparison between its estimate and that of Geologix as the Geologix estimates were not reported in confidence categories (i.e. Measured, Indicated and Inferred). MSA has not had sight of the 2006 estimate.

In 2017 MSA reviewed the VBKom Mineral Resource and was not in agreement with the results. Issues found included:

- the V_2O_5 grade reported by VBKom for the Intermediate Seam is considerably higher than should be expected for this seam and is unrealistic;
- the V_2O_5 grade reported by VBKom for the Lower Seam Indicated Mineral Resource is considerably higher than should be expected for this seam and is unrealistic;
- errors in the database were found, particularly regarding whole rock V_2O_5 and magnetite concentrate V_2O_5 grades where in many cases the values were in the incorrect column;
- MSA did not agree with the estimation parameters and found that searches were not aligned with the deposit layering; and
- the conversion constant used to convert V_2O_5 was incorrect in the VBKom Mineral Resource table.

For the aforementioned reasons, MSA considered the VBKom estimate to be invalid and the Mineral Resource was re-estimated by MSA.

A comparison between the 2017 MSA Mineral Resource Estimate and the current Mineral Resource Estimate is discussed in Section 7.10.

Table 4-3

VBKom Mineral Resource Estimate for the Vametco Mine as at 31 December 2015

Mineralised Layer	Resource Category	Tonnage (Mt)	% Magnetics	% V in magnetics	% V_2O_5 in magnetics	SiO_2 (%)	CaO (%)
Upper Seam (US)	Measured	-	-	-	-	-	-
	Indicated	-	-	-	-	-	-
	Measured and Indicated	-	-	-	-	-	-
	Inferred	8.45	23.56	0.59	0.71	1.34	0.31
	Total	**8.45**	**23.56**	**0.59**	**0.71**	**1.34**	**0.31**
Intermediate Seam (IS)	Measured	-	-	-	-	-	-
	Indicated	0.37	28.30	1.69	3.02	1.64	0.33
	Measured and Indicated	0.37	28.30	1.69	3.02	1.64	0.33
	Inferred	19.56	34.12	1.46	2.34	1.64	0.33
	Total	**19.94**	**34.01**	**1.46**	**2.35**	**1.64**	**0.33**
Lower Seam (LS)	Measured	-	-	-	-	-	-
	Indicated	34.80	29.64	1.62	2.48	3.72	0.53
	Measured and Indicated	34.80	29.64	1.62	2.48	3.72	0.53
	Inferred	75.43	29.09	1.50	2.02	3.12	0.52
	Total	**110.23**	**29.26**	**1.54**	**2.17**	**3.31**	**0.52**
Total	Measured	-	-	-	-	-	-
	Indicated	35.17	29.63	1.62	2.49	3.70	0.53
	Measured and Indicated	35.17	29.63	1.62	2.49	3.70	0.53
	Inferred	103.45	29.59	1.42	1.97	2.69	0.47
	Total	**138.62**	**29.60**	**1.47**	**2.10**	**2.95**	**0.48**

Note: *Mineral Resources classified in compliance with the SAMREC Code (2009)*
a. Figures reported are based on 100% of Mineral Resources
b. Reporting is prepared on an inclusive basis – Mineral Resources reported includes Mineral Reserves
c. Mineral Resources tonnes and grades are reported on an in-situ dry basis
d. Reporting was prepared on block models developed by VBKom in 2016
e. Rounding of figures may cause computational discrepancies

Source: *Botha and Botes (2016)*

Table 4-4
MSA Vametco Upper, Intermediate and Lower Seam Mineral Resources, 06 October 2017

Category	Gross				Net (26.6 %)			
	Tonnes (millions)	Magnetite (%)	V_2O_5 % contained in magnetite	Total V (tonnes)	Tonnes (millions)	Magnetite (%)	V_2O_5 % contained in magnetite	Total V tonnes attributable to BMN (26.6 %)
Upper Seam								
Inferred	11.8	37.86	1.70	75,947	3.14	37.86	1.70	20,202
Intermediate Seam								
Inferred	21.6	30.45	1.87	122,994	5.75	30.45	1.87	32,716
Lower Seam								
Indicated	61.5	27.23	2.01	336,604	16.36	27.23	2.01	89,537
Inferred	47.4	29.75	1.99	280,620	12.61	29.75	1.99	74,645
Total	**108.9**	**28.33**	**2.00**	**617,224**	**28.97**	**28.33**	**2.00**	**164,182**
Total Mineral Resource								
Indicated	61.5	27.23	2.01	336,604	16.36	27.23	2.01	89,537
Inferred	80.9	31.12	1.92	479,561	21.50	31.12	1.92	127,563
Total	**142.4**	**29.44**	**1.96**	**816,165**	**37.86**	**29.44**	**1.96**	**217,100**

Notes: *Mineral Resources classified in compliance with the JORC Code (2012)*
All tabulated data has been rounded therefore minor computational errors may occur.
The Mineral Resources are total in-situ Mineral Resources for the Project.
Bushveld Mineral Limited attributable share @ 26.6 %
Mineral Resources which are not Ore Reserves have no demonstrated economic viability.
Mineral Resources are inclusive of Ore Reserves.

Source: *MSA (2017)*

4.4 Previous Ore Reserve Estimates

Previous Mineral/Ore Reserve Estimates were completed by VBKom in November 2011, VBKom December 2015 (Botha and Botes, 2016) and MSA in 2017 (Mostert and Witley, 2017). The Ore Reserve estimate by VBKom in 2011 was a high level estimate and was not done in compliance with any reporting code.

The results of the previous Mineral/Ore Reserve estimates by VBKom and MSA are summarised in Table 4-5 and Table 4-6 respectively.

Table 4-5
VBKom Vametco Mineral Reserve Statement – VBKom, effective date: 13 April 2016

Mineralised Layer	Reserve Category	Tonnage (Mt)	% Magnetics	% V in magnetics	% V_2O_5 in magnetics	SiO_2 (%)	CaO (%)
Upper Seam (US)	Proved	-	-	-	-	-	-
	Probable	-	-	-	-	-	-
	Total	0	0	-	-	-	-
Intermediate Seams (IS)	Proven	-	-	-	-	-	-
	Probable	0.35	28.41	1.72	3.08	0	0
	Total	0.35	28.41	1.72	3.08	0	0
Lower Seams	Proven	-	-	-	-	-	-
	Probable	26.42	29.78	1.63	2.54	3.61	0.5
	Total	26.42	29.78	1.63	2.54	3.61	0.5
Total	Proven	-	-	-	-	-	-
	Probable	26.77	29.76	1.63	2.55	3.56	0.49
	Total	26.77	29.76	1.63	2.55	3.56	0.49

Notes: *Ore Reserves classified in compliance with the JORC Code (2012)*
1. Figures reported are based on 100% of Ore Reserve
2. Reporting is prepared on an inclusive basis – Ore Reserves reported are included in Mineral Resources reported and should not be seen as additional tonnes
3. Ore Reserve tonnes and grades are reported on dry ROM (plant feed) basis after mining modifying factors have been applied but before beneficiation down-stream recoveries/losses have been applied
4. Reporting was prepared on block models developed by VBKom in 2016
5. Rounding of figures may cause computational discrepancies

Source: *Botha and Botes(2016)*

Table 4-6
Vametco Upper, Intermediate and Lower magnetite seams Ore Reserves - MSA, effective date 16 October 2017

		Gross				Net (26.6 %)			
Mineralised Layer	Reserve Category	Tonnage (Mt)	Percentage Magnetics	Percentage V_2O_5 in magnetics	Contained Metal Total V (tonnes)	Tonnage (Mt)	Percentage Magnetics	Percentage V_2O_5 in magnetics	Contained Metal Total V (tonnes)
Upper Seam (US)	Proven	-	-	-	-	-	-		-
	Probable	-	-	-	-	-	-		-
	Total	**-**	**-**	**-**	**-**	**-**	**-**		**-**
Intermediate Seams (IS)	Proven	-	-	-	-	-	-		-
	Probable	-	-	-	-	-	-		-
	Total	**-**	**-**	**-**	**-**	**-**	**-**		**-**
Lower Seams	Proven	-	-	-	-	-	-		-
	Probable	26.12	26.79	1.96	137,152	6.95	26.79	1.96	36,482
	Total	**26.12**	**26.79**	**1.96**	**137,152**	**6.95**	**26.79**	**1.96**	**36,482**

Notes: *Ore Reserves classified in compliance with the JORC Code (2012)*
1. Figures reported are based on 100 % of Ore Reserve
2. Reporting is prepared on an inclusive basis – Ore Reserves reported are included in Mineral Resources reported and should not be seen as additional tonnes
3. Ore Reserve tonnes and grades are reported on dry ROM (plant feed) basis after mining modifying factors have been applied but before beneficiation down-stream recoveries/losses have been applied
4. Reporting was prepared on block models developed by MSA in 2017
5. Rounding of figures may cause computational discrepancies
Source: *MSA (2017)*

4.5 Previous Production

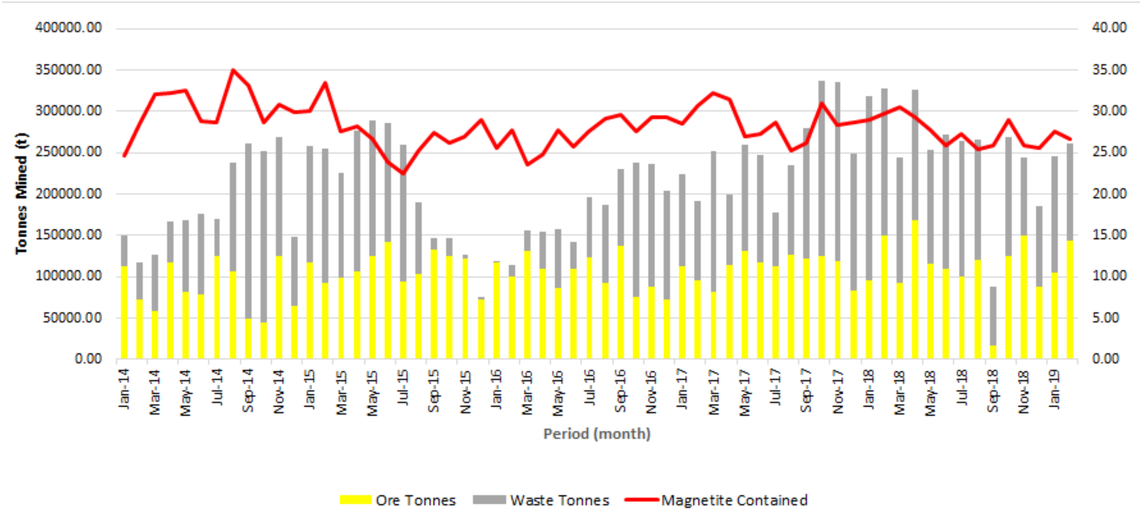
Vametco has the ability to produce vanadium contained final products either through the processing of its vanadium containing magnetite.

Historically the mining operating philosophy has been adjusted based on the availability of vanadium containing slag. Towards Q2 2016, slag supply had been constrained due to various reasons by Evraz requiring the maximisation of ore mining which has yielded fairly consistent magnetite production barring the maintenance shutdowns in September/October 2016 and March 2017.

With the poor availability and high cost of slag units, it necessitated the operation to initiate various debottlenecking initiatives at relatively low cost, maximising the magnetite production volumes in an attempt to sustain the final product volumes without the slag contribution. To this effect during April 2017, Phase 1 of the ore beneficiation expansion capital project was successfully commissioned in September 2017. Phase 2 of the ore beneficiation project was commissioned towards end of Q2 2018.

Both Figure 4-3 depicts actual production from a mining from January 2014 to February 2019 and Figure 4-4 depicts actual final product from January 2014 to March 2019.

Figure 4-3
Vametco Mining Actual Production (Jan 2014 – February 2019)

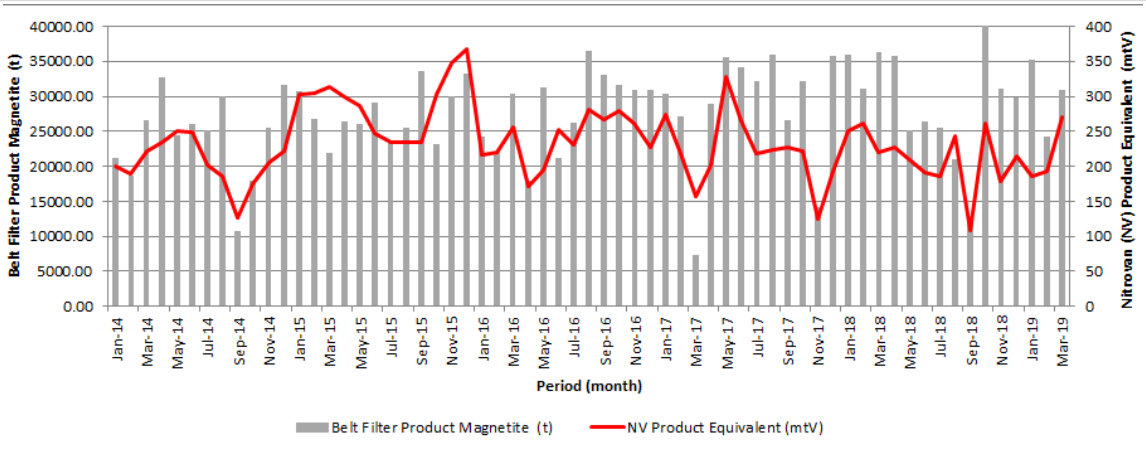


Source: *Vametco (2019)*

Historically with the availability of slag, waste stripping was not prioritised which resulted in limited ore being exposed. During the twelve month period commencing July 2014 waste stripping had been increased in an attempt to have more ore exposed. This initiative paid off during the periods of low pricing and the non-availability of slag reducing mining costs while maximising magnetite production.

The mining operating philosophy in 2018 was to increase the waste stripping during elevated price environments ensuring sufficient ore is available at all times for the processing plant in low pricing periods.

Figure 4-4
Vametco Actual Plant Production (January 2014 – March 2019)



Source: *Vametco (2019)*

Figure 4-4 depicts historical Magnetite and Nitrovan[TM] equivalent production volumes. The Nitrovan[TM] production volumes are relatively constant on average around 250 mtV per month

Nitrovan™, ensuring a sustainable supply to Bushveld Vametco's customers. The Vametco Project has historically demonstrated its capabilities in achieving production targets, both from a mining and beneficiation point of view.

5 GEOLOGICAL SETTING, MINERALISATION AND DEPOSIT TYPE

5.1 Geological Setting

5.1.1 Regional Geology

Vanadium mineralisation occurs in vanadium-bearing titaniferous magnetite-rich layers that occur within the Upper Zone of the Rustenburg Layered Suite ("RLS") of the Bushveld Complex. The magnetite-rich layers are part of the layered sequence and are concordant, continuous along strike and down-dip, although thickness variability occurs.

The mafic and ultramafic portion of the Bushveld Complex is known as the RLS and comprises several lobes or limbs, known as the Far Western, Western, Eastern, Southeastern (or Bethal) and Northern Limbs, which together form an ellipse (in plan) of approximately 200 km by 370 km in extent (Figure 5-1). The Vametco Project occurs in the Western Limb.

The Bushveld Complex comprises, from oldest to youngest (Cawthorn *et al.*, 2006):

- the ~3.5 km thick felsite-dominated volcanic Rooiberg Group;
- the RLS comprised of mafic and ultramafic units; and
- the Lebowa Granite Suite ("LGS") and the Rashoop Granophyre Suite ("RGS").

The RLS and LGS were intruded into the Transvaal Supergroup sequence along an unconformity between the Magaliesburg quartzites and the overlying Rooiberg felsites approximately 2,060 Ma (million years) ago.

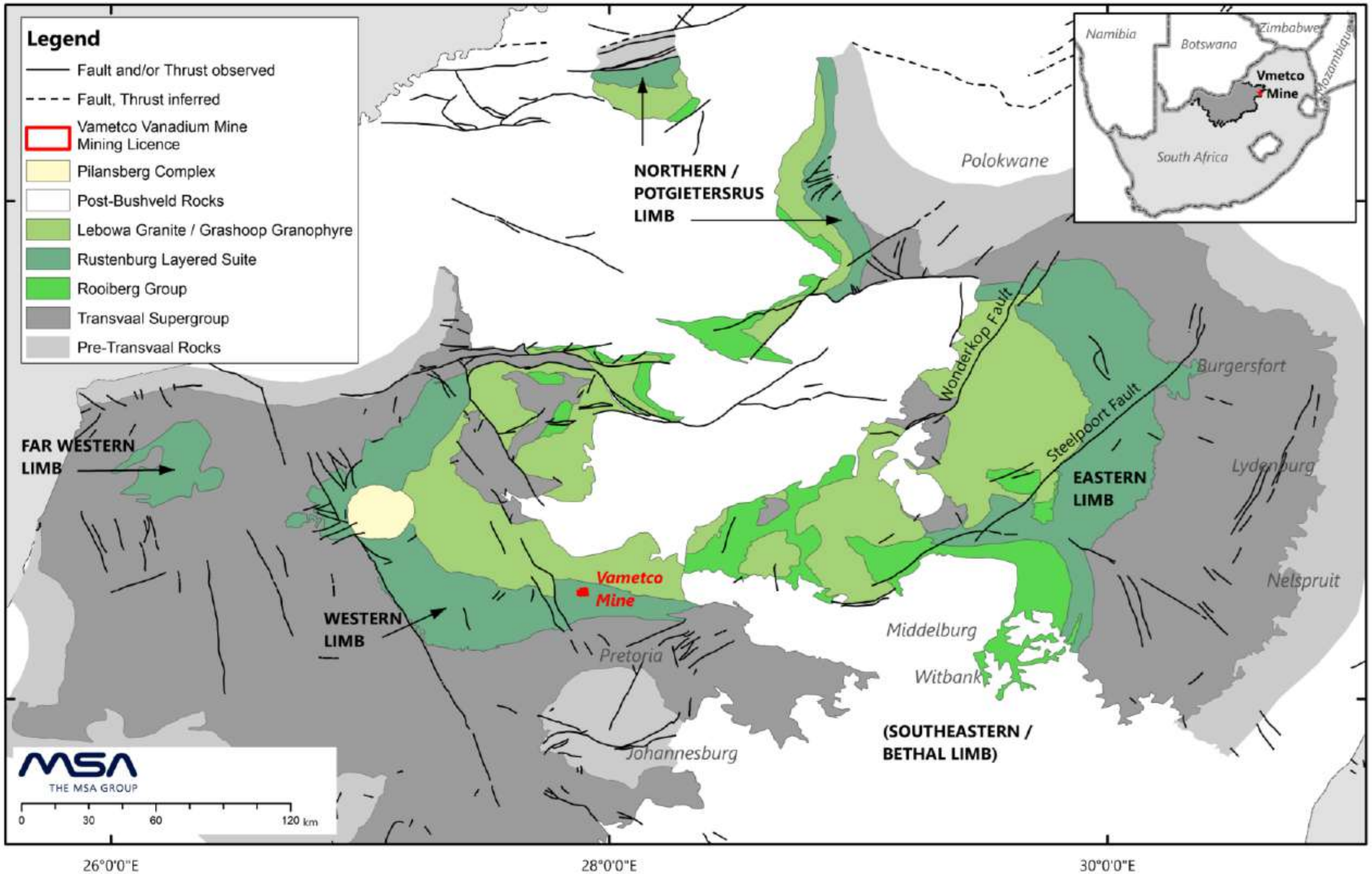
The rocks of the Bushveld Complex are interpreted to underlie an area of approximately 66,000 km^2 from Zeerust in the west to Burgersfort in the east, and from Bethal in the south to Villa Nora in the north, approximately 55 % of which is covered by younger formations (Cawthorn *et al.*, 2006; Viljoen and Schürmann, 1998). The maximum vertical thickness of the layered rocks approaches 8 km. Some layers can be traced for over 150 km along strike (Cawthorn *et al.*, 2006).

The rock types of the RLS range from dunite, pyroxenite and chromitite, through norite, gabbro, gabbro-norite, anorthosite and magnetite to apatite-rich quartz diorite. The Bushveld Complex contains the world's largest known deposits of platinum group metals ("PGM"), chromium and vanadium. The regional geology of the Bushveld Complex is shown in Figure 5-1 and the zonal stratigraphy of the RLS is summarised in Table 5-1.

The RLS consists of five distinct zones, namely the Upper Zone, Main Zone, Critical Zone, Lower Zone and Marginal Zone. The vanadium bearing magnetite deposits that are mined by Vametco occur in the Upper Zone close to the contact with the underlying Main Zone. The Upper Zone comprises dominantly gabbro, magnetite bearing gabbro and olivine diorite with subordinate anorthosite layers and magnetite layers. The base of the Upper Zone is identified by the first occurrence of cumulus magnetite. The Upper Zone has a sharp basal contact and a gradational upper contact. The Upper Zone has been divided into three different sub-zones, namely:

- Subzone A - at the base;
- Subzone B - cumulus Fe-rich olivine appears; and
- Subzone C - where apatite appears as an additional cumulus phase.

Figure 5-1
Simplified geology of the Bushveld Complex



Source: *Modified from Cawthorn et al. (2006)*

Table 5-1
Stratigraphic zones of the Rustenburg Layered Suite

Unit	Sub-unit	Average Thickness	Dominant Lithology	Description
Upper Zone		~1,500 m	Gabbros with banded anorthosite and magnetite layers	Divided into three distinct sub-zones. The base of the Upper Zone is defined as the first appearance of cumulus magnetite. No chilled contact with the hangingwall rocks, which consist of rhyolites and granophyres.
Main Zone		3,500 m	Norite, gabbro-norite, anorthosite and minor pyroxenite	Comprises half of the RLS. Banding and layering not well developed.
Critical Zone	Upper Critical Zone (UCZ)	1,400 m	Layered feldspathic pyroxenite, norite, anorthosite and chromitite	The base of the UCZ is marked by the first appearance of cumulus plagioclase. Norites dominate the UCZ, with subordinate feldspathic pyroxenite and anorthosite layers present at regular intervals through the UCZ. Economic chromite mineralisation is hosted in the Upper Group (UG) and Middle Group (MG) chromitite layers. The MG series straddles the boundary between the LCZ and UCZ. The PGM-rich Merensky Reef and UG2 occur within the UCZ.
	Lower Critical Zone (LCZ)		Feldspathic pyroxenite inter-layered with harzburgite and chromitite	Economic chromite mineralisation is hosted in the MG1 and MG2 seams and the Lower Group (LG) chromitite layers. The LG contains seven chromitite layers.
Lower Zone		Varies – reaches a maximum of 1,700 m	Cyclically layered units of dunite-harzburgite and pyroxenite	Thickness varies and thins over basement highs. The most complete sequence is in the northeastern part of the Eastern Limb of the RLS where a series of dunite-harzburgite-pyroxenite cyclically layered units are well-exposed.
Marginal Zone		Several metres to hundreds of metres	Unlayered, heterogeneous ultramafic rocks, mostly norites	Contamination of the basic magmas by the enclosing host rocks. Sedimentary rock fragments are contained as xenoliths in the lower portions. Exposures of this zone are poor.

Source: *Modified after Clay et al. (2014)*

A total of 25 layers of cumulus magnetite exist within the Upper Zone. The fourth layer, known as the Main Magnetite layer, is the most prominent. The magnetite-rich layers vary considerably in thickness, as well as concentrations of magnetite, vanadium pentoxide and titanium dioxide. The highest vanadium contents occur in the lowermost layers, which are characterised by grades of around 1.6 % V_2O_5. This concentration decreases to about 0.25 % higher up in the stratigraphy. The titanium content varies and has an inverse relationship to the vanadium content. Titanium contents vary from about 11 % in the lowest layer to about 18 % TiO_2 in the top layer. Most of the vanadium is present in the magnetite grains, where it substitutes for trivalent iron.

5.1.2 Project Geology

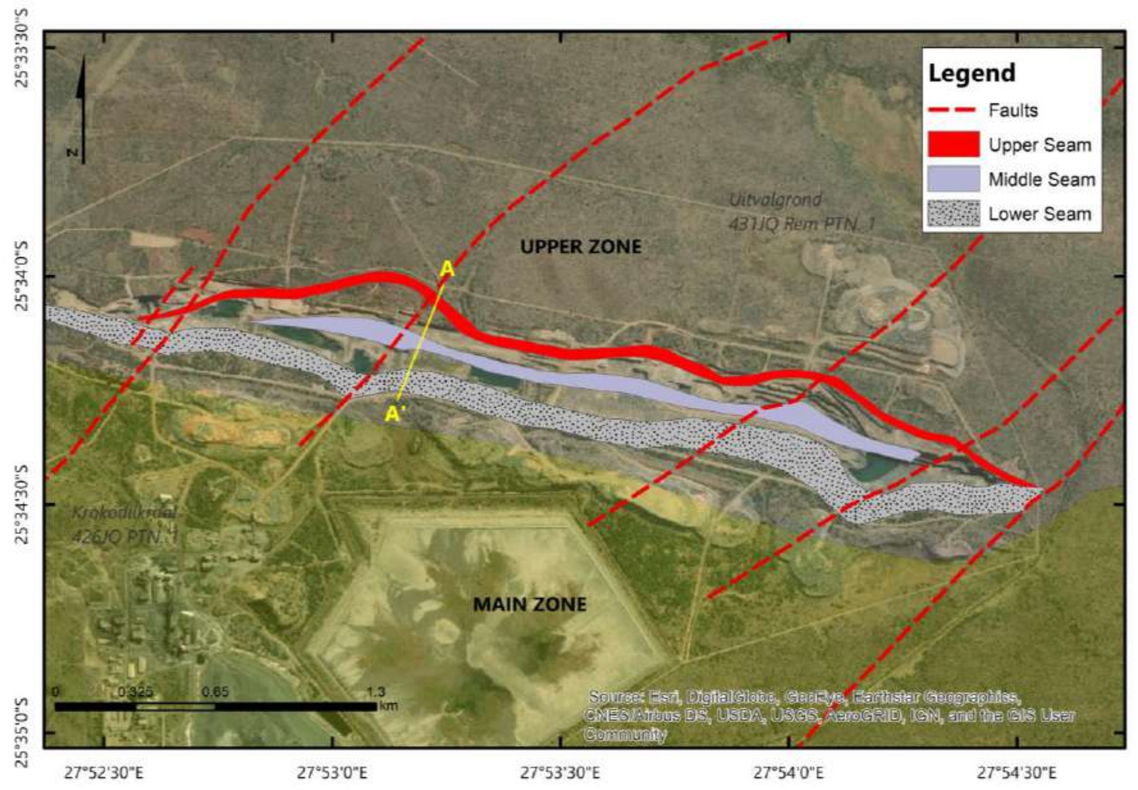
Both the Main Zone (Pyramid Gabbronorites) and the Upper Zone (Bierkraal Magnetite Gabbros) occur on the Vametco Mining Right Area (MRA). Underlying the northern regions of the Vametco MRA are the Bierkraal Magnetite Gabbros, whilst the southern part of the Vametco MRA is underlain by Pyramid Gabbro-Norites. The mafic layers are east-west striking and north dipping, with an average dip of 19°. The lithologies associated with the Main Zone (Pyramid Gabbro-Norite) are gabbro-norite, and locally anorthosite and pyroxenite bands. The lithologies in the Upper Zone (Bierkraal Magnetite Gabbro), that occurs on the northern part of the Property, include magnetite–bearing gabbro, olivine-diorite and some anorthosite and magnetite layers. The well-developed magnetite seams in the lower portion of the Upper Zone are currently being mined at Vametco for their vanadium content.

At Vametco, the magnetite bearing layers are grouped into three seams, namely the Upper, Intermediate and Lower seams, all of which dip to the north at approximately 19°. The seams occur just above the lower contact of the Upper Zone with the Main Zone and the Lower Seam rests on a prominent anorthosite layer.

A geological map of the Mineral Rights area is provided in Figure 5-2 and a schematic cross section through the mine stratigraphy is provided in Figure 5-3. The schematic geological log illustrated in Figure 5-4.

Figure 5-2

Interpretation of the geology of the Vametco Project

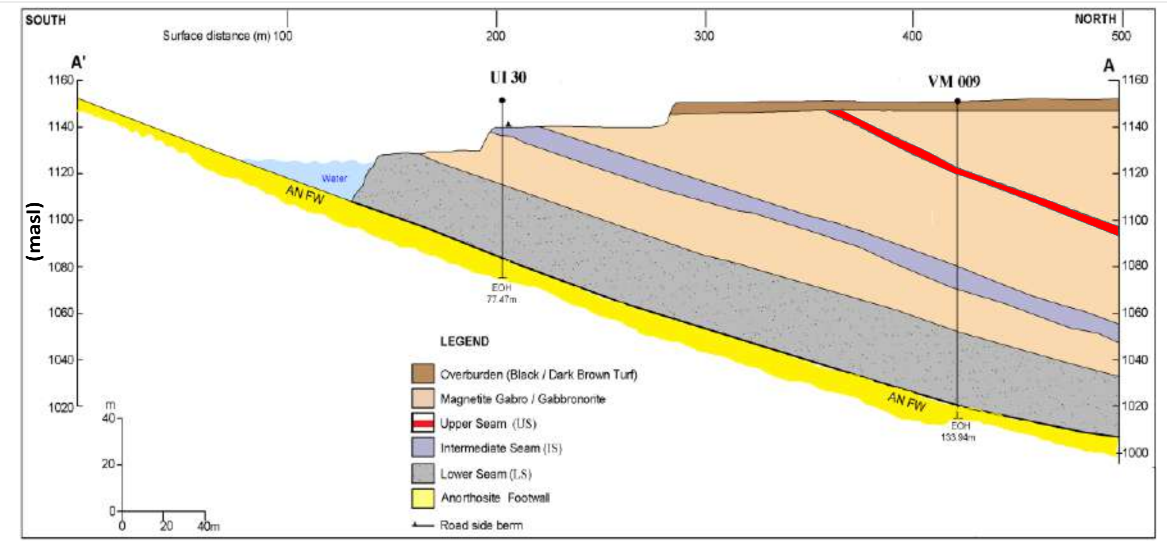


Note: *Cross Section A-A' depicted in Figure 5-3 below*

Source: *Modified from Vametco (2019); background imagery from ESRI World Imagery (sourced from Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community)*

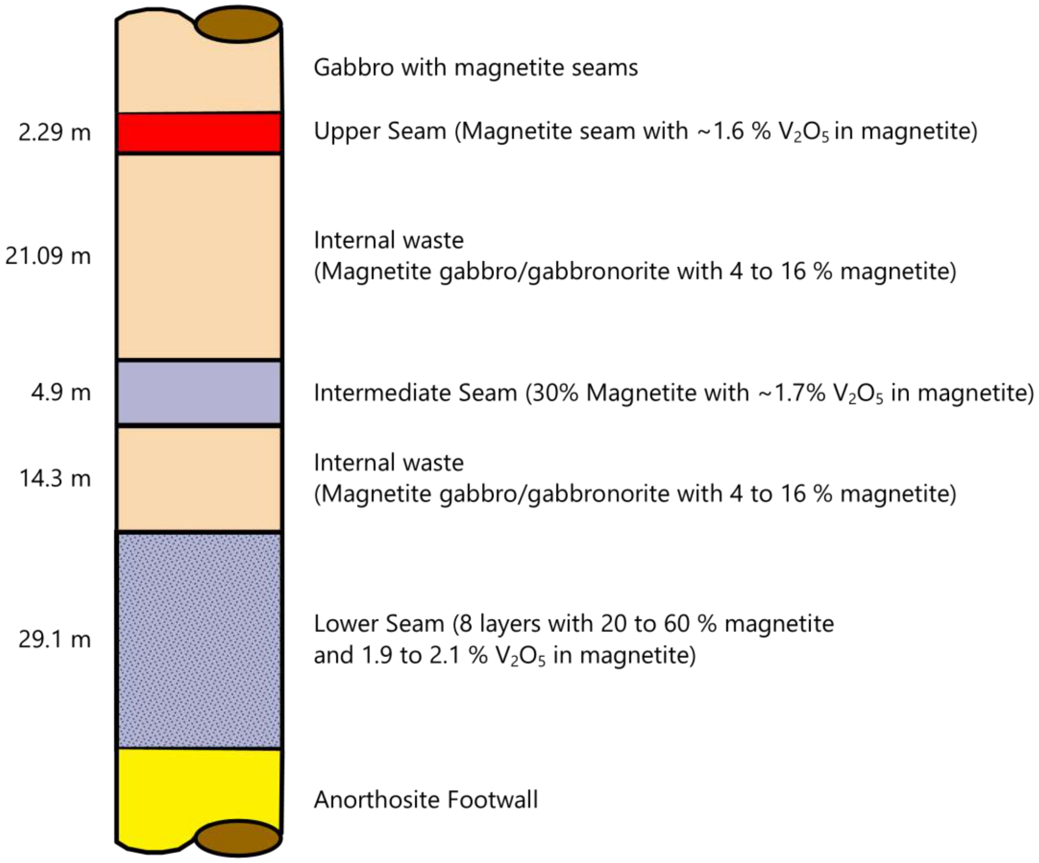
Figure 5-3

Cross Section A-A' through the stratigraphy of the magnetite-rich seams at Vametco



Source: *Vametco (2019)*

Figure 5-4
Schematic drillhole log depicting the typical stratigraphy at the Vametco Project



Source: *Modified from JMA (2015)*

The magnetite layers are mostly covered by a black organic soil and outcrops are not common in the pre-mining area. The weathering has destroyed the original structure of the mafic rocks for a couple of metres below the surface where after the weathering is seen as calcium and silica fill in fractures.

5.1.2.1 Structure and intrusions

At least five faults have been identified, one of which, towards the far east of the Vametco MRA, has a significant throw and forms the eastern limit of the open pit mine. The faults have been exposed by mining.

Linear intrusions in the form of dolerite dykes are present within the Vametco MRA. The dolerite dykes were intersected in drillholes VMB-11, VMB-13 and VMB-14. The dolerite is younger than and intruded into the lithologies of the RLS (JMA, 2015).

Slumps/potholes occur in the stratigraphy have been exposed during open-pit mining. These are of several tens of metres in extent and the magnetite layers are preserved within them.

5.1.2.2 *Vanadium Mineralisation*

Vanadium-rich magnetite bearing layers occur at the base of the Upper Zone and have a cumulative thickness of over 125 m. According to the magnetite content, the layers of magnetite-bearing rocks have been classified into five major units, then further subdivided into 22 seams. The local stratigraphy with corresponding thicknesses and grade is provided in Table 5-2.

Table 5-2
Thickness and magnetic content of the interpreted vanadium-rich magnetite layers

Seam Zone	Seam Sub-division	Thickness Range (m)	Magnetics Range (%)
C-Zone	C-2	10.23-12.7	25-38
	C-1	12.0-23.2	14-19
Upper Seam (US)	US-4	1.5-4.3	26-54
	US-3	2.4-4.8	11-19
	US-2	4.2-6.1	33-44
	US-1	1.8-3.8	72-89
B-Zone	B	21.0-51.4	1-4
Intermediate Seam (IS)	INT-3	0.6-8.9	32-48
	INT-2	1.2-5.8	8-21
	INT-1	1.2-3.7	30-48
A-Zone	A-4	1.2-4.0	12-23
	A-3	2.7-7.9	1-7
	A-2	3.0-12.8	10-16
	A-1	7.0-15.5	14-20
Lower Seam (LS)	LS-8	1.5-9.0	18-27
	LS-7	7.0-13.7	33-42
	LS-6	1.8-7.0	21-30
	LS-5	3.0-6.7	7-22
	LS-4	2.6-5.3	25-46
	LS-3	0.8-2.4	46-78
	LS-2	1.5-3.7	23-38
	LS-1	0.9-1.5	64-96

Source: *VBKom (2016)*

At Vametco the Seam sub-division was simplified to the Seam Zones for ease of reference and mine planning. All Mineral Resource estimates are based on the Seam Zones. The Upper Seam as determined for the Mineral Resource comprises US-1.

5.1.2.3 *Geological Models*

The long history of mining platinum group elements and chrome from the Bushveld Complex has led to thorough understanding of the geology. The origin of the concordant magnetite layers is a subject of debate with the currently most widely accepted theory being as follows:

- introduction of magma to the magma chamber resetting the crystallisation phase;
- decrease in the magma chamber pressure;
- settling and sorting of crystals through gravity; and

- change in oxygen content of the chamber.

Although their genesis is not fully understood, the occurrence of these magnetite layers in the same stratigraphic units is well documented throughout the Bushveld Complex.

5.1.2.4 Nature of Deposits on the Property

The magnetite layers are continuous over large distances. However, the Intermediate Seam pinches out in some parts of the property. The layers strike in an east-west direction for 3.3 km and dip northwards at 19° within the Project area. The lower layers have been intersected at a depth of 270 m below surface, which equates to 830 m down-dip from outcrop on the plane of mineralisation.

Layer thicknesses are variable. The range of thicknesses for each layer is shown in Table 5-3.

Table 5-3
Layer thicknesses of mineralised layers

Magnetite Layer	Minimum thickness (m)	Maximum thickness (m)	Average thickness (m)
Upper Seam (US-1)	1.84	6.78	2.60
Intermediate Seam	4.57	28.89	11.82
Lower Seam	21.90	47.89	33.84

6 EXPLORATION DATA/INFORMATION

6.1 Desktop Studies

A desktop study was undertaken on available literature pertinent to the Vametco Project by Vametco personnel.

Bushveld Vametco personnel undertook a review of available hand-drawn hard copy cross-section compiled in the 1970s as part of the historical drilling campaigns with a view to obtaining a better understanding of the stratigraphy, consistency and continuity of the magnetite deposits in the Project area.

6.2 Geological Mapping

A geological mapping programme was undertaken by Bushveld Vametco to delineate the contacts of the Upper and Main Zone of the RLS in the Project area. The desktop studies undertaken were used to inform the mapping programme, coupled with mining information available at the Vametco Mine offices.

Mapping included the identification of major fault zones in the Vametco Project open pit. The revised geological map is shown in Figure 5-2.

6.3 Drilling

A drilling plan for the 2018 programme was compiled based on the results of the desktop studies, geological mapping and available historical drillhole data. From the 1960s until 2006, 53 diamond drillholes and 28 percussion drillholes were drilled on the Vametco MRA (Table 4-1). A thorough review of the historical drillhole data was undertaken in 2018 and 2019. Some drillholes have been excluded based on incomplete records and/or loss of legibility of the original hardcopies (see Section 8.11). As a result, 29 diamond drillholes and 23 percussion drillholes were considered for the estimation of the Vametco Mineral Resource.

Diamond drilling extracts a continuous cylinder of core by cutting the rock with a diamond impregnated drilling bit with a central opening. The cut core is pushed up through the opening into a core barrel through the downward force of the diamond drill rig. Once the core barrel is filled, the core is extracted via a wireline or manual extraction by removing each rod manually up to the core barrel. The core is then placed into core trays for storage and processing.

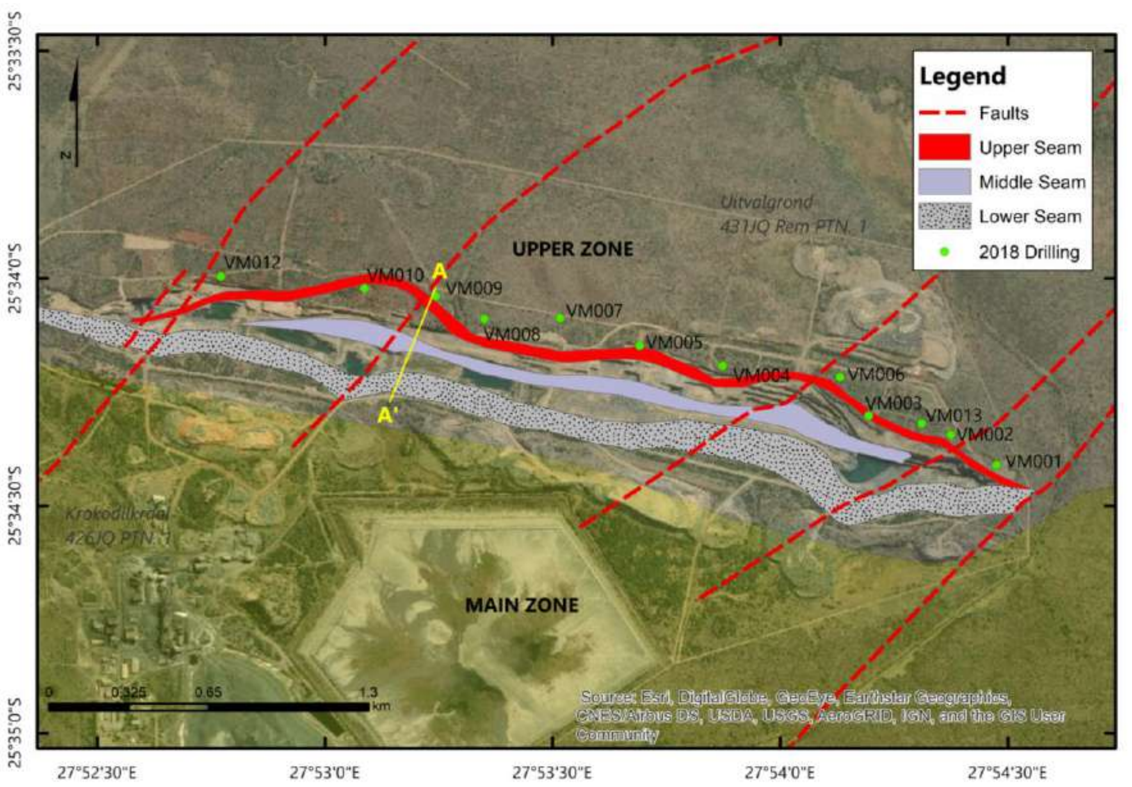
Percussion drilling (historical drilling) produces a sample consisting of broken rock fragments which range in size from silt to chips of up 3 cm diameter. In standard rotary percussion drilling, a percussion or hammer action in conjunction with a chisel bit is used to penetrate the rock. The broken rock is blown to the surface along a narrow space between the drill roads and the side of the hole. No information is available on the sample collection methodology for the historical percussion drilling, although it is evident from the sample and logging records that samples were taken at one foot (approximately 30.5 cm) intervals.

The 2018 drilling plan was designed to target the mineralisation north of the highwall area of the Vametco Project open pit, with an objective to provide verification of the historical drilling programmes, to ensure the seam down-dip continuity and to infill the previous drilling.

The drilling (2018) was carried out by a specialised contractor, Diabor Geotechnical & Exploration Drilling (Pty) Ltd mobilized out of Rosslyn town, South Africa. All drilling was undertaken by diamond drill coring and are near - vertical at their collars. Generally, drillholes were drilled using NQ core (47.6 mm core size). No drillhole cores were oriented.

Thirteen exploration diamond drillholes (VM001 to VM013) were drilled by Vametco from the 2nd May to the 22nd June 2018 as shown in Figure 6-1. A total of 1,506.35 m of drill core were recovered during this drilling programme. Twelve of the thirteen drillholes, combined with data from the historical diamond and percussion drilling, were used to update the Mineral Resource Estimates for Vametco Mine. One drillhole was excluded as it did not intersect the mineralisation, it being incorrectly collared. Diamond drillhole core is stored in the Vametco core shed, located on the Vametco Mine Property.

Figure 6-1
Drillholes drilled for the 2018 Vametco Mine exploration programme



Note: *Diamond drillhole VM011 not indicated on the map as collared incorrectly; Cross Section A-A' depicted in Figure 5-3*

Source: *Background imagery from ESRI World Imagery (sourced from Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community)*

Historical drillholes include the KO, KR, UI and UO series holes, which were drilled by Union Carbide Exploration from the mid 1960's until 1982. In the mid-1960's, the vanadium magnetite potential of the Property was explored through the drilling of 9 diamond drillholes. In 1970 a further six diamond drillholes were drilled to follow up on the earlier drilling campaign, with a further 16 diamond and 28 percussion drillholes drilled between 1975 and 1976. The latter diamond and percussion drillholes served to outline the vanadium magnetite deposit and to inform the open pit mining. A further 16 diamond holes were drilled in 1982 to test the correlation between calcium and fracturing. In 2018 and 2019, a review of the historical data was completed that resulted in the removal of the UO and KO series drillholes from the database due to incomplete drillhole data and illegible hard copy records.

The VA series diamond drillholes, holes (VA1 to VA6), were drilled by EVRAZ Vametco in 2006 in order to verify seam down-dip continuity of the magnetite-rich layers.

The VM series holes (VM001 to VM013) were drilled by Bushveld Minerals in 2018.

6.3.1 Logging of the 2018 Drillholes

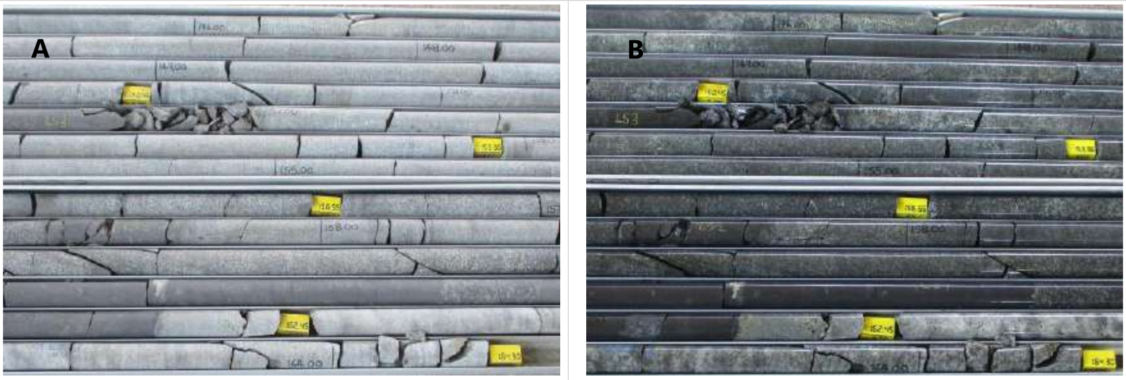
Detailed geological logging of core from the 2018 exploration drilling was by qualified geologists who captured the information onto proforma capture sheets under supervision of the project geologist. The core was logged according to lithology, stratigraphic units; and mineralisation (visual percentage estimate of magnetite content of the rock). All cores were logged from the collar to end of hole ("EOH"). The total length of core in the 12 drillholes used for both the geological model and the Mineral Resource estimate is 1,385.66 m.

Once the geological logging was completed, the logs were captured in Microsoft Excel spreadsheets and the logs printed. A qualified geologist then checked the core against the captured logs to verify that the data were recorded and captured correctly. The printed logs were then signed off and stored in the drillhole file. Each drillhole has an individual physical file in which all the hardcopy information relating to that drillhole is stored; this includes geological logs, survey certificates, collar certificates, sampling sheets, assay certificates etc. This hardcopy file is kept in addition to the electronic copies of all the drillhole data which is stored on local computers and the company's central computer server.

6.3.1.1 Core Photography – 2018 drilling

Photographs of all the drill core (dry and wet) were taken before splitting of the core for sampling (Figure 6-2). Photos were taken per two 1.5 m core trays in sequence and the complete drillhole was photographed from collar to EOH.

Figure 6-2
An example of core photography (A) dry and (B) wet, from the 2018 Vametco diamond drilling programme



Source: *Vametco (2019)*

6.3.2 Logging of Historical Drillholes

The logging of historical drillholes was performed using standard logging sheets but the procedures pertaining to the logging are not known to the authors. All cores and chips were logged for lithology and seam unit. The data were captured by Vametco and are stored in Microsoft Excel spreadsheets.

The logging was qualitative and the cores were not photographed. All cores/chips were logged from the top to end of the hole with more detail when they intersected magnetite-rich gabbro. The total length of core in the 65 drillholes used for the geological model is 3,503.87 m and the total length of core in the 37 drillholes used for the estimate is 2,374.86 m.

6.3.3 Orientation of Data in Relation to Geological Structure

All drillholes were drilled vertically. The vanadium-rich magnetite-gabbro layers dip at an average of 19° to the north. The drilling intersected the various magnetite layers at an angle, but, given the thickness of the magnetite layers and reasonably high intersection angle, the angle of intersection will not introduce any bias in the Mineral Resource estimation.

6.3.4 Drillhole Sample Recovery

Drillhole core sample recoveries for new exploration drillholes included recording interval length, core recovered, total solid core, number of fractures, frequency of fractures and Rock Quality Designation (RQD).

No core recovery data were available for historical drillholes.

No discernible relationship exists between core recovery and grade.

6.3.5 Sample storage and security

All 2018 drillhole core is stored in the core shed at the Vametco Mine.

Samples were not removed from the secured storage location without completion of a chain-of-custody document; this forms part of a continuous tracking system for the movement of the samples and persons responsible for their security. Ultimate responsibility for the secure and timely delivery of the samples to the chosen analytical facility rests with the Project Geologist and samples were not transported in any manner without the Project Geologist's permission.

During the process of transportation between the Project site and analytical facility, the samples were inspected and signed for by each person or company handling them. It is the mandate of both the Supervising and Project Geologist to ensure secure transportation of the samples to the analytical facility. The original chain-of-custody document always accompanied the samples to their destination. The Supervising Geologist ensured that the analytical facility was aware of the Bushveld Vametco standards and requirements.

It is the responsibility of the analytical facility to inspect for evidence of possible contamination of, or tampering with, the shipment received from Bushveld Vametco. A photocopy of the chain-of-custody document, signed and dated by an official of the analytical facility, was e-mailed back to the dispatching Project Geologist.

The analytical facility's instructions are that if they suspect the sample shipment was tampered with, they will immediately contact the Supervising Geologist, who will arrange for someone in the employment of Bushveld Vametco to examine the sample shipment and confirm its integrity prior to the start of the analytical process.

Bushveld-Vametco's procedures are that if, upon inspection, the supervising Geologist has any concerns whatsoever that the sample shipment may have been tampered with or otherwise compromised, the responsible Geologist will immediately notify the Bushveld Vametco Management in writing and will decide, with the input of Management, how to proceed. In most cases, analyses may still be completed, although the data must be treated, until proven otherwise, as suspect and unsuitable as a basis for a news release until additional sampling, quality control checks and examination prove their validity. Should there be evidence or suspicions of tampering or contamination of the sampling, Bushveld Vametco will immediately undertake a security review of the entire operating procedure. The investigation will be conducted by an independent third party, whose report is to be delivered directly and solely to the directors of Bushveld Vametco, for their consideration and drafting of an action plan. In cases such as above, exploration activities are required to be suspended until the review is complete and the findings are conveyed to the directors of the company and acted upon.

A chain of custody is in place for the entire sample handling process from the sample preparation point to and from the laboratory.

6.4 Sampling and Assaying

6.4.1 Sampling of the 2018 Drillholes

Sampling of the 2018 drillhole core was carried out at the core shed at the Vametco Mine.

Technical Personnel from Bushveld Vametco were responsible for:

- sample collection;
- core splitting;
- sample dispatch to the analytical laboratory;

- sample storage; and
- sample security.

When the geological logging of the drillhole core was completed and validated, the qualified geologist identified the units to be sampled based on stratigraphic, lithological and visible magnetite mineralisation criteria. The cores were continuously sampled from the top of the mineralised zone to well below footwall contacts. Not all drillhole core was sampled, but all core with visually identifiable magnetite mineralisation was sampled.

The geologist varied the thickness of sampling intervals according to changes in stratigraphy, lithology and mineralisation in order to ensure that samples did not cross-cut these boundaries. The sampling start and end positions were based on the lithological contacts and/or the occurrence of significant magnetite concentration. High grade zones (magnetite concentration >20%) were identified and the sample interval was limited to a maximum interval of 0.5 m and minimum interval of 0.3 m, whilst the low-grade zones (magnetite concentration < 20%) were sampled to a maximum of 1.0 m. Where the magnetite concentration fell below 10%, the sample interval was increased to a maximum of 2.0 m. 50% of all samples taken were equal to or less than 0.50 m in length. The intervals were varied to respect geological boundaries. Areas of core loss were recorded, and depths of the samples carefully noted to exclude these intervals.

The geologist prepared the sampling instruction sheet for the samples, which included sample depths and sample numbers together with the depths where blank and standard samples were to be inserted.

Before any sampling took place, the core was orientated and secured together with buffing tape in places where it was broken to ensure the core splitting line remained the same from the start to the end of the samples (Figure 6-3 A). A continuous line, marking the estimated plane of symmetry, was drawn on the core by the sampling geologist to ensure that all cores were split correctly. Drill core was cut longitudinally in half using a rotating diamond saw blade (Figure 6-3 B). The split core was placed back in the core tray (Figure 6-3 C) and put in the sun to dry. When the core was dry, samplers marked the sample intervals and the sample number on the core. The cores were marked on both the section of core to be sampled and the core to remain in the tray as per instructions on the sample sheet. All drillhole core was sampled dry. It was the responsibility of the sampler to ensure that representative samples were taken, i.e. one side of the core was sampled for all samples (Figure 6-3 D), to ensure that the correct ticket was allocated to the sample as stated on the sample sheet, and that the sample plastic bags were properly labelled (Figure 6-3 D and E).

A Certified Reference Materia; ("CRM") (AMIS0368) standard sample was inserted after every 20th sample and a blank sample (AMIS0439) was inserted every alternate 10th sample so that a QAQC sample was inserted after every 10th sample within the sample stream.

The section of core to be sampled was placed in a plastic bag by the sampler or their assistant after any tape was removed. A sample ticket from the ticket book was inserted and the sample bags were stapled closed. For CRM's, the label identifying the standard was removed and stored in a separate bag for reference purposes. The sample number assigned to the CRM was written on the standard label itself. The sachet was then placed in a sample bag with the sample ticket.

For blank samples, material was placed in the sample bag with the corresponding sample ticket. The sample number was also written on the bag itself. Samples were placed together into a bigger bag (Figure 6-3 F) and sealed prior to dispatch.

Figure 6-3
The sampling procedure at Vametco Mine

Note: *A) Sample preparation; B) drillcore splitter; C) split drillcore; D) sample bagging; E) sample stream in small bags; F) big bag containing small sample bags ready for submission to the laboratory.*

Source: *Vametco (2019)*

A total of 1,143 core samples were prepared from the 2018 drilling programme. Fifty-five AMIS0368 CRMs and 52 AMIS0439 blank samples were inserted into the sample stream.

6.4.1.1 Quality control prior to dispatch

The project geologist was responsible for timely delivery of the samples to the relevant laboratory. The supervising and project geologists ensure that samples were transported by designated Bushveld Minerals drivers.

When the samples were prepared for shipment to the analytical facility, the following procedure was followed:

- samples are sequenced within the secure storage area (Figure 6-3 E) and the sample sequences examined to determine if any samples were out of order or missing;
- The sample sequences and numbers shipped are recorded both on the chain-of-custody form and on the analytical request form;
- the samples are placed according to sequence into large plastic bags (Figure 6-3 F) (the numbers of the samples were enclosed on the outside of the bag with the shipment, waybill or order number and the number of bags included in the shipment);

- the chain-of-custody form and analytical request sheet are completed, signed and dated by the project geologist before the samples are removed from secured storage. The project geologist keeps copies of the analytical request form and the chain-of-custody form on site; and
- once the above is completed and the sample shipping bags are sealed, the samples may be removed from the secured area. The method by which the sample shipment bags were secured must be recorded on the chain-of-custody document so that the recipient can inspect for tampering of the shipment.

6.4.2 Sampling of the Historical Drillholes

Sampling of the magnetite layers was carried out continuously through the magnetite-rich zones. A total of 65 holes were drilled vertically. Fifty-two drillholes had adequate information to use in the geological model and 37 were used for the Upper, Intermediate and Lower Seam grade estimate. Fifteen drillholes were excluded for a number of reasons such as no magnetite concentrate assays or missing survey data. The positions of these excluded holes were examined and were found to be in close proximity to the holes that were accepted and so no impact on the overall drilling grid occurred.

The majority of the cores (at least 50% of all samples) were sampled at one foot (approximately 0.305 m) intervals, although this was not always consistently applied, with some holes being sampled at 0.5 m intervals and in some cases more irregular intervals that honoured the geology and intensity of magnetite mineralisation. The position where sampling of the core commenced and ended for each layer was based on the occurrence of significant magnetite concentration defined as greater than approximately 20%. Low grade zones (magnetite concentration <20%) were identified and analysed for magnetite content but were not always assayed for V_2O_5, SiO_2 and CaO.

It is assumed that the core was split in half longitudinally and that half cores were taken as standard practice; this however could not be verified. The half core samples were then bagged and numbered before being dispatched to the laboratory while the other half remained in the core tray. The processes for sampling percussion core are not known to the authors, although records indicated that samples were taken at one foot (approximately 0.305 m) intervals.

The disseminated and layered style of mineralisation is not sensitive to sample size. The sample length is generally shorter than required, but samples were composited into longer lengths during estimation

The exploration processes were not in accordance with modern day best practice in that no QAQC samples were inserted into the sample stream in the field. The measures taken to ensure sample security of samples from the historical drillholes could not be confirmed.

6.4.3 Assaying

Once at the laboratory, the samples were assayed. Typical analyses include:

- percentage of magnetic material by Davis Tube test;
- percentage vanadium pentoxide (V_2O_5) in the magnetic material;

- the percentage of calcium in the magnetic material; and
- the percentage of silica in the magnetic material.

6.4.3.1 2018 Drillhole Samples

The primary laboratory used for the analyses was UIS Analytical Services ("UIS") located in Centurion, South Africa. ALS Global (Edenvale, Johannesburg, South Africa) ("ALS") was used for the analysis of the umpire samples.

UIS followed the following sample preparation process:

- the core samples are received and weighed;
- the samples are crushed to 70 % passing 2 mm; and
- 250 g is split from the crushed sample and pulverised to 85 % passing 75 µm.

X-ray fluorescence ("XRF") spectroscopy using the fusion technique was used for analysis of whole rock and concentrate. Davis Tube wet magnetic separation was used to separate the magnetic portion (concentrate) from the head sample.

Blank and standard samples were inserted in the sample stream by the laboratory for QAQC purposes. Five per cent of samples (duplicates) using different sample IDs were assayed as duplicated by the primary laboratory. QAQC plots were completed on assay results received to ensure they are acceptable.

UIS analysed a total of 1,143 whole rock samples and 667 magnetic portion samples (wet magnetic separation from the whole rock samples). ALS analysed approximately 6 % of the total whole rock samples, i.e. 73 umpire samples were analysed.

6.4.3.2 Historical Drillhole Samples

A Davis tube was presumably used to determine the magnetite content. Assays of the magnetite concentrate were carried out for V_2O_5, SiO_2 and CaO. Whole rock assays were also performed for some samples. QAQC was not performed on any of the historical drilling. However, mining operations indicate that actual mined vanadium values are consistent with those determined from drilling.

MSA is not aware of the exact nature of the historical assaying methods or the laboratory used.

6.5 Digital Terrain Model and Orthophoto

Premier Mapping CC carried out a Drone survey of the Vametco Mine area on the 29th March 2019 in order to produce an updated digital terrain model ("DTM"). This DRM was used to deplete the mined area from the Mineral Resource model.

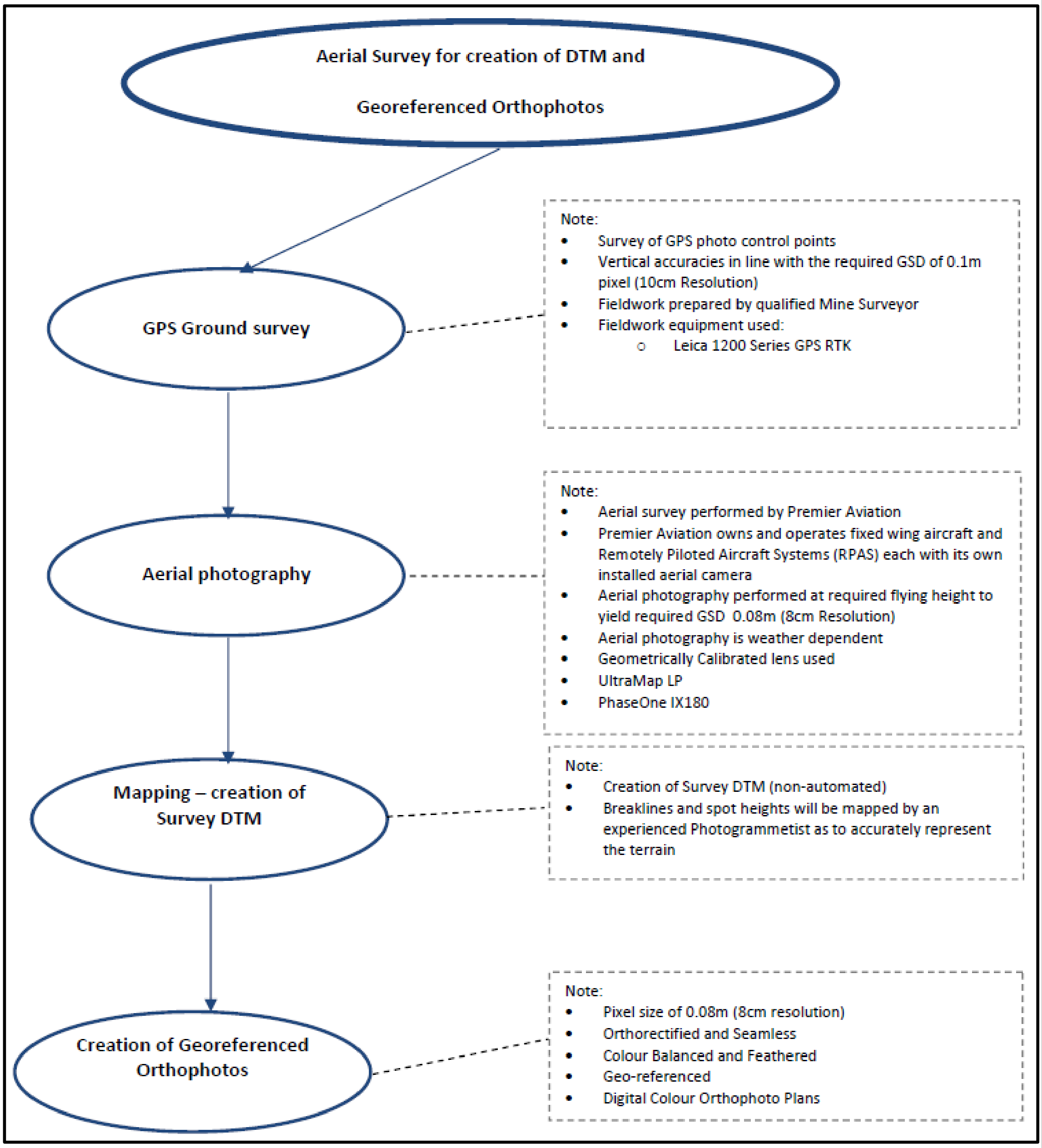
Methodology:

- The Project Geologist provided Premier Mapping CC with a Google Earth KML file for the target area, which included the open pit and adjacent areas.
- Premier Mapping CC established a control point in the area of interest and a number of pre-marks (white crosses) were placed around the borders of the requested area.
- The area was then surveyed and linked to the existing mine survey system.

- A drone with a large format camera and calibrated lens was used to capture an image of the target area.
- The images were processed to create an intense point cloud, which was then intelligently filtered to a more manageable data size (100's of millions of points were reduced down to 2 to 3 million points).
- An experienced operator checked all the data visually in stereo and added in additional break lines or survey points where required. Any points identified as having been incorrectly filtered were removed.
- An orthophoto was created from the completed DTM.

The diagram in Figure 6-4 summarises the methodology employed for the creation of a DTM and/or orthophoto.

Figure 6-4
Methodology employed in the creation of a digital terrain model and/or orthophoto



Source: *Vametco (2019)*

6.6 Database Management

All drilling information was captured and validated in a Microsoft Excel™ spreadsheet. Information includes the collar position of the drillhole, drillhole number, logging geologist and depth intervals of various lithologies. The samples taken from the various magnetite layers were captured into a second Microsoft Excel™ spreadsheet. The data was then saved on a central computer network for future access.

6.7 QAQC Analyses

6.7.1 QAQC for the 2018 exploration drillholes

The laboratories used for the analysis of the Bushveld Vametco 2018 exploration program samples are listed below together with their associated certifications:

- UIS Analytical Services is an accredited ISO/IEC 17025 analytical chemistry laboratory (SANAS Accreditation Number T0184). This facility was used as the primary laboratory for Bushveld Vametco exploration samples; and
- ALS is an ISO 17025 accredited analytical chemistry laboratory (SANAS Accreditation Number T0387). This facility was used as a secondary laboratory for check samples ("umpire" analyses).

Commercial mineralised and blank CRMs, obtained from African Mineral Standards ("AMIS"), were inserted in the field by the samplers to assess the quality of the assays. The details of those CRMs are shown in Table 6-1.

Table 6-1
Details of the blanks and CRMs inserted in the 2018 sample stream

CRM	Description	Fe (%)	Ti (%)	V (%)
AMIS0368	Vanadium bearing titaniferous magnetite ore reference material	53.01	8.26	0.84
AMIS0439	Blank silica chips			

At least one blank and one CRM sample were inserted alternatively every ten samples resulting in approximately 5 % of the assays being from the CRM and 5 % from the blank sample.

Five per cent of the total sample rejects submitted to the primary laboratory were selected and resubmitted as duplicates to compare the results with the original.

A further 5 % of total sample rejects were randomly selected and sent to a secondary laboratory as "umpire samples" to check the results from the primary laboratory.

6.7.1.1 Results of the QAQC assays

QAQC plots for the assay data sets were completed and the assay data received from the secondary laboratory was compared with that of the primary laboratory. The blanks sample results indicate that no material contamination took place during the assaying process (Figure 6-5). The CRM results demonstrate that the assays are accurate (Figure 6-6).

Figure 6-5

Blank Sample Analyses for Vametco 2018 drillhole samples

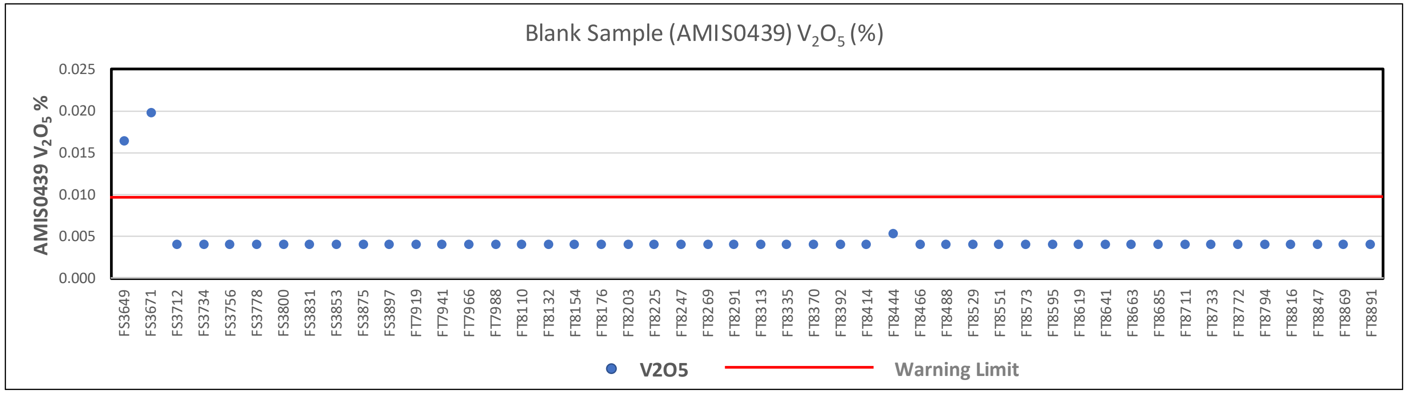
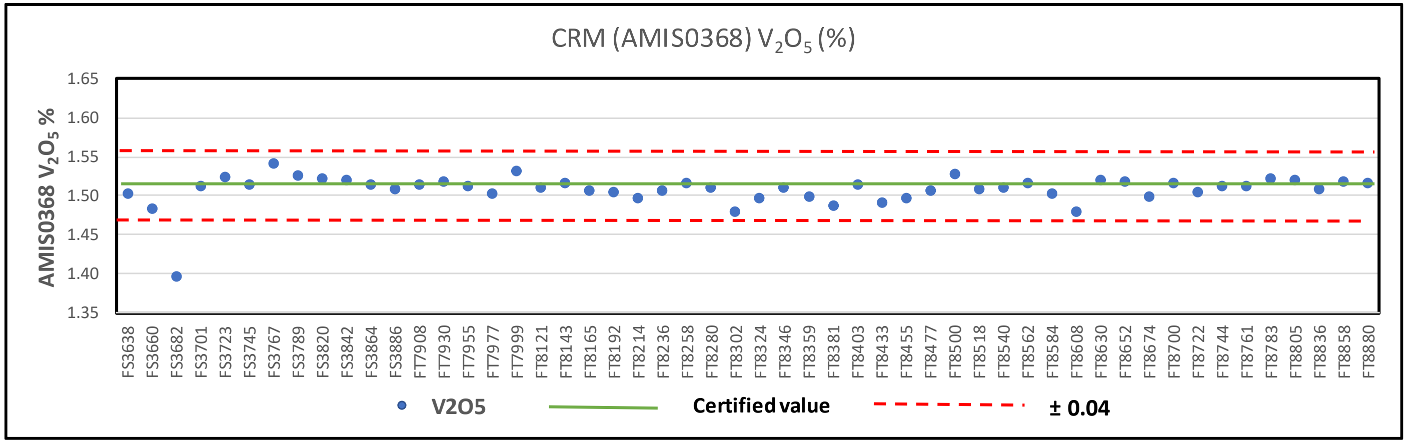


Figure 6-6

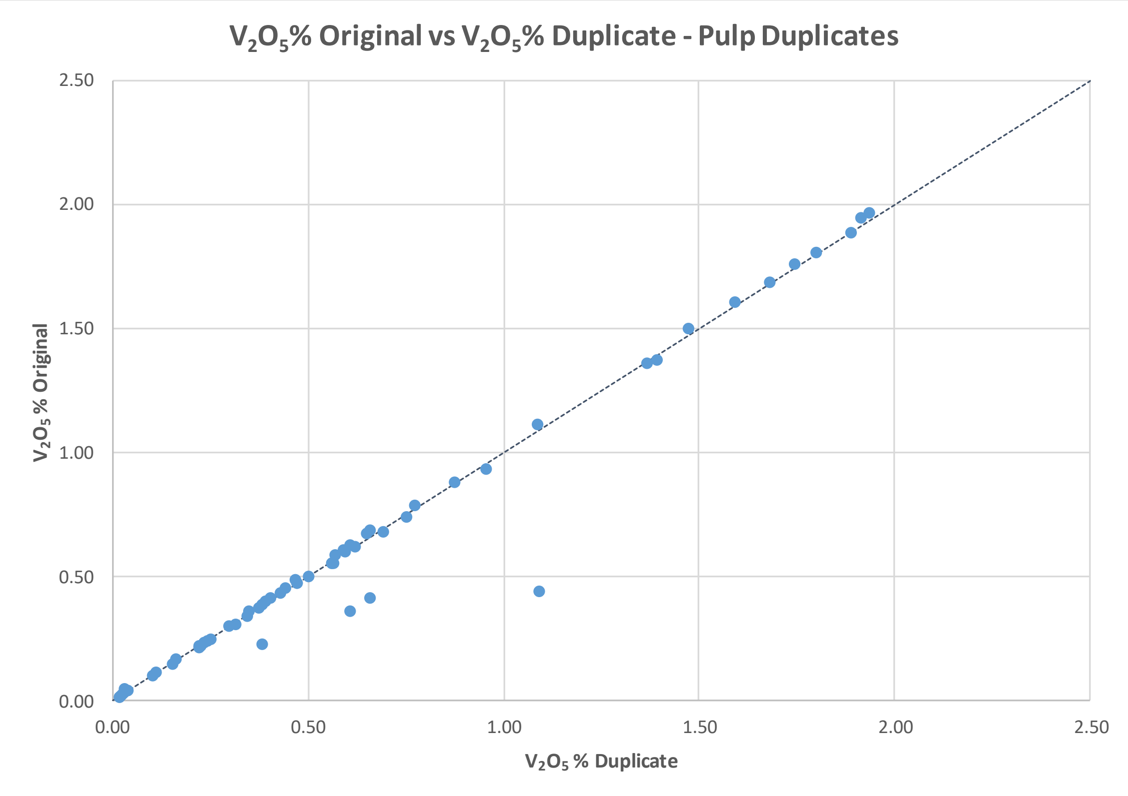
CRM Sample Analyses for Vametco 2018 drillhole samples



The within laboratory pulp duplicates show that most of the time UIS was able to repeat the original analyses with a high degree of precision although 4 samples were outside normal; acceptable limits of 5 % (Figure 6-7).

Figure 6-7

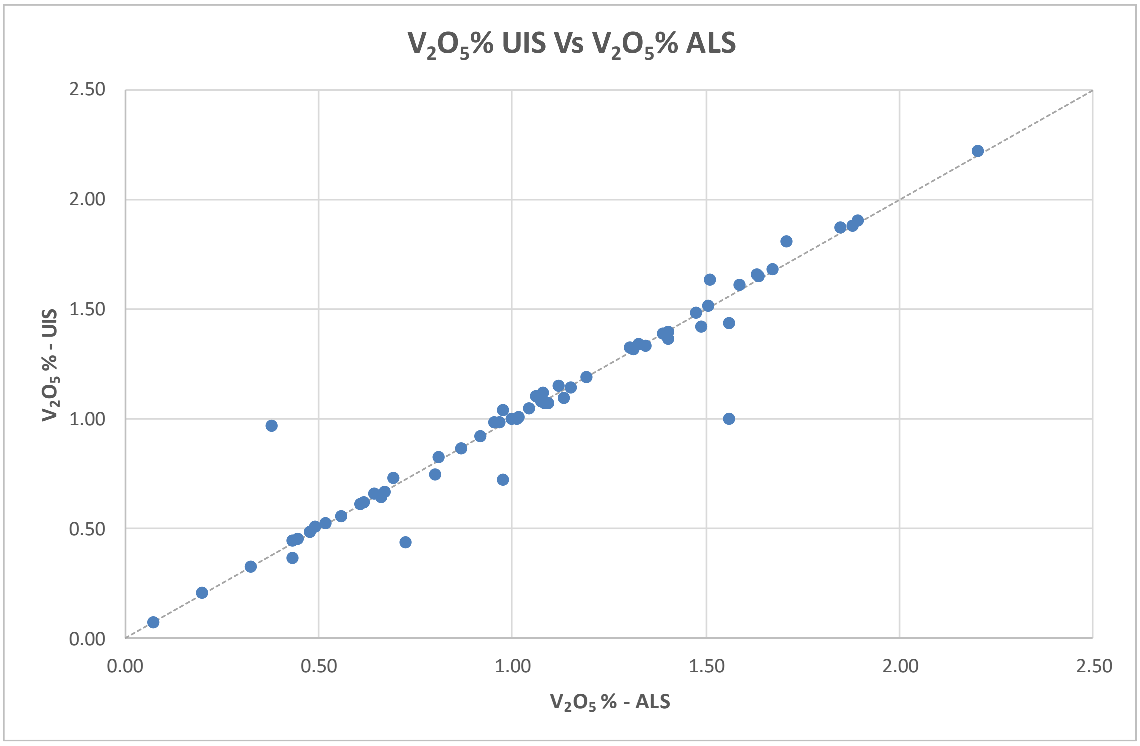
Pulp Duplicate V_2O_5 Analyses for Vametco 2018 drillhole samples – within lab - UIS



The analysis of duplicate samples by the second laboratory (ALS) were within close limits of the primary laboratory and therefore the two laboratories are in agreement. This is with the exception of four samples where a difference was noted outside of the normally acceptable 10 % limits (Figure 6-8).

Figure 6-8

Pulp Duplicate V_2O_5 Analyses for Vametco 2018 drillhole samples – between lab UIS vs ALS



The Competent Person (Mr J Witley) considers that the 2018 exploration sample V_2O_5 assays for Vametco Mine were completed with a high degree of accuracy and precision, and that no significant contamination occurred. The V_2O_5 assays by the primary laboratory (UIS) were confirmed by analysis at a second laboratory (ALS).

6.7.2 QAQC for the Historical Drillholes

No QAQC results are available for historical drilling programmes. Although a formal QAQC process did not exist, historical mining grades correlate with grades measured from drillhole intersections in areas that have already been mined. If a sampled intersection did not correlate with the typical mining grade, the sample was flagged for corrective action.

6.8 Location of Data

The grid system for the Project is WGS84 LO27.

When mining operations began in 1967, many companies used their own local grid systems, or they made use of the Clark 1880 coordinate system. The historical surveys were performed with a theodolite referenced from a fixed survey beacon. Two of the historical drillholes were located in the field and surveyed by the Vametco Mine Surveyor using a Digital Global Positioning System ("DGPS"). The coordinates in WGS84 LO27 grid system of the historical drillholes were derived from information on historical plans combined with the verified surveys of the two historical drillholes.

The collars from the 2006 drilling program were surveyed with a DGPS with a "real time" repeater from a fixed survey beacon. The six drillholes were surveyed in WGS84 LO29.

All the drillholes drilled in the 2018 exploration campaign were surveyed by the Vametco Mine Surveyor using DGPS survey equipment. All holes were drilled vertically. No downhole surveys were conducted, and all holes were assumed as being collared for their entire length.

The depths of drilling range between 75 m and 161 m (for the 2018 drillholes) and between 5 m and 271 m (for the historical drillholes).

The survey methods applied are sufficient to spatially locate topography and drillholes for use in Mineral Resource estimation to a reasonable level of confidence.

6.9 Data Verification, Audits and Reviews

6.9.1 2018 Exploration Drilling, Sampling and Assaying

No twin drillholes were drilled. Assays were confirmed by a second laboratory (ALS Global – Johannesburg).

The Competent Person examined the cores and verified the presence of the magnetite mineralisation during a site visit to the property on 28 May 2019. The CP found that the sampling and logging were of reasonable quality for the purposes of Mineral Resource estimation.

6.9.2 Historical drilling, Sampling and Assaying

Historical drilling data were captured from hard copies. No verification work of significant intersections has been completed and no twin holes have been drilled, however the results of the drilling are broadly consistent with the recent drilling and mining operations indicating that actual mined vanadium values are consistent with those determined from drilling.

All recent data are stored in a Microsoft Excel™ database. No statistical adjustments were applied to the data. The historical data capturing was verified by MSA by comparing the original assay sheets with the digital data and it was corrected where required and declared to be accurate. The authors are unaware of any QAQC completed when the historical assaying was conducted.

6.10 Exploration Budget and Programme

Exploration expenditure (Table 6-2) for the Vametco Project for 2018 was of the order of approximately ZAR 2,457,000. No exploration expenditure is currently planned for 2019-2020.

Table 6-2
Exploration expenditure (FY2018)

Description	Amount (ZAR)
Drilling	533,043.47
Sample Analysis	87,397.04
Mineral Resource Review	81,090.00
Davis Tube Testwork	96,423.88
Drillhole sample analysis	1,658,611.28

Source: *Vametco (2019)*

7 MINERAL RESOURCE ESTIMATES

The Mineral Resources presented herein have an effective date of 29 March 2019, this being the data of the last pit survey. The Mineral Resource estimate incorporates drilling data from holes completed by Union Carbide Exploration from the mid-1960s until 1982, EVRAZ Vametco in 2006 and Bushveld Vametco in 2018.

The Mineral Resource was prepared in accordance with the guidelines of the 2012 Edition of the JORC Code. To the best of the CP's knowledge there are currently no title, legal, taxation, marketing, permitting, socio-economic or other relevant issues that may materially affect the Mineral Resource described in this report.

The Mineral Resource estimate was conducted using Datamine Studio RM software (Version 1.4), together with Microsoft Excel, JMP and Snowden Supervisor (Version 8.9) for data analysis, and Leapfrog Geo (Version 4.4) for geological modelling. The Mineral Resource estimate was completed by Mrs Kaylan Bartlett, a Mineral Resource Consultant for MSA under the guidance and supervision of Mr Jeremy Charles Witley, Head of Mineral Resources for MSA and the Competent Person for this Mineral Resource estimate.

7.1 Input Data

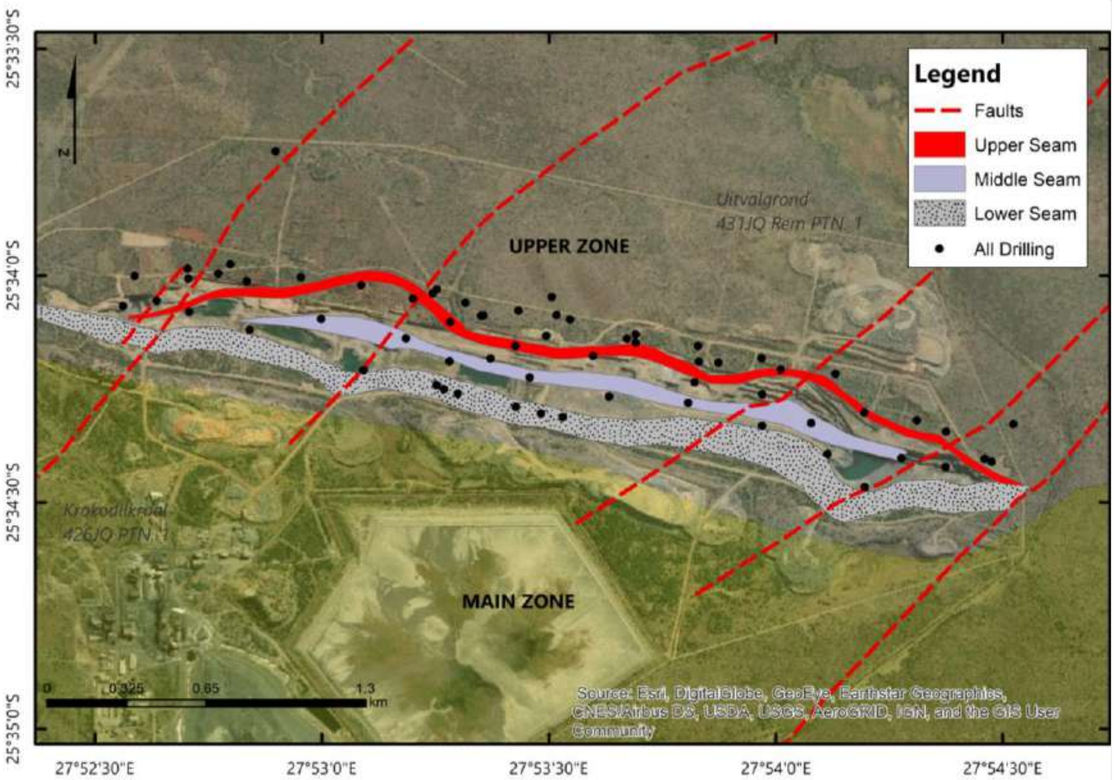
The database provided by Bushveld Vametco for the Mineral Resource estimate consists of information from diamond drillholes ("DD") and percussion holes ("PH"), and includes information for:

- collar surveys;
- sampling and assay data;
- geology logs, containing rock type and seam name; and
- a DTM completed on 29 March 2019.

No density data were available for the historical drilling campaigns; however, the 2018 drilling campaign provided density data on the magnetite-rich seams as well as the waste zones between the magnetite-rich layers.

The drillhole data were provided in a Microsoft Excel™ spreadsheet. A summary of the drillhole data in the Excel database provided to MSA is shown in Appendix 2. The drillhole spacing at Vametco is not based on a fixed grid pattern (Figure 7-1).

Figure 7-1
Plan view of the geological mapping supplied by Vametco with drillhole localities highlighted in black



Source: *Background imagery from ESRI World Imagery (sourced from Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community)*

The KO, KR, UI and UO series holes were drilled by Union Carbide Exploration from the mid-1960s until 1982. The VA series holes (VA1 to VA6) were drilled by EVRAZ Vametco in 2006. The VM series holes (VM001 to VM013) were drilled by Bushveld Minerals in 2018. In 2018 and 2019, a review of the historical data was completed that resulted in the removal of the UO and KO series drillholes from the database due to incomplete drillhole data and illegible hard copy records.

The holes were drilled vertically downwards through the magnetite layers. The drillhole intersections of the mineralised zones are spaced between approximately 50 m and 300 m apart on the plane of mineralisation. Not all the layers were intersected in each hole, some of the holes being collared within the footwall of the Upper and Intermediate Seams or some stopping before the Lower Seam was reached.

7.2 Exploratory Analysis of the Raw Data

The data provided by Bushveld Vametco consist of sampling and logging data from 67 DD holes. The following attributes are of direct relevance to the estimate:

- whole rock and magnetite concentrate Vanadium pentoxide (V_2O_5), whole rock calcium oxide (CaO), and whole rock silicon dioxide (SiO_2) assays, and magnetite content (Mag) in percent. The magnetite content is the result of Davies Tube tests. V_2O_5 assays are available for both magnetite concentrate and whole rock; and
- seam names – Upper (US), Intermediate (IS) and Lower Seam (LS).

V_2O_5 mineralisation is known to occur within continuous layers of magnetite-rich gabbro in the Upper Zone. Drilling intersected magnetite mineralisation in all the holes drilled along approximately 3.3 km of strike within the 4.7 km mining licence area. The maximum depth of the intersections of the Upper, Intermediate and Lower Seams is at approximately 60 m, 100 m and 150 m below surface respectively. The average drillhole spacing is 150 m by 150 m.

One hole (UI16) was drilled 490 m to the northeast of the main drilling area, intersecting the Lower Seam. The Upper and Intermediate Seams were not logged or sampled in this hole. All other holes intersected Upper and Intermediate Seams where expected.

The Upper Seam drilled thickness is between 1.84 m and 6.78 m with an average thickness of 2.60 m. This zone is an almost massive layer of magnetite and has the highest magnetite content of the three seams, but the V_2O_5 grade of the magnetite is the lowest.

The Intermediate Seam drilled thickness is between 4.57 m and 28.89 m with an average thickness of 11.82 m. The magnetite content and V_2O_5 grade of the magnetite is generally between that of the Upper and the Lower Seam. The Intermediate Seam is not consistent across the deposit and pinches out along strike. Down-dip there is no evidence that the seam pinches out.

The Lower Seam intersection drilled thickness is between 21.90 m and 47.89 m with an average thickness of 33.84 m. This zone is the thickest of the three magnetite layers and has the highest V_2O_5 grade of the magnetite.

As the holes are vertical and the dip of the magnetite bearing seams is approximately 19°, true thicknesses will be approximately 95% of the drilled thicknesses stated above.

7.2.1 Validation of the data

The validation process consisted of:

- examining the sample assay, collar survey and geology data to ensure that the data are complete for all drillholes;
- examining the de-surveyed data in three dimensions to check for spatial errors;
- examining the assay data to ascertain whether they are within expected ranges; and
- checks for "From-To" errors, to ensure that the sample data do not overlap one another or that there are no unexplained gaps between samples.

The data validation exercise revealed the following:

- as at the effective date of this report there were no outstanding drilling data;

- SG measurements were supplied for the 2018 drilling campaign and none were available for historical drilling campaigns;
- there are no unresolved errors relating to missing intervals and overlaps in the drillhole logging data;
- no default values were found;
- the position where sampling of the core commenced and ended for each layer was based on the occurrence of significant magnetite concentration – greater than 20 %. Within the individual layers, zones of low-grade are apparent. The low-grade zones were analysed for magnetite content but were not always assayed for V_2O_5, SiO_2 or CaO unless the magnetite was greater than 20 %;
- examination of the drillhole data in three dimensions shows that the collar coordinates of the drillholes plot in their expected positions and mineralised intersections coincide well with mined areas; and
- high-grade assays were checked, and none were found that are outside of expected limits for the style of mineralisation at the Project.

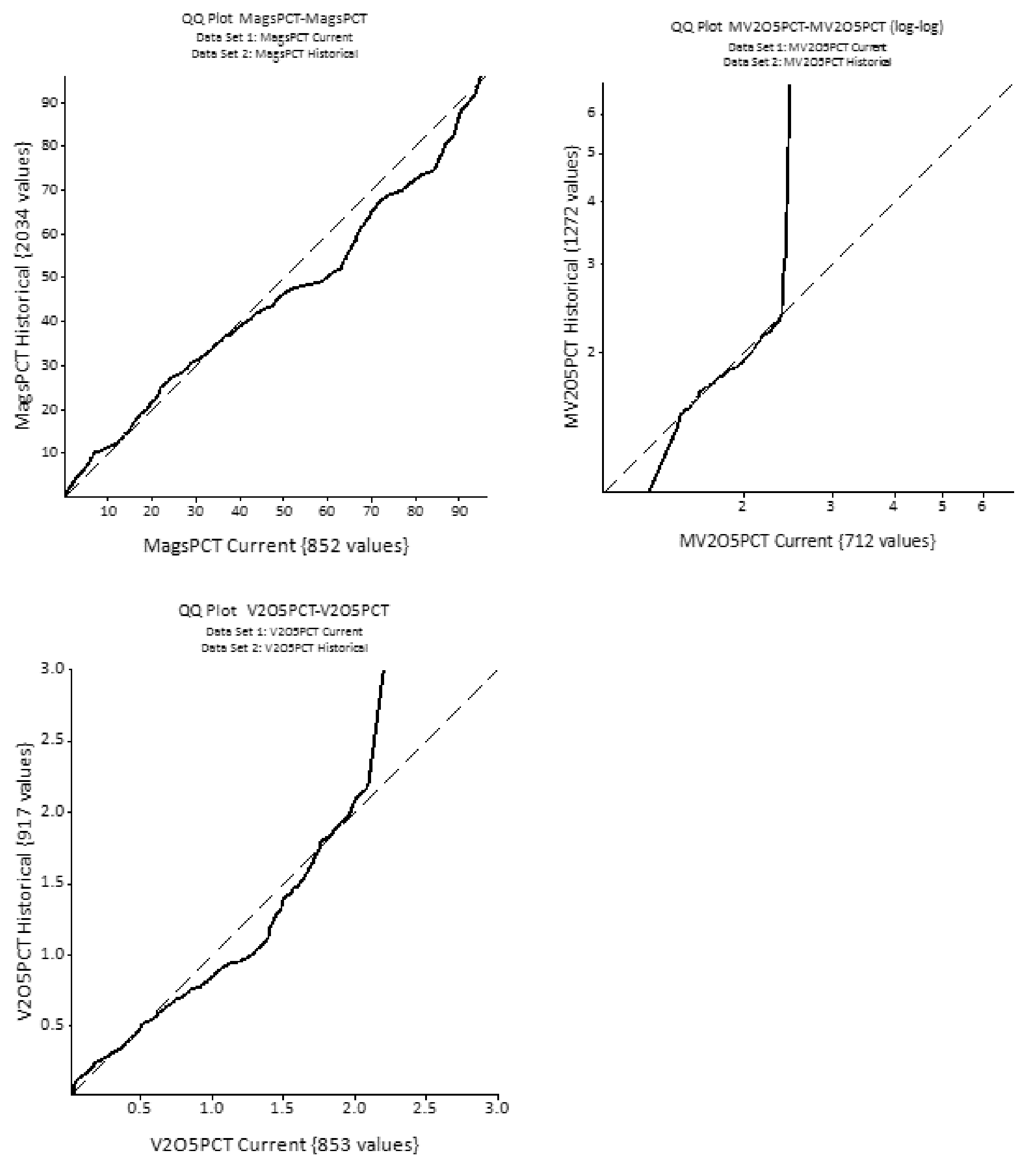
A further check was made by comparing the V_2O_5 magnetite concentrate assays with the magnetite content, as it is expected that the V_2O_5 magnetite concentrate grade should not vary considerably in the magnetite concentrate between holes within an individual layer.

The un-assayed data within the mineralised layers were left as null values rather than zero values, as the estimate is for the grade in magnetite and these values are relatively constant. This allows for estimation into the un-assayed data using the surrounding assay data. Assigning a zero value would bias the estimate of V_2O_5 in magnetite. Although samples were not always assayed for V_2O_5 they were assayed for magnetite content, so no bias was introduced in this respect.

A validation process was required to ensure that the historical assay data are consistent with the new 2018 drilling campaign assay data. A Q-Q plot was created (Figure 7-2) to check whether both datasets could be used for estimation. The magnetite grade and V_2O_5 assays for both whole rock and within magnetite for the 2018 and historical data compare closely and therefore the historical assay data were considered acceptable to be used in the estimate.

Figure 7-2

Q-Q plot of the historical data versus the 2018 drilling campaign



A further validation test was completed to compare the assay data of drillhole VM001 with the assay data of the other twelve 2018 drillholes. This was necessary as the samples from VM002 to VM013 were assayed at a commercial laboratory (UIS Laboratories) rather than at Vametco's on-site laboratory. A bias of the V_2O_5 assays in magnetite was noted whereby the Vametco laboratory reports around 0.1 % higher V_2O_5 than the commercial laboratory (Figure 7-3). No biases were noted for magnetite grade and the whole rock V_2O_5 grade. The average grades of the magnetite, whole rock V_2O_5 and V_2O_5 contained in magnetite of the LS of VM001 was compared to a nearby hole VM002 (Table 7-1). The grades compare well between the holes and no bias was therefore considered to have been introduced by using different laboratories.

Figure 7-3

Q-Q plot of the Vametco on-site lab for hole VM001 versus the commercial lab for the other 2018 drilling campaign holes

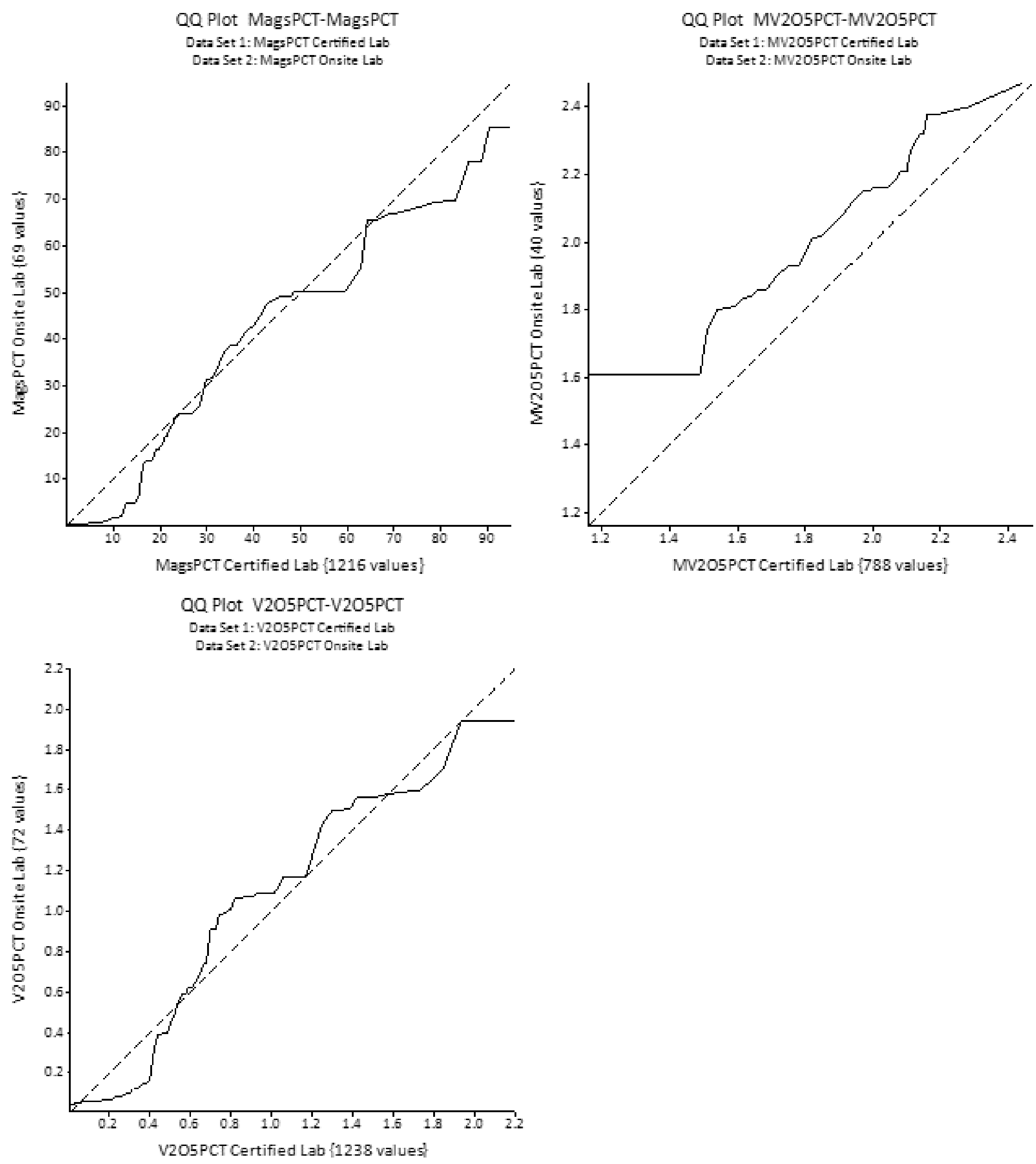


Table 7-1

Comparison of the hole VM001 and VM002

Variable	Mean value VM001 (%)	Mean value VM002 (%)
Mag	36.27	33.52
WR V_2O_5	2.08	2.05
WR V_2O_5	0.86	0.83

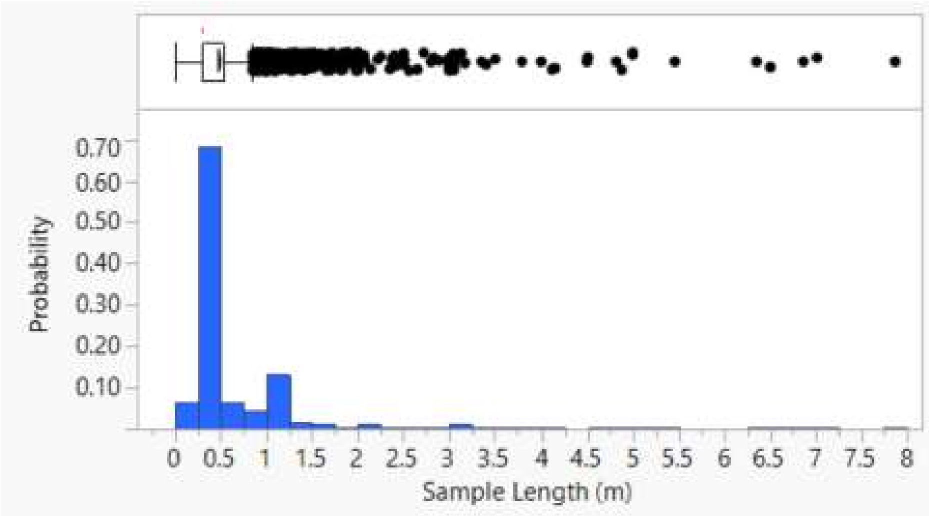
Of the 65 drillhole data supplied to MSA, the assay data from two drillholes were excluded based on the data not being verifiable during a validation process of original scanned copies of drillhole logs and the captured database in excel (drillholes UI25 and UI26). All the other data passed validation and was used in the estimation.

7.2.2 Statistics of the Sample Data

A total of 6,480 validated sample assays occur in the database for Vametco.

A histogram of the accepted sample lengths is presented in Figure 7-4. Seventy per cent of the sample lengths are 0.3 m or less. No relationship between sample length and V_2O_5 grade is apparent. Where sample lengths are greater than 2 m, these samples are from the historical drillholes with the UI and KR prefix and represent waste units.

Figure 7-4
Histogram of the sample length data



7.2.3 Statistics of the Assay Data

7.2.3.1 Univariate analysis

A summary of the assay data statistics for the raw data at Vametco is shown in Table 7-2.

Table 7-2
Summary of the raw validated sample assay data at Vametco (length-weighted mean)

Variable	Number of assays	Mean value (%)	Minimum value (%)	Maximum value (%)
Mag	6,480	22.27	0.02	96.10
WR V_2O_5	2,744	0.59	0.01	3.00
WR SiO_2	1,216	36.43	0.30	52.74
WR CaO	1,215	8.41	0.01	20.48

Note: *WR – Whole rock analysis*

7.2.3.2 Bivariate analysis

Scatterplots were constructed that compare the grades of each variable with one another in order to understand any relationships that may exist in the data that should be preserved in the Mineral Resource estimate. A weak linear relationship between SiO_2 and CaO grade was observed, with the grade of SiO_2 increasing with increasing grade of CaO.

7.2.4 Summary of the Exploratory Analysis of the Raw Dataset

- Most sample lengths are 0.30 m or less.
- The host rock to the vanadium mineralisation is magnetite-rich gabbro contained within three layers or seams.
- The magnetite-rich seams are defined by areas where the magnetic content is greater than 20 %.
- Low magnetite content samples were not assayed for V_2O_5.
- SG data were only provided for the 2018 drilling campaign completed by Bushveld Vametco.

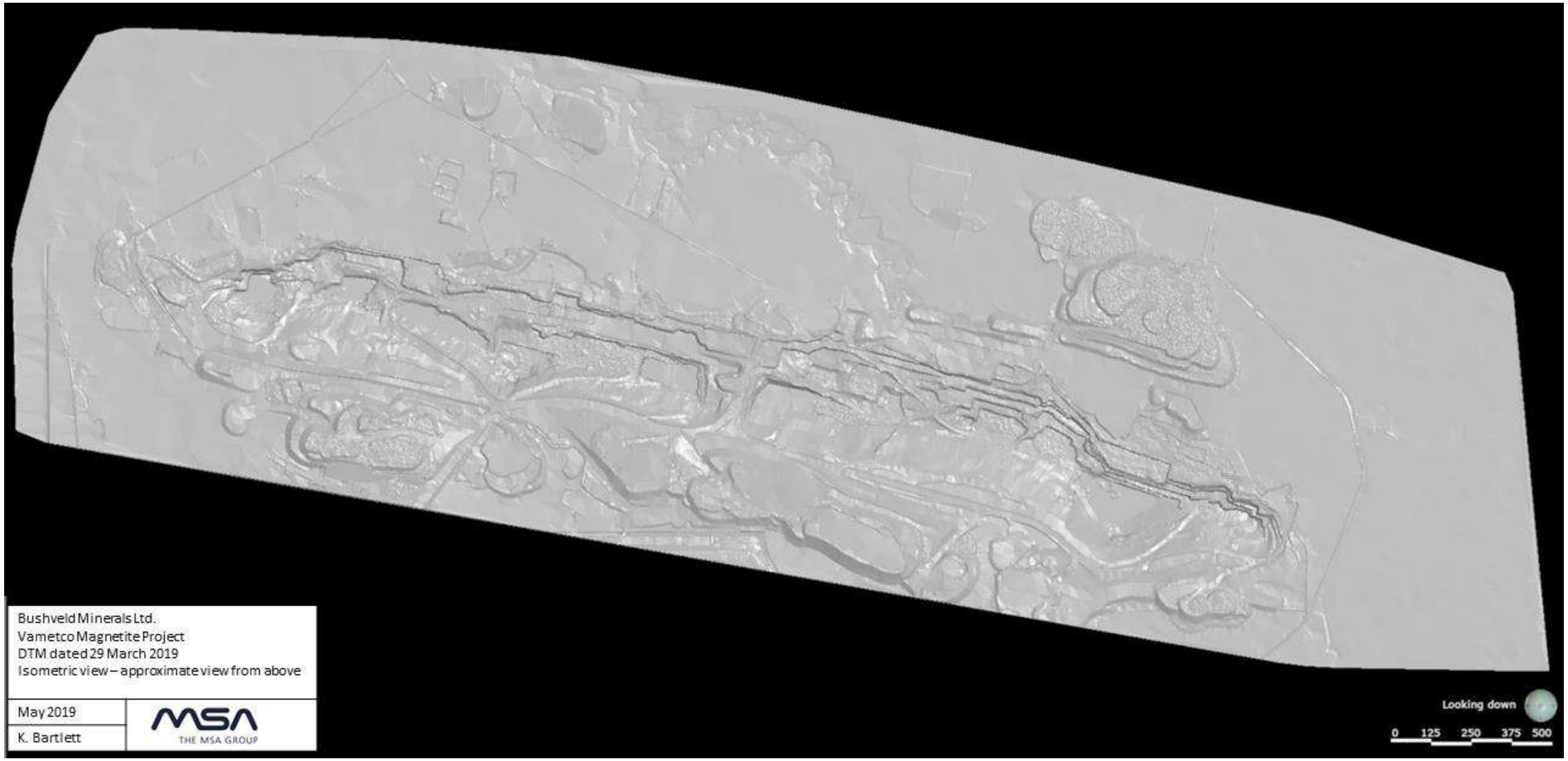
7.3 Geological Modelling

7.3.1 Topography

A high-resolution digital terrain model ("DTM") of the topography was supplied to MSA by Bushveld Vametco for the mine area (Figure 7-5). This includes a recent open pit survey (29 March 2019), which allowed for the reporting of the remaining Mineral Resource.

Figure 7-5

An isometric view of the 29 March 2019 DTM– view from approximately above



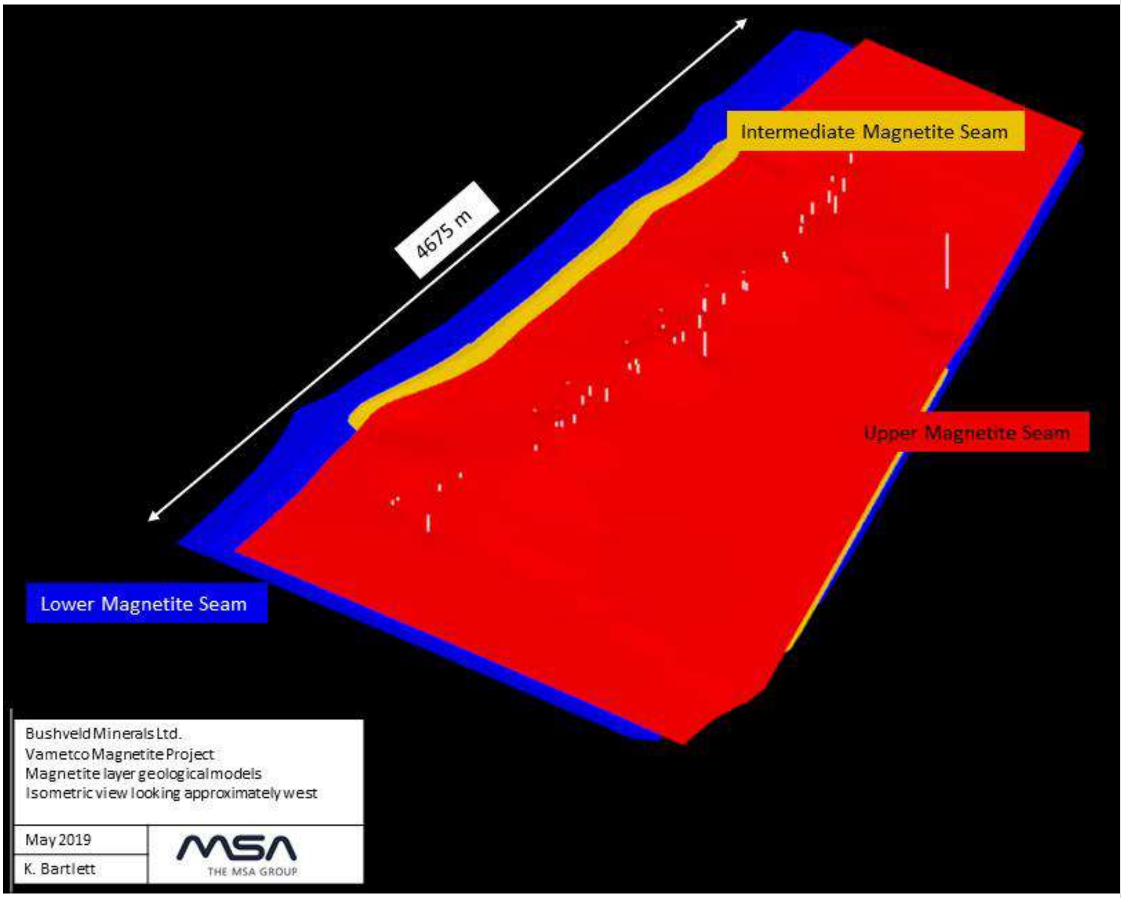
Note: *north is towards the top of the image*

7.3.2 Mineralised Zones

The geological model was based on information obtained from the cores of 65 DD and percussion holes. The model is based on the well-known layering of the RLS, the mineralisation has been exposed by open pit mining and no alternative interpretation exists that could materially impact the Mineral Resource.

A geological model of three magnetite layers was constructed based on the sampling and logging of the drillholes (Figure 7-6). Internal waste zones were not separately defined.

Figure 7-6
Isometric view of the magnetite layers geological model, looking approximately to the west

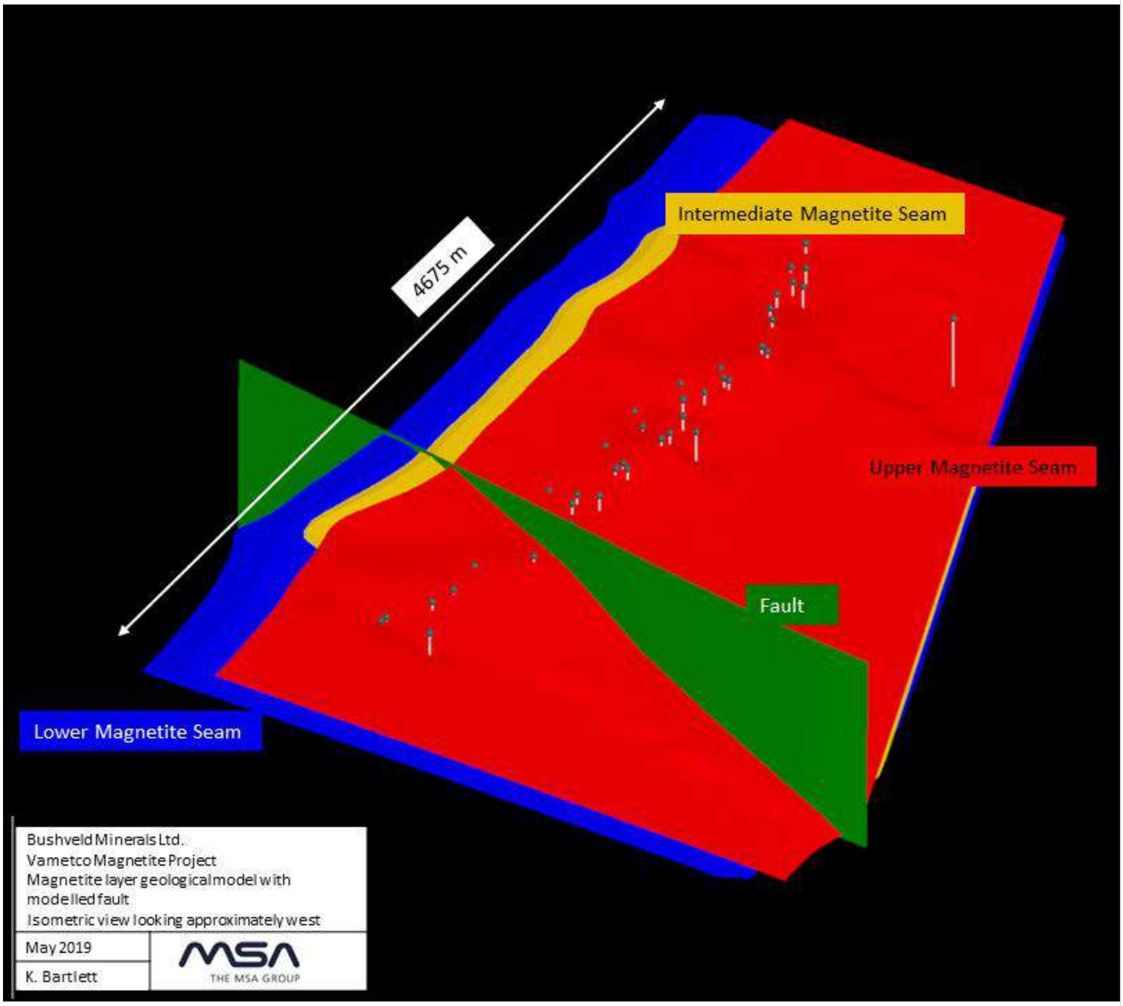


One fault within the Mineral Resource area towards the south-east of the licence has been modelled. The location and extent of the fault was defined by geological mapping by Bushveld Vametco. The fault has a downthrow of 7 m to the east and separates the east block from the west block (Figure 7-7).

The model is based on the well-known layering of the RLS, the mineralisation has been exposed by open pit mining and no alternative interpretation exists that could materially impact the Mineral Resource.

No geological losses were applied; the faults and dykes expected to account for geological losses of less than 1 %.

Figure 7-7
Isometric view of the modelled fault in the geological model, looking approximately to the west



Mining has occurred on the Lower Seam along most of the defined strike length near surface. The northing and easting extents of these open pit workings are well defined through the DTM topography provided by Bushveld Vametco. The extent of the open pit mining was removed from the grade block model to account for depletion.

7.3.3 Oxidation/Weathering Surfaces

No overburden/weathering horizon has been modelled. Most of the near surface material has been mined. The RLS in this area is typically covered by approximately 5 m of black cotton soil.

7.4 Statistical Analysis of the Composite Data

The data within each magnetite layer were composited to 2 m lengths and summary statistics were compiled for each mineralised zone (Table 7-3).

Table 7-3
Summary statistics of the 2 m composite assay data

Variable	Number of composites	Minimum (%)	Maximum (%)	Mean (%)	CV	Skewness
Upper Seam						
Mag	42	9.21	91.44	62.48	0.46	-0.92
V_2O_5 Magnetics	39	1.42	2.24	1.79	0.11	1.01
V_2O_5 whole rock	20	0.94	1.74	1.48	0.19	-0.72
CaO	13	0.03	5.99	1.85	1.61	1.03
SiO_2	13	1.82	18.42	8.35	1.09	0.43
Intermediate Seam						
Mag	108	6.39	89.66	32.08	0.65	1.37
V_2O_5 Magnetics	105	1.48	2.27	1.85	0.13	-0.11
V_2O_5 whole rock	73	0.15	1.60	0.63	0.62	0.86
CaO	66	0.61	11.46	7.64	0.35	-0.98
SiO_2	66	2.97	46.12	32.45	0.34	-1.08
Lower Seam						
Mag	628	1.36	76.29	30.81	0.69	0.61
V_2O_5 Magnetics	328	1.53	2.82	2.02	0.10	0.42
V_2O_5 whole rock	478	0.07	1.92	0.67	0.68	1.04
CaO	169	2.43	11.66	8.20	0.35	-0.79
SiO_2	169	12.03	49.40	34.95	0.33	-0.78

Note: *CV = Coefficient of variation*

The statistical analysis revealed:

- most of the data are in the Lower Seam;
- the Upper and Intermediate Seams have the highest magnetite concentration;
- the average V_2O_5 grade of the magnetite increases from the Upper Seam downwards through to the base of the Lower Seam;
- the coefficient of variation is low for magnetite content (0.46 and 0.69), V_2O_5 in magnetics (0.10 and 0.13), V_2O_5 whole rock (0.19 and 0.68), and SiO_2 (0.33 and 1.09) grade; and
- the coefficient of variation for CaO is the highest - between 0.35 and 1.61.

7.4.1 Cutting and Capping

The log probability plots and histograms of the composite data were examined for outlier values that have a low probability of re-occurrence. There are no distributions that exhibit outlier data.

7.5 Geostatistical Analysis

7.5.1 Semi-variograms

An attempt was made to model variograms for both magnetic grade and whole rock V_2O_5 but they show poor structure due to the limited amount of data. The variography indicated a range of approximately 210 m in the plane of mineralisation.

7.6 Block Modelling

The block model prototype parameters are shown in Table 7-4. A block size of 20 mX by 20 mY by 5 mZ was used, which is small relative to the drillhole spacing. As the mineralisation dips at 19° a larger block size would not retain the layering within the seam without rotating the block model. The cells were split to a minimum sub-cell of 5 mX by 5 mY by 1 mZ in order to fill the wireframe model boundaries accurately.

Table 7-4
Block model prototype parameters for Vametco

Block size (m)			Model origin			Number of cells		
X	Y	Z	X	Y	Z	X	Y	Z
20	20	5	87,100	-2,830,500	650	260	110	130

Block models were created by filling within the geological model for the Upper, Intermediate and Lower Seams. The model volume above the topography was removed after grade estimation was complete.

7.6.1 Validation of the Block Model Volumes with the Wireframe Volumes

The volume of the block model was validated by comparing it to the volume of the wireframe (Table 7-5).

Table 7-5
Volume (m^3)validation comparison of wireframes and block models

	Geological model wireframe	Block model	Percentage difference
Upper Seam	15,892,000	15,922,675	0.19
Intermediate Seam	34,621,800	34,654,400	0.09
Lower Seam	222,176,000	222,464,325	0.12

The model volumes compare well with the corresponding wireframe volumes and are thus acceptable for use in estimation.

7.7 Estimation

Of the 65 holes in the database, a total of 36 intersections of the Upper Seam, 22 of the Intermediate Seam and 42 of the Lower Seam were used to estimate the grade of the Mineral Resource (Table 7-6).

Table 7-6
Number of drillholes per seam and drilling type

	Number of historical percussion drillhole intersections	Number of historical diamond drillhole intersections	Number of recent (2018) drillhole intersections
Upper Seam	12	12	12
Intermediate Seam	8	4	10
Lower Seam	8	22	12

Attributes were estimated into the individual mineralised zones using the 2 m composite drillhole sample data for each seam. Inverse distance to the power of two was used to estimate the grades into parent cells.

SG data are available for the 2018 drilling programme holes for samples within the magnetite-rich seams. These were completed using laboratory pycnometer, which is considered a reasonable method given the non-porous nature of the crystalline igneous rocks at Vametco. A strong relationship between SG and magnetite grade of the samples was found, which was modelled using a third order polynomial regression:

*DENSITY= 2.9255738 + (0.0126181*MAGPCT) + (0.000054014*^(MAGPCT-29.2311,2)) + (0.0000010948*^(MAGPCT-29.2311,3))*

This regression equation was used to assign density values to samples within the mineralised layers that did not have density values.

No density measurements were available for the waste zones, which were assigned average density values as follows:

- 2.8 g/cm^3 for the Lower Seam footwall;
- 2.9 g/cm^3 for the strata between the Lower Seam and Intermediate Seam;
- 2.9 g/cm^3 for the strata between the Intermediate Seam and Upper Seam; and
- 3.0 g/cm^3 for the hanging wall strata of the Upper Seam.

The search ellipse used for estimation was based on the indicative variogram range. A search of 200 m strike by 200 m dip by 10 m across strike was used to select the sample composites for block estimation. The minimum number of composites required for a block to be estimated is 6 while a maximum of 12 composites was used. These criteria were applied to the Upper, Intermediate and Lower Seam. If a block was not estimated from the initial search ellipse, the ellipse size was doubled. Should a block still not be estimated, a larger search ellipse was used by expanding the search by ten times the original search ellipse extent. The percentage of cells filled by each search is shown in Table 7-7.

Table 7-7
Search volume grade estimation summary for Vametco

Seam Name	Blocks filled within each search volume as a percent		
	First search volume	Second search volume	Third search volume
Upper Seam	0.38	40.22	59.40
Intermediate Seam	23.74	68.39	7.87
Lower Seam	51.59	42.01	6.40

7.7.1 Validation of the Estimates

The models were validated by:

- visual examination of the input data against the block model estimates; and
- comparison of the input data statistics against the model statistics.

The block model was examined visually in sections to ensure that the drillhole grades were locally well represented by the model. The model validated well against the data and identified internal low-grade stratiform zones as expected in the layered style of deposit at Vametco. Examples of sections showing the block model and drillholes shaded by percent magnetite content are shown in Figure 7-8 and for V_2O_5 in magnetite in Figure 7-9.

Figure 7-8

Sections through block models and drillhole data illustrating correlation between model and data – percent magnetite

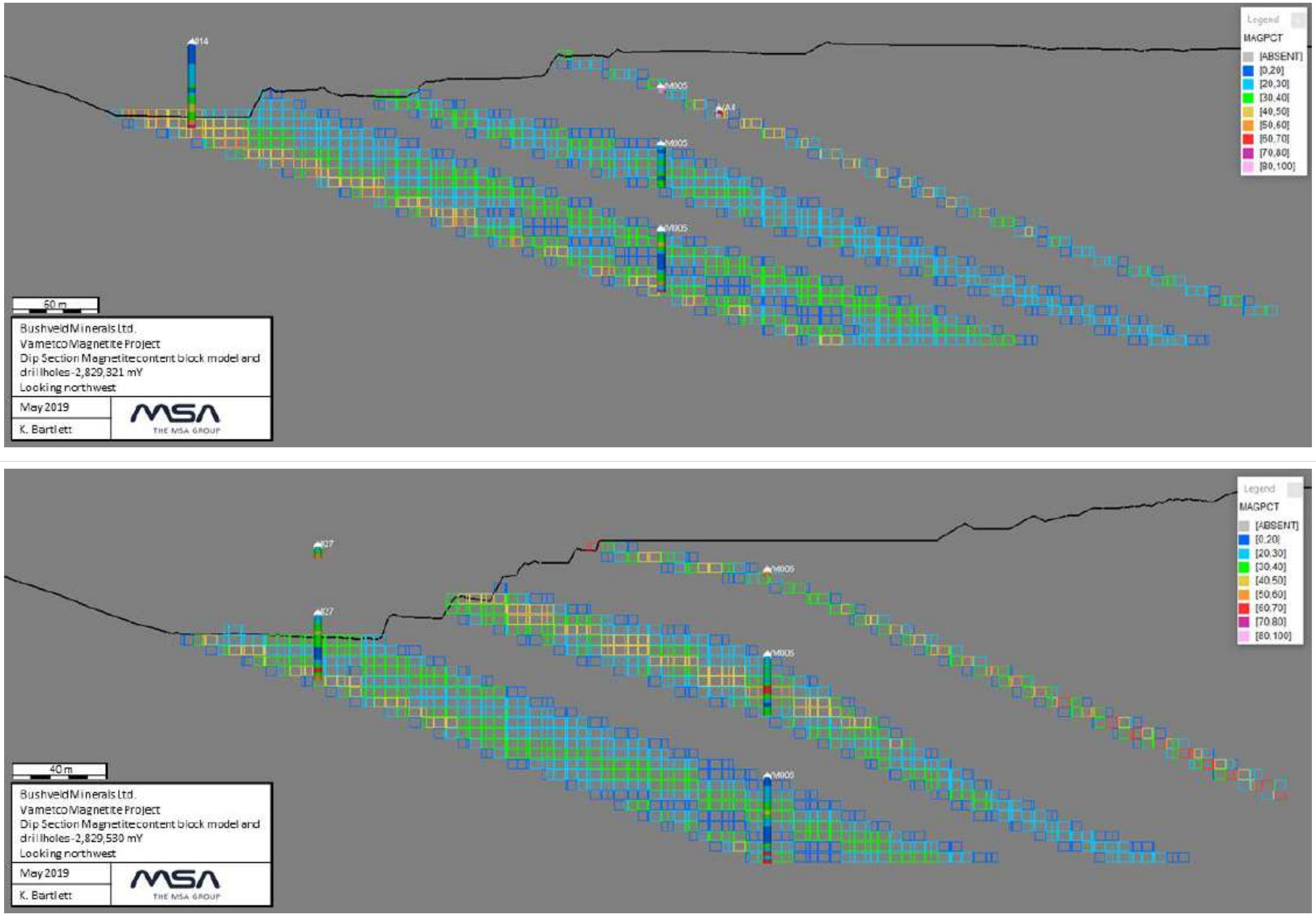
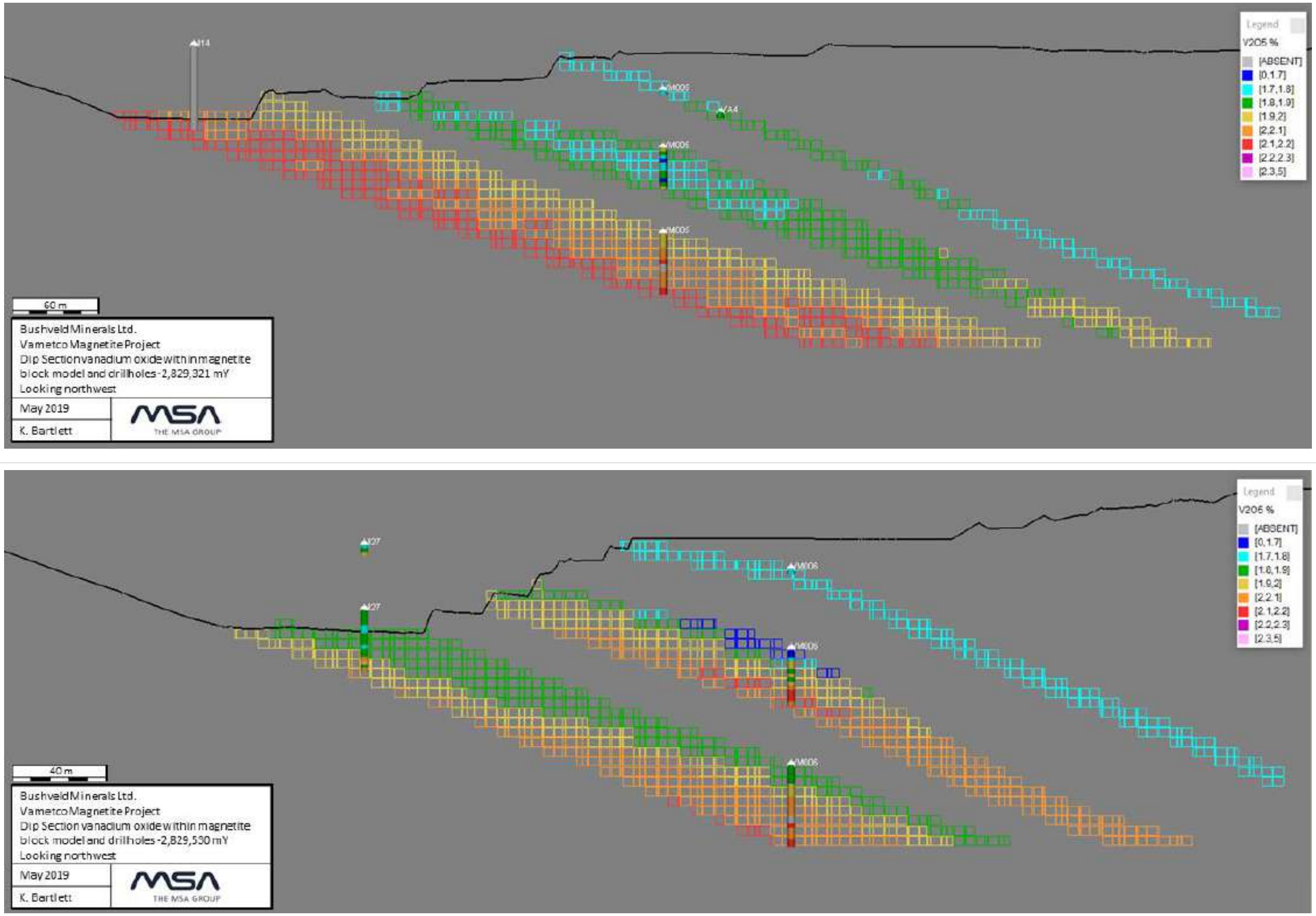


Figure 7-9

Sections through block models and drillhole data illustrating correlation between model and data – V_2O_5 grade (%) of magnetite



The mean composite grades of the drillholes were compared with the model grades (Table 7-8). The model and the data averages compare well for most areas and attributes, the comparison being influenced by the irregular drilling and the extrapolation.

Table 7-8
Comparison between drillhole and model data values

Variable	Mean model (%)	Mean 2 m composite data with top cap (%)
Upper Seam		
Mag	64.19	62.48
V_2O_5 in Magnetite	1.77	1.79
V_2O_5 whole rock	1.45	1.48
CaO	1.95	1.85
SiO_2	8.87	8.35
Intermediate Seam		
Mag	32.15	32.08
V_2O_5 in Magnetite	1.90	1.85
V_2O_5 whole rock	0.66	0.63
CaO	7.49	7.64
SiO_2	32.05	32.45
Lower Seam		
Mag	33.47	30.81
V_2O_5 in Magnetite	2.02	2.02
V_2O_5 whole rock	0.74	0.67
CaO	7.72	8.20
SiO_2	33.06	34.95

7.8 Mineral Resource Classification

Classification of the Vametco Mineral Resource was based on confidence in the data, confidence in the geological model, geological continuity and the spacing of drilling data. The main considerations in the classification of the Vametco Mineral Resource are as follows:

- all of the data that inform the Mineral Resource have been collected by Union Carbide Exploration, EVRAZ Vametco and Bushveld Vametco. These data have been validated and obvious erroneous data were removed. For the historical data there are no QAQC data for the assays, but otherwise the data appear to have been collected using reasonable practices in place at the time. The data for the Bushveld Vametco 2018 drilling campaign were collected based on industry best practice principles and QAQC was performed on the assay data;
- the historical data compare well with the recent data;
- the interpretation of the geological framework of the mineralisation as three magnetite layers gently dipping to the northeast at approximately 19° with V_2O_5 mineralisation within the magnetite layer is sound, having been confirmed by mining;
- the extent of the mineralisation along strike away from the drillholes is uncertain and potential exists for faulting at the pit limits;

- pit optimisation carried out for the Ore Reserve conversion indicates an economic pit depth of 150 m below the original land surface. The mine may decide that there are more economical options than extracting mineralisation on this property at depth, however eventual economic extraction can be assumed; and
- the drillhole spacing is on average 150 m in dip by 200 m in strike for the LS and IS. The drillhole spacing is on average 150 m in dip by 290 m in strike for the US. The drillhole spacing confirms the geological continuity of all three seams.

In consideration of the aforementioned points, the Vametco Mineral Resource was classified as follows:

- the Upper Seam estimate is informed by 36 holes. The well drilled portions of the Upper Seam were classified as Indicated Resources up to a distance of 125 m from the drillhole grid. The remainder of the model to the 150 m depth extent was classified as Inferred Resources up to 400 m along strike from the nearest drillhole;
- the Intermediate Seam estimate is informed by 22 holes. The well drilled portions of the Intermediate Seam were classified as Indicated Resources up to a distance of 125 m from the drillhole grid. The remainder of the model to the 150 m depth extent was classified as Inferred Resources up to 400 m along strike from the nearest drillhole; and
- the Lower Seam estimate is informed by 42 holes. The well drilled portions of the Lower Seam were classified as Indicated Resources up to a distance of 125 m from the drillhole grid. The remainder of the model to the 150 m depth extent was classified as Inferred Resources up to 400 m along strike from the nearest drillhole.

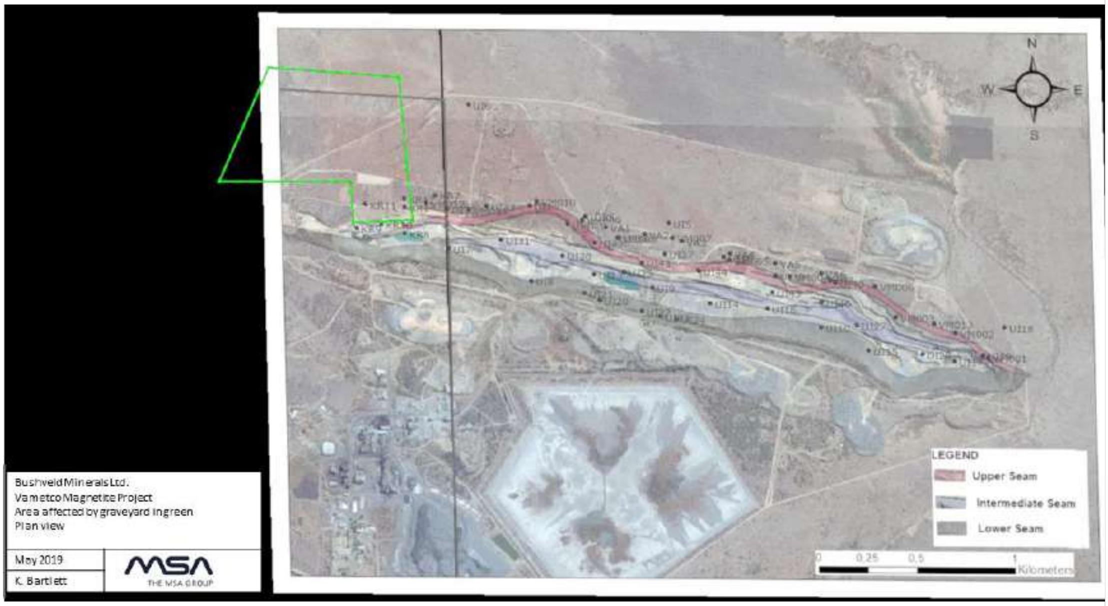
7.8.1 Cultural Features

In the assessment of reasonable prospects for eventual economic extraction (RPEEE), cultural and community features were considered. There is a graveyard that is still in use, that overlies a portion of the down-dip mineralisation in the northwestern part of the Vametco MRA. Vametco has agreed with the local community not to mine within 100 m of the graveyard and that mining should not obstruct access to the graveyard. The Mineral Resource area therefore excludes the mineralisation that directly underlies the footprint of the graveyard, as well as a buffer area 100 m to the west, south and east of the graveyard and all the mineralisation directly to the north of the graveyard. A 50 m buffer to the south of the access road to the west of the graveyard and anything north of this was also not included in the Mineral Resource (Figure 7-10). MSA estimates that the total tonnage of mineralisation underlying the excluded areas is in the order of 17 million tonnes.

The classified areas are shown in Figure 7-11 for the Upper, Intermediate and Lower Seams.

Figure 7-10

Plan view of the area (in the green perimeter) removed from the Mineral Resource based on the proximity of the graveyard and position of the access road

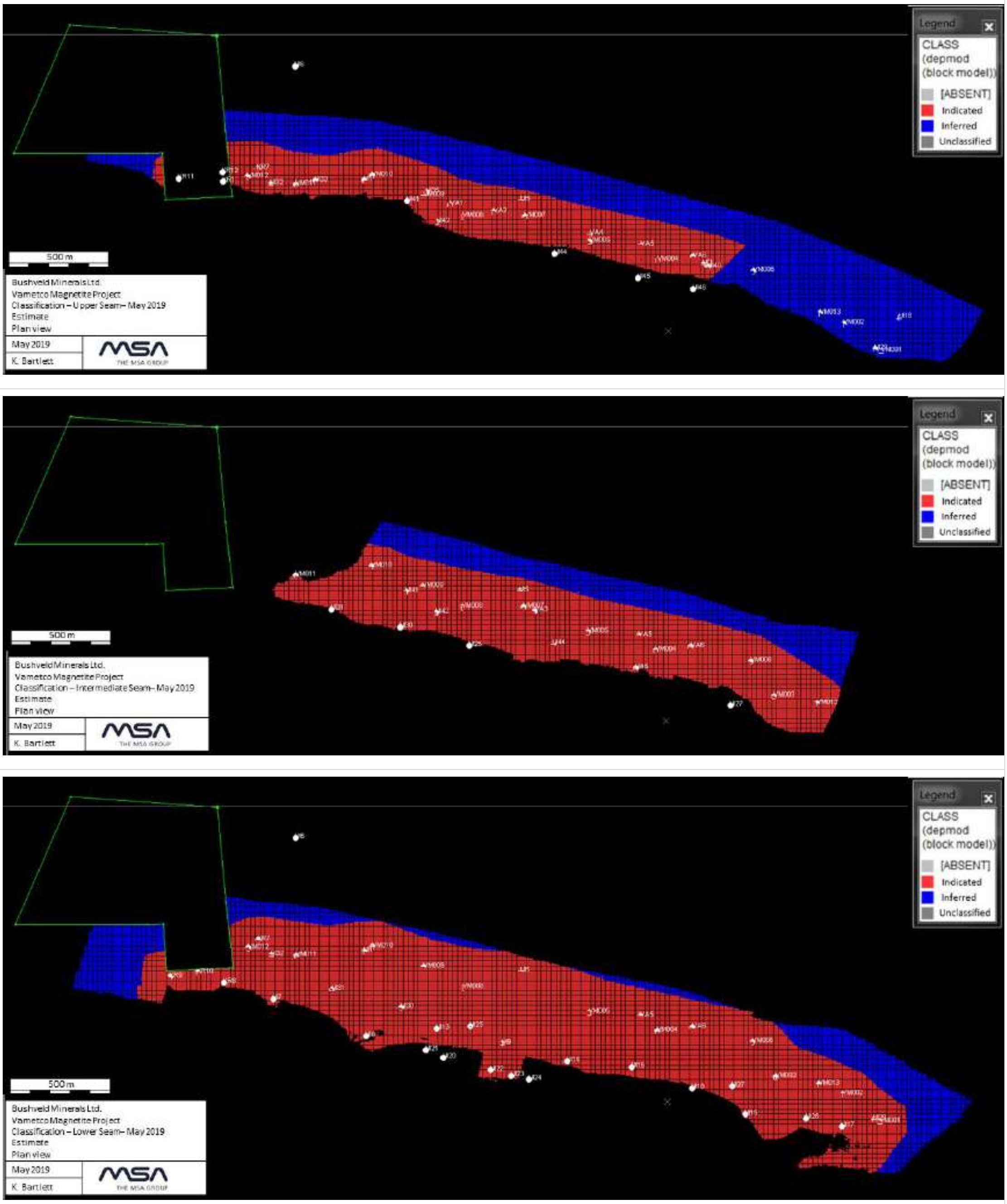


To the best of the CP's knowledge there are no further environmental, permitting, legal, tax, socio-political, marketing or other relevant issues which may materially affect the Mineral Resource estimate as reported in this Competent Persons Report.

The Mineral Resource will be affected by further infill and exploration drilling which may result in increases or decreases in subsequent Mineral Resource estimates. Inferred Mineral Resources are considered to be low confidence estimates that may change significantly with additional data. It cannot be assumed that all or part of an Inferred Mineral Resource will necessarily be upgraded to an Indicated Mineral Resource as a result of continued exploration. The Mineral Resource may also be affected by subsequent assessments of mining, environmental, processing, permitting, taxation, socio-economic and other factors.

Figure 7-11

Plan view of the classification of Vametco Upper, Intermediate and Lower Seams (models shown after mining depletion)



Note: *Drillhole intersection positions shown in white. North is to the top of the figures*

Graveyard and access exclusion area shown as a green perimeter

7.9 Mineral Resource Statement

The Mineral Resource estimate has been completed under the supervision of Mr J. C. Witley who is a professional geologist with more than 30 years' experience in base and precious metals exploration and mining as well as Mineral Resource evaluation and reporting. He is Head of

Mineral Resources for MSA, is registered with SACNASP and is a Fellow of the GSSA. Mr Witley has the appropriate relevant qualifications, experience, competence and independence to be considered a "Competent Person" under the definitions provide in the 2012 Edition of the JORC Code.

The Mineral Resource estimate as at 29 March 2019 is presented in Table 7-9. In the CP's opinion, the Mineral Resource reported herein has reasonable prospects for eventual economic extraction, given that it is an operating mine and associated processing facility with a market for the vanadium product. An open-pit optimisation exercise has been completed by MSA for the purposes of estimating Ore Reserves to a depth of 150 m below the original land surface. The Mineral Resource was prepared in accordance with the guidelines of the 2012 Edition of the JORC Code. The Mineral Resource is classified into the Indicated and Inferred categories as shown in Table 7-9 and the Mineral Resource on an attributable basis in Table 7-10.

The Mineral Resource dips at approximately 19° to the northeast and strikes from northwest to southeast. The Upper Seam Mineral Resource extends for approximately 4,000 m along strike and approximately 230 m in the dip direction. The Intermediate Seam Mineral Resource extends for approximately 2,600 m along strike and approximately 290 m in the dip direction. The Lower Seam Mineral Resource extends for approximately 3,900 m along strike and approximately 230 m in the dip direction. The Mineral Resource estimate is limited to 150 m below surface. The mineralisation is open down-dip. The Upper Seam Mineral Resource Estimate is on average 2.6 m thick, the Intermediate Seam 11.8 m and the Lower Seam 33.8 m.

Table 7-9

Vametco Mineral Resource at a cut-off grade of 20 % magnetite, 29 March 2019 – Gross Basis

Class	Seam Name	Tonnes (millions)	V_2O_5 grade of whole rock (%)	Magnetite grade of whole rock (%)	V_2O_5 grade of magnetite concentrate (%)	Tonnes V_2O_5 in magnetite concentrate (thousands)	Tonnes V in magnetite concentrate (thousands)
Indicated	Upper	5.7	1.44	65.9	1.78	67.0	37.5
	Intermediate	28.7	0.68	32.7	1.91	179.2	100.4
	Lower	109.4	0.72	32.4	2.03	719.7	403.1
	Total	**143.8**	**0.74**	**33.8**	**2.00**	**965.9**	**541.1**
Inferred	Upper	10.5	1.46	63.5	1.75	116.3	65.1
	Intermediate	7.0	0.67	32.1	1.92	43.4	24.3
	Lower	25.4	0.74	31.3	2.00	158.5	88.8
	Total	**42.9**	**0.90**	**39.3**	**1.92**	**318.2**	**178.2**
Indicated and Inferred	Upper	16.2	1.45	64.3	1.76	183.3	102.7
	Intermediate	35.7	0.67	32.6	1.91	222.6	124.7
	Lower	134.8	0.72	32.1	2.03	878.2	491.9
	Total	**186.7**	**0.78**	**35.0**	**1.98**	**1,284.1**	**719.3**

Notes:

1. *All tabulated data have been rounded and as a result minor computational errors may occur.*
2. *Mineral Resources which are not Ore Reserves have no demonstrated economic viability.*
3. *Mineral Resources are inclusive of Ore Reserves (not indicated in the table).*
4. *Magnetite content (grade) is determined as the proportion of magnetite concentrate recovered using Davis Tube methodology.*
5. *Due to the magnetite grade being a recovered grade, differences will occur between whole rock V2O5 grades back-calculated from concentrate, versus those derived from whole rock assays.*
6. *Depleted as at 29 March 2019.*
7. *Reported on a Gross Basis. Bushveld Minerals shareholding in Vametco Alloys is 74 %.*

Table 7-10

Vametco Mineral Resource at a cut-off grade of 20 % magnetite, 29 March 2019 – Attributable Basis

Class	Seam Name	Tonnes (millions)	V_2O_5 grade of whole rock (%)	Magnetite grade of whole rock (%)	V_2O_5 grade of magnetite concentrate (%)	Tonnes V_2O_5 in magnetite concentrate (thousands)	Tonnes V in magnetite concentrate (thousands)
Indicated	Upper	4.2	1.44	65.9	1.78	49.6	27.8
	Intermediate	21.2	0.68	32.7	1.91	132.6	74.3
	Lower	81.0	0.72	32.4	2.03	532.6	298.3
	Total	**106.4**	**0.74**	**33.8**	**2.00**	**714.8**	**400.4**
Inferred	Upper	7.7	1.46	63.5	1.75	86.1	48.2
	Intermediate	5.2	0.67	32.1	1.92	32.1	18.0
	Lower	18.8	0.74	31.3	2.00	117.3	65.7
	Total	**31.7**	**0.90**	**39.3**	**1.92**	**235.4**	**131.9**
Indicated and Inferred	Upper	12.0	1.45	64.3	1.76	135.6	76.0
	Intermediate	26.4	0.67	32.6	1.91	164.7	92.3
	Lower	99.7	0.72	32.1	2.03	649.8	364.0
	Total	**138.1**	**0.78**	**35.0**	**1.98**	**950.2**	**532.3**

Notes:

1. *All tabulated data have been rounded and as a result minor computational errors may occur.*
2. *Mineral Resources which are not Ore Reserves have no demonstrated economic viability.*
3. *Mineral Resources are inclusive of Ore Reserves (not indicated in the table).*
4. *Magnetite content (grade) is determined as the proportion of magnetite concentrate recovered using Davis Tube methodology.*
5. *Due to the magnetite grade being a recovered grade, differences will occur between whole rock V2O5 grades back-calculated from concentrate, versus those derived from whole rock assays.*
6. *Depleted as at 29 March 2019.*
7. *Reported on a Gross Basis. Bushveld Minerals shareholding in Vametco Alloys is 74 %.*

7.10 Previous Estimates

7.10.1 VBKom 31 December 2015

VBKom completed an Independent Competent Persons Report (VBKom, 2016) and reported a Mineral Resource estimate in accordance with the 2007 edition of the SAMREC Code (as amended in 2009) as summarised in Table 7-11.

Table 7-11
Vametco Mineral Resource VBKom - effective date 31 December 2015

Class	Seam Name	Tonnes (millions)	Magnetite grade of whole rock (%)	V_2O_5 grade of magnetite concentrate (%)	V grade of magnetite concentrate (%)
Indicated	Upper	-	-	-	-
	Intermediate	0.37	28.30	3.02	1.69
	Lower	34.80	29.64	2.48	1.62
	Total	**35.17**	**29.63**	**2.49**	**1.62**
Inferred	Upper	8.45	23.56	0.71	0.59
	Intermediate	19.56	34.12	2.34	1.46
	Lower	75.43	29.09	2.02	1.50
	Total	**103.45**	**29.59**	**1.97**	**1.42**
Indicated and Inferred	Upper	8.45	23.56	0.71	0.59
	Intermediate	19.94	34.01	2.35	1.46
	Lower	110.23	29.26	2.17	1.54
	Total	**138.62**	**29.60**	**2.10**	**1.47**

Notes:

1. *Figures reported are based on 100 % of Mineral Resources*
2. *Reporting is prepared on an inclusive basis – Mineral Resources reported includes Ore Reserves*
3. *Mineral Resources tonnes and grades are reported on an in-situ dry basis*
4. *Reporting was prepared on block models developed by VBKom in 2016*
5. *Rounding of figures may cause computational discrepancies*

Source *VBKom (2016)*

MSA reviewed the VBKom Mineral Resource in 2017 and was not in agreement with the results. Issues found included:

- The V_2O_5 grade reported by VBKom for the Intermediate Seam is considerably higher than should be expected for this seam and is unrealistic.
- The V_2O_5 grade reported by VBKom for the Lower Seam Indicated Mineral Resource is considerably higher than should be expected for this seam and is unrealistic.
- Errors in the database were found, particularly regarding whole rock V_2O_5 and magnetite concentrate V_2O_5 grades where in many cases the values were in the incorrect column.
- MSA did not agree with the estimation parameters and found that searches were not aligned with the deposit layering.
- The conversion constant used to convert V_2O_5 was incorrect in the VBKom Mineral Resource table.

For the aforementioned reasons, MSA considered the VBKom estimate to be invalid and the Mineral Resource was re-estimated by MSA.

7.10.2 MSA, 06 October 2017

MSA completed an Independent Competent Persons Report (MSA, 2018) and reported a Mineral Resource estimate in accordance with the 2012 edition of the JORC Code as summarised in Table 7-12. MSA used the same drillholes as used by VBKom in 2015 after corrections to the database had been made by MSA.

Table 7-12
Vametco Mineral Resource MSA - effective date 06 October 2017

Class	Seam Name	Tonnes (millions)	Magnetite grade of whole rock (%)	V_2O_5 grade of magnetite concentrate (%)	V grade of magnetite concentrate (%)
Indicated	Upper	-	-	-	-
	Intermediate	-	-	-	-
	Lower	61.5	27.23	2.01	1.13
	Total	**61.5**	**27.23**	**2.01**	**1.13**
Inferred	Upper	11.8	37.86	1.70	0.95
	Intermediate	21.6	30.45	1.87	1.05
	Lower	47.4	29.75	1.99	1.11
	Total	**80.9**	**31.12**	**1.92**	**1.08**
Indicated and Inferred	Upper	11.8	37.86	1.70	0.95
	Intermediate	21.6	30.45	1.87	1.05
	Lower	108.9	28.33	2.00	1.12
	Total	**142.4**	**29.44**	**1.96**	**1.10**

Notes:

1. *All tabulated data has been rounded therefore minor computational errors may occur.*
2. *The Mineral Resources are total in-situ Mineral Resources for the Project.*
3. *Bushveld Mineral Limited attributable share @ 26.6 %.*
4. *Mineral Resources which are not Ore Reserves have no demonstrated economic viability.*
5. *Mineral Resources are inclusive of Ore Reserves.*

***Source**: MSA (2018)*

The overall tonnage of the 2017 Mineral Resource is similar to that of VBKom, however the grade estimates were different. The results were discussed with Vametco management who advised MSA that the grades in the MSA estimate were similar to those experienced during mining.

7.11 Comparison between MSA 2017 (06 October 2017) Mineral Resource estimate and the current estimate (29 March 2019)

In 2018, Bushveld Vametco completed a twelve-hole exploration programme aimed at converting Inferred Mineral Resources to Indicated by infill drilling. The additional drilling served to provide further verification of the historical drilling data upon which the previous Mineral Resource estimates were based. The geological modelling process was refined and the Upper Seam was now modelled as a massive magnetite layer. A comparison of the MSA 2017 and 2019 Mineral Resource estimates is summarised in Table 7-13.

Table 7-13
Comparison between MSA 2017 and MSA 2019 Mineral Resource estimates for Vametco

		MSA 2017			MSA 2019		
Class	**Seam Name**	**Tonnes (millions)**	**Magnetite grade of whole rock (%)**	**V_2O_5 grade of magnetite concentrate (%)**	**Tonnes (millions)**	**Magnetite grade of whole rock (%)**	**V_2O_5 grade of magnetite concentrate (%)**
Indicated	Upper	-	-	-	5.7	65.9	1.78
	Intermediate	-	-	-	28.7	32.7	1.91
	Lower	61.5	27.2	2.01	109.4	32.4	2.03
	Total	**61.5**	**27.2**	**2.01**	**143.8**	**33.8**	**2.00**
Inferred	Upper	11.8	37.9	1.70	10.5	63.5	1.75
	Intermediate	21.6	30.5	1.87	7.0	32.1	1.92
	Lower	47.4	29.8	1.99	25.4	31.3	2.00
	Total	**80.9**	**31.1**	**1.92**	**42.9**	**39.3**	**1.92**
Indicated and Inferred	Upper	11.8	37.9	1.70	16.2	64.3	1.76
	Intermediate	21.6	30.5	1.87	35.7	32.6	1.91
	Lower	108.9	28.33	2.00	134.8	32.1	2.03
	Total	**142.4**	**29.4**	**1.96**	**186.7**	**35.0**	**1.98**

Notes:

1. *All tabulated data has been rounded therefore minor computational errors may occur.*
2. *The Mineral Resources are total in-situ Mineral Resources for the Project.*

Notable differences between the 2017 and 2019 estimates include:

- Tonnages are significantly higher. The 2018 drilling programme allowed for additional Mineral Resources to be reported for the project, particularly for the Upper and Intermediate Seams that were previously less well drilled than the Lower Seam. Most of the additional tonnage is due to the extension of the Mineral Resource from 120 m below the original surface to 150 m below the original surface. This was the result of recent pit optimisation that demonstrated that the Mineral Resources would have reasonable prospects for eventual economic extraction at these depths at current vanadium prices.
- The Upper Seam Mineral Resource has a considerably higher magnetite grade. The higher grade is the result of closer definition of the magnetite seam towards the massive magnetite layer (US-01).
- The Intermediate Seam and Lower Seam Mineral Resources are of higher grade. This is due to better definition of the seam boundaries and the application of a cut-off grade of 20 % magnetite. Previously the total tonnage and grade within the seam was reported.

Changes to the Mineral Resource estimate are to be expected given the changes in the drilling data:

- in 2018, many of the historical holes had not been used in the Mineral Resource Estimation as the data was not complete - either geology logs or assay data was missing;
- the UI holes up to and including UI25 (UI02, UI05 to UI10, UI13 to UI17, UI19 to UI21 and UI23 to UI25) and KR9 were excluded;
- in 2019, most of the holes excluded in the 2018 Mineral Resource were verified and added;
- in 2019, some data were excluded:
    - the KO holes up to and including KO1 to KO3;
    - the UO holes up to and including UO1 to UO13; and
- in 2019, the 2018 drilling was added:
    - the VM holes up to and including VM001 to VM013.

A re-coding exercise was undertaken by MSA for the 2019 Mineral Resource which included each hole and was conducted in collaboration with the Bushveld Vametco Exploration Manager. The magnetite grade of 20 % was more strictly adhered to for defining the limits of the magnetite-rich seams than in previous estimates and the geology seam logging was used as a guide rather than a hard boundary in 2018.

The density applied in 2017 was a constant of 3.3 t/m^3 as no density data were available. Density measurements were taken for the 2018 drillholes and a regression was applied to the historical data to derive a density for each block based on the magnetite content. As a result, the tonnage estimates were refined and a positive relationship between grade and density resulted in a slight increase in grade.

7.12 Assessment of Reporting Criteria

Criteria for assessing this Mineral Resource estimate are presented in Appendix 3, which references the relevant aspects of Table 1 of the JORC Code (2012) to the pertinent sections in this report.

8 TECHNICAL STUDIES

The Vametco Mine is an integrated mining and processing operation comprising an open pit, processing plant and supporting infrastructure.

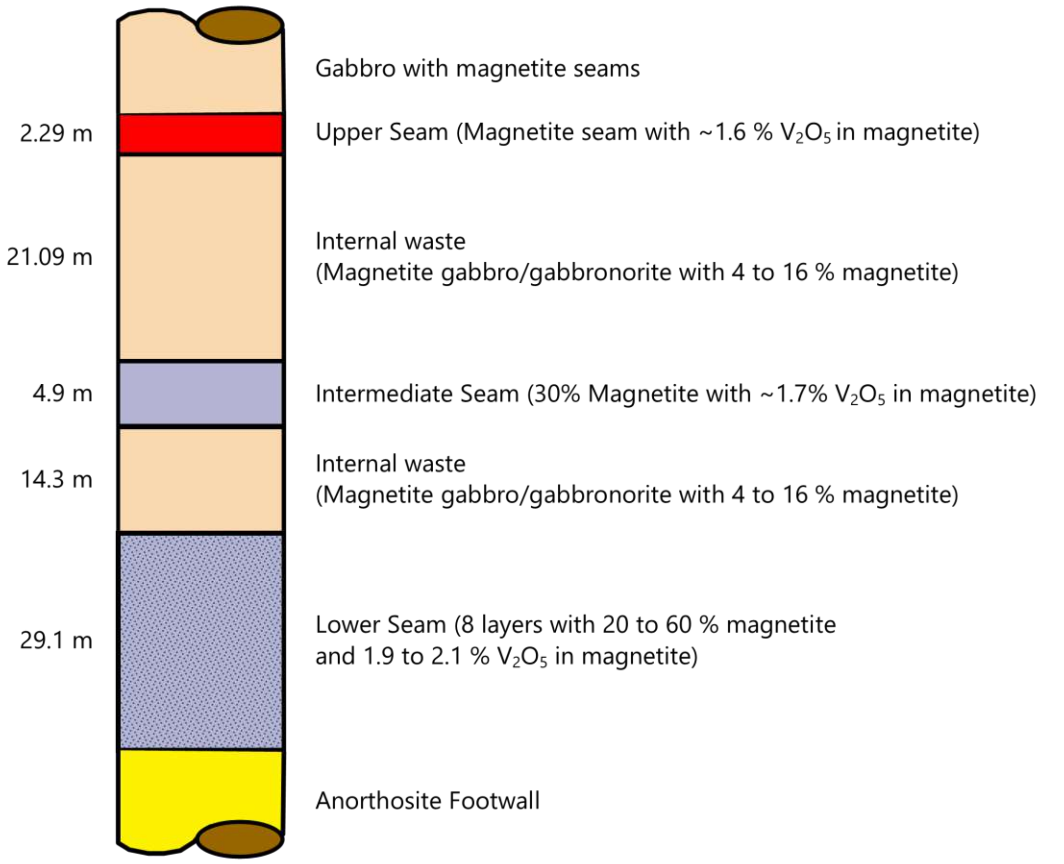
Mining commenced at the current site in 1967.

8.1 Geotechnical

The opencast operations of Bushveld Vametco are located on the southern portion of the western limb of the Bushveld Complex close the town of Brits. The Main Magnetite layer extends from north of Pretoria westwards towards Rustenburg. The southern half of the area is underlain by the Pyramid Gabbro-norite and the northern half by the Bierkraal Magnetite Gabbro. Locally within the gabbro-norite, anorthosite bands are also present. Well-developed magnetite bodies are present in the magnetite Gabbro. The magnetite bodies are the target horizon at Vametco Alloys for their vanadium content.

Linear intrusions in the form of diabase sills and dykes are present, with the remainder of the geological formations having a shallow dip in a northerly direction. A typical stratigraphic column of the host rock and deposit is shown in Figure 8-1. The main ore body mined is the Lower Seam ("LS") 1-8, with an average vertical thickness of approximately 33 m. Due to the relatively thin internal waste portions between the Intermediate and Upper seams these two ore bodies are mined as blended ore as they are mined as part of the waste stripping needed to expose the Lower Seam.

Figure 8-1
Lithostratigraphic column at the Vametco Mine



Source: *Modified from JMA (2015)*

8.1.1 Mine-scale Structures

Jointing is the most persistent structural weakness encountered at the Vametco Mine (Figure 8-2 and Figure 8-3). The number of joint sets varies but generally at least three sets are encountered.

The dominant major fault trend is northeast-southwest. The faults tend to be steeply dipping with throws varying between 3 m and 6 m. Mining has stopped in certain sections due to major faults. Most major dykes are 5 m to 40 m wide and composed of dolerite. As with the dominant fault direction, the dykes tend to strike mainly northwest-southeast.

The RLS has also been intruded by east-west striking dykes of Karoo age, some of which are associated with small faults with limited displacements. These dykes have thicknesses <10 m. Generally, the dykes are competent but intensive jointing is sometimes associated with the dyke/reef interfaces.

A pothole may be described as a circular or elliptical area in which a portion of the footwall succession of the seam is absent resulting in the seam and its hanging wall slumping into the void created. Steeper seam dips can be expected over potholes.

Figure 8-2

Typical transitional blocky conditions, Vametco

Figure 8-3

Blocky magnetite seam conditions, Vametco

8.1.2 Rock Mass Conditions

Host rock uniaxial compressive strengths are typically 140 MPa and the magnetite seams 250 MPa. Rock mass ratings are similar for all horizons with values of 45 in disturbed rock masses and 65 in undisturbed rock masses (Table 8-1).

Table 8-1
Geomechanical characteristics of the host rock and deposit

	Anorthosite						Magnetite					
	Undisturbed			Disturbed (blasted)			Undisturbed			Disturbed (blasted)		
RMR	65			45			65			45		
UCS	140 MPa			140 MPa			250 MPa			250 MPa		
mi	15			15			15			15		
D	0	0.7	1	0	0.7	1	0	0.7	1	0	0.7	1
Cohesion	3.2	2.1	1.6	1.4	0.8	0.6	5.2	3.3	2.5	2.0	1.1	0.8
Friction	56	53	49	55	47	40	58	55	52	58	51	44
Tension	0.7	0.4	0.3	0.1	0.1	0.05	1.2	0.7	0.6	0.3	0.1	0.09
Density	2.8	2.8	2.8	2.8	2.8	2.8	3.3	3.3	3.3	3.3	3.3	3.3

Note: *Cohesion and tensile strength are in MPa, friction angle is in degrees. All are estimated from a best fit straight line to the Hoek-Brown curve over a range in minor principal stress from zero to 2 MPa, which is the expected range in confinement down to 100 m pit depth.*

8.1.3 Stability Analysis

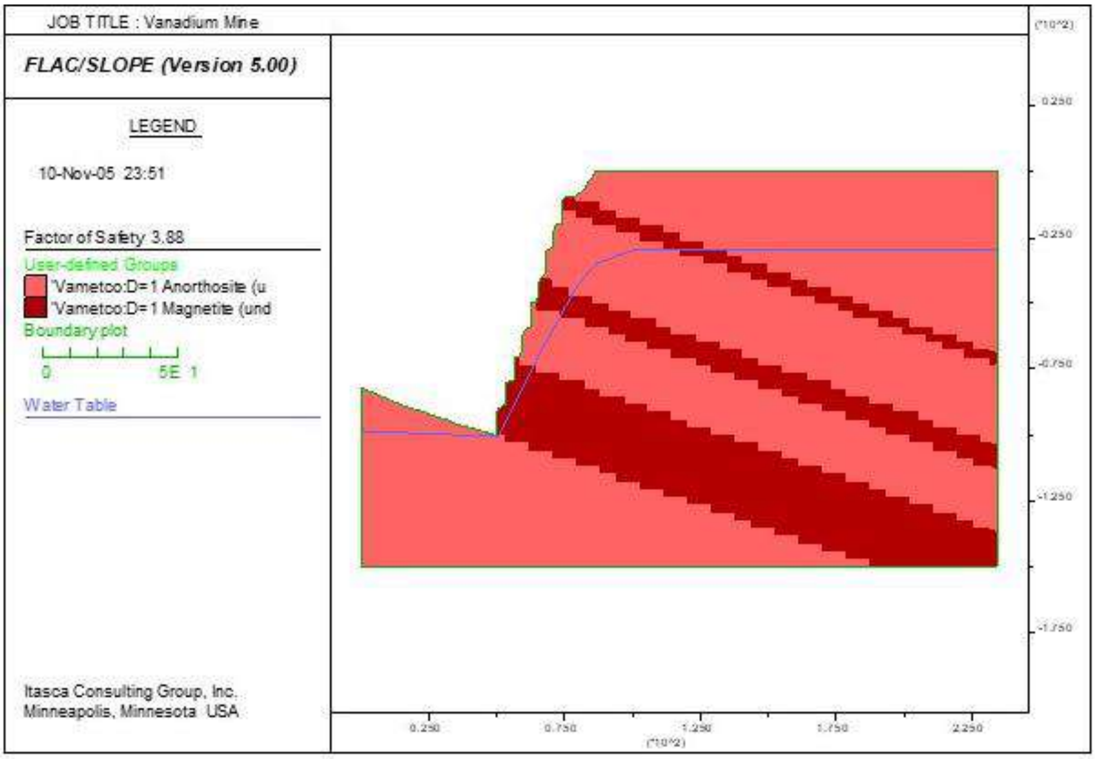
There are two scales of slope analysis:

- overall slope scale - where the objective is to identify any limiting slope angle; and
- individual bench scale - where the objective is to identify limiting batter angles for the face of the bench.

Both cases have been analysed using FLAC-slope. This program is a two-dimensional finite difference code, which represents the rock mass as a continuum assemblage of zones. Failure mechanisms assessed include deep-seated rotational failures, shear through the rock mass, and large-scale tensional failure. Aspects such as localised wedge failure, or joint-bound toppling failures are not represented, as joints or other discontinuities are not explicitly represented. For long-term slope stability, slopes are often designed with a factor of safety of either 1.2 or 1.5. FLAC-Slope calculates factors of safety by testing a series of runs for each model, where the rock properties are progressively reduced until slope instability is induced. Instability is indicated by sustained velocity of movement in a region of the slope – i.e. static equilibrium is not maintained. The ratio between the set of properties required to induce failure and the defined set of properties (Table 8-1), provides the factor of safety in the model. A model was set up to represent slopes associated with pits of both 60 m and 100 m depth. The typical geometry is shown in Figure 8-4.

Figure 8-4

Example of model geometry, showing 100 m deep pit slope, layers corresponding to anorthosite and magnetite seams, and the assumed water table position



Summaries of the worst-case factors of safety, with D=1 (from Table 8-1), for both undisturbed, and disturbed (blasted) rock masses are listed in Table 8-2. In all cases factors of safety exceed 1.5, although in the case of a 100 m high slope, with an extensively disturbed rock mass (GSI = 45), this criterion is only just exceeded. However, as noted above, a general GSI of 45 is considered unlikely and is really only expected to be limited to bench faces, not deep in the rock mass. Based on this, the models tend to indicate that an overall slope angle of 70 degrees (based on limiting bench heights of 10 m and bench widths of 3 m) is safe for pits down to 100 m depth in this rock mass. This is slightly steeper than implied by the Haines-Terbrugge chart in Figure 8-5.

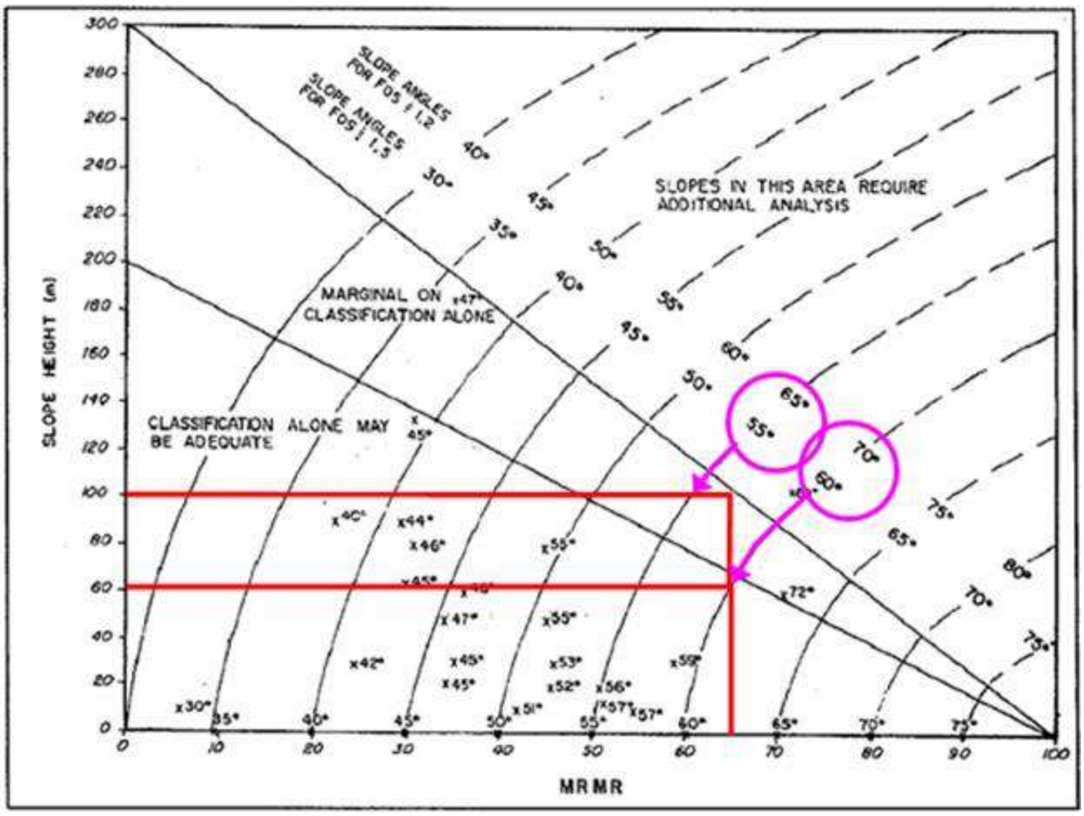
Table 8-2

Examples of factors of safety derived in overall slope models

Model example	Factor of Safety ("FOS")
100 m slope, 70 degrees, undisturbed rockmass, D=1	3.88
100 m slope, 70 degrees, disturbed (blasted) rockmass, D=0.7	2.08
100 m slope, 70 degrees, disturbed (blasted) rockmass, D=1	1.54
60 m slope, 70 degrees, undisturbed rockmass, D=1	6.56
60 m slope, 70 degrees, disturbed (blasted) rockmass, D=1	2.44

The FOS calculated from the numerical models for batter angles ranging from 900 to 400 were assessed against the thickness of softs for varying soil types. The analysis enabled the appropriate soft overburden batter angle to be selected for the Vametco Mine for a firm-silt clay soil, which, based on observations is the likely overburden soil type. A 50-degree batter angle is recommended for soft overburden material.

Figure 8-5
Empirical slope design chart



Source: *Chart developed by Haines and Terbrugge (1991)*

8.1.4 Suggested Slope Angles

Stack angles for weathered and fresh material are 37.80 and 54.32 degrees, respectively (Table 8-3). The overall slope angle should be planned at 56.95 degrees, which includes catch benches.

Table 8-3
Slope angles suggested for Vametco

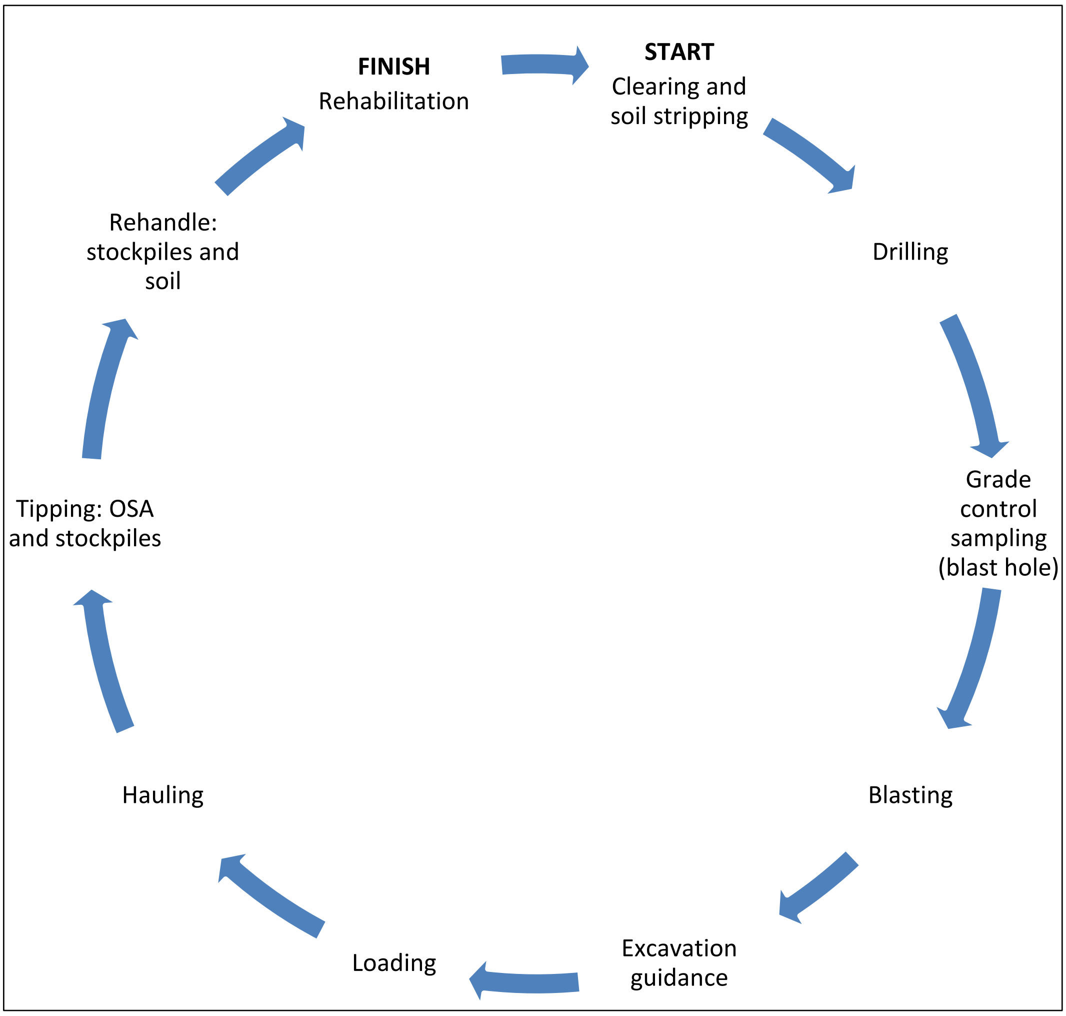
Material type	Bench heights (m)	Berm widths (m)	Stack height (m)	Bench face angle (°)	Stack angle (°)	Maximum depth (m)	Overall slope angle (°)	Comments
Weathered	10	4.5	10	50	37.80	10	60.72	No catch benches
Fresh	10	4.5	90	75	54.32	60		
Catch bench (every 5th bench)	10	9	40	75	54.32	100	56.95	With a single catch bench

8.2 Mine Design

8.2.1 Mining Cycle

The current mining cycle for the Project is conventional drill, blast, load and haul with the opportunity of free-dig in some areas of weathered material. Figure 8-6 summarises the current mining cycle.

Figure 8-6
Vametco Mine mining cycle



Prior to mining in a particular area, all vegetation cover and useable soil is removed and placed on a separate soil stockpile. Waste rock and ore are blasted at irregular intervals and removed to waste rock dumps or the primary crusher, respectively. Material is loaded onto 20- or 40-tonne haul trucks using hydraulic shovels and front-end loaders. The mining is not a constraint and there is potential to increase the ore production in excess of 2.6 Mtpa (if required) based on the strike length, dip and orientation of the orebody. Due to the stratified nature of the ore deposit, Bushveld Vametco uses a combination of strip mining and open pit mining. For current mining activities, the potential for concurrent backfilling is being investigated in order to determine the most effective method/sequence. The most practical solution is to backfill the areas where the pit has been mined to the final high-wall and for this reason the western portion of the pit near the graveyard is amenable to be backfilled first (if an agreement to move the graveyard at some point in the future cannot be reached).

Figure 8-7 shows a schematic of the mining method. The open pit mining approach can be typified as bench mining where faces are opened up in one area through overburden and waste stripping. The exposed ore is mined and transported to the plant by a fleet of trucks and shovels. A pit optimisation study (described in section 8.2.5) was done to generate different pit shells in order to identify the pit shell which should render the optimal value based on practical technical constraints over the Life of Mine ("LOM").

8.2.2 Mining Equipment

Vametco uses a series of contractors to perform the mining. There are currently four contractors operating at Vametco:

- McKenzie Plant Hire (load and hall);
- ALS Plant Hire (load and haul);
- Mabunda Drilling Contractor; and
- BME explosive and blasting contractor.

In addition, Bushveld do some excavator loading of the ore.

Based on observations made during the site visit to Vametco Mine (28 May 2019), the mining fleet appears to be relatively well maintained and sufficient to cater for the production targets in the long-term plan. The main primary and auxiliary fleet comprises the following:

- 9x B40 Bell articulated dump trucks ("ADTs");
- 3x B45 Bell ADTs;
- 3x CAT 730 ADTs;
- 1x B30 Bell ADT;
- 3x 40t PC 400 Komatsu excavators;
- 3x drill rigs;
- 2x dozers (CAT D9 and D8);
- 1x grader; and
- 2x water trucks.

8.2.3 Methodology

A mining model prepared by regularising the Mineral Resource model using Datamine. The mining model was imported into GEOVIA's Whittle Four-X™ ("Whittle"). Whittle uses the Lerch-Grossman algorithm to produce a number of incremental pit shells (nested) based on varying the input price. These nested pit shells are used in selecting the "optimum" pit shell, guiding the location of pushbacks/stages and determining Mineral Resource envelopes.

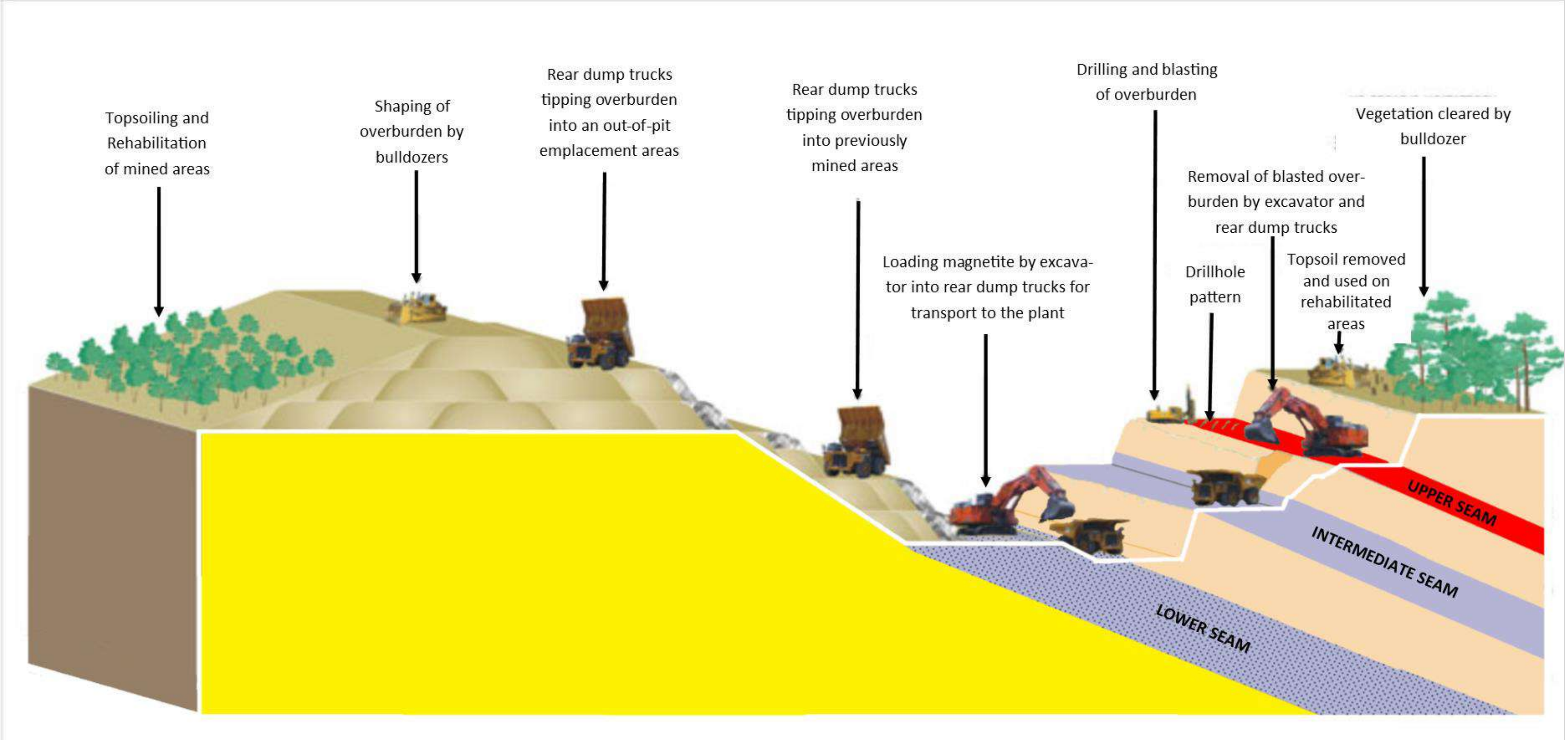
8.2.4 Mining Model

The Mineral Resource model used was named "vamregm – 04-05-2019". The following processes were applied to the Mineral Resource models to derive the mining models:

The dilution and mining losses was applied based on re-blocking the Mineral Resource model to 10 mX x 10 mY x 5 mZ which was considered the Smallest Mining Unit ("SMU"). This SMU block size was determined after consideration of the size of the excavator bucket and expanded to mimic the mixing associated with blasting and loading.

Mining, processing and product cost and pricing estimates were coded into the model.

Figure 8-7
Mining method schematic



Source: *Modified from Glencore (2019)*

8.2.5 Pit optimisation

8.2.5.1 Mineral Resource classification

Only Indicated Mineral Resources (Section 7.9) were used in the base case pit optimisation. There are no Measured Mineral Resources in the Mineral Resource Statement.

For the pit optimisation, in order to focus the pit design on the Lower Seam ("LS"), the Intermediate Seam ("IS") and Upper Seam ("US") were treated as waste for this exercise only. The final pit design includes all the seams as ore which were reported in the Ore Reserve Statement.

8.2.5.2 Boundaries

An exclusion area for the local graveyard was coded into the model with an additional surrounding 100 m boundary pillar to protect this heritage area.

8.2.5.3 Geotechnical Constraints

Table 8-4 summarises the slope angles used in the pit optimisation.

Table 8-4
Pit Optimisation Slope Angles

Material Type	Overall slope (°)
Weathered	37.80
Fresh	56.95

8.2.5.4 Dilution and mining recovery

Based on the size and selectivity of the proposed mining equipment sizes the Mineral Resource model was modified by re-blocking to 10 mX x 10 mY x 5 mZ. The blocks incurred dilution and mining loss to the Upper, Intermediate and Lower seams; no additional unplanned losses were included.

8.2.5.5 Processing Rate

A build up to a process feed rate of 1.5 Mpta of RoM to the plant was used by MSA. There is potential to increase the RoM feed rate to the milling circuit. The key constraint in the process plant is the feed rate through the kiln. Vametco are investigating the potential to increase the kiln feed rate. Until this work (to Pre-feasibility or Feasibility levels of confidence) has been proven and completed, MSA have the view that the current plant is able to build up to approximately 3,400 mtV p.a. of Nitrovan^{TM} per annum. From observations made and discussions held during the site visit (28 May 2019), the plant and kiln were being restricted by the excessive SiO_2 in the Lower Seam ("LS") ore. In order to mitigate this, Intermediate Seam ("IS") ore which has a lower SiO_2 content has been used in the production schedule to blend with the LS ore to reduce the SiO_2 and improve the plant throughput. The SiO_2 in the IS <2.6 %, whilst the SiO_2 in the LS is >2.8 %.

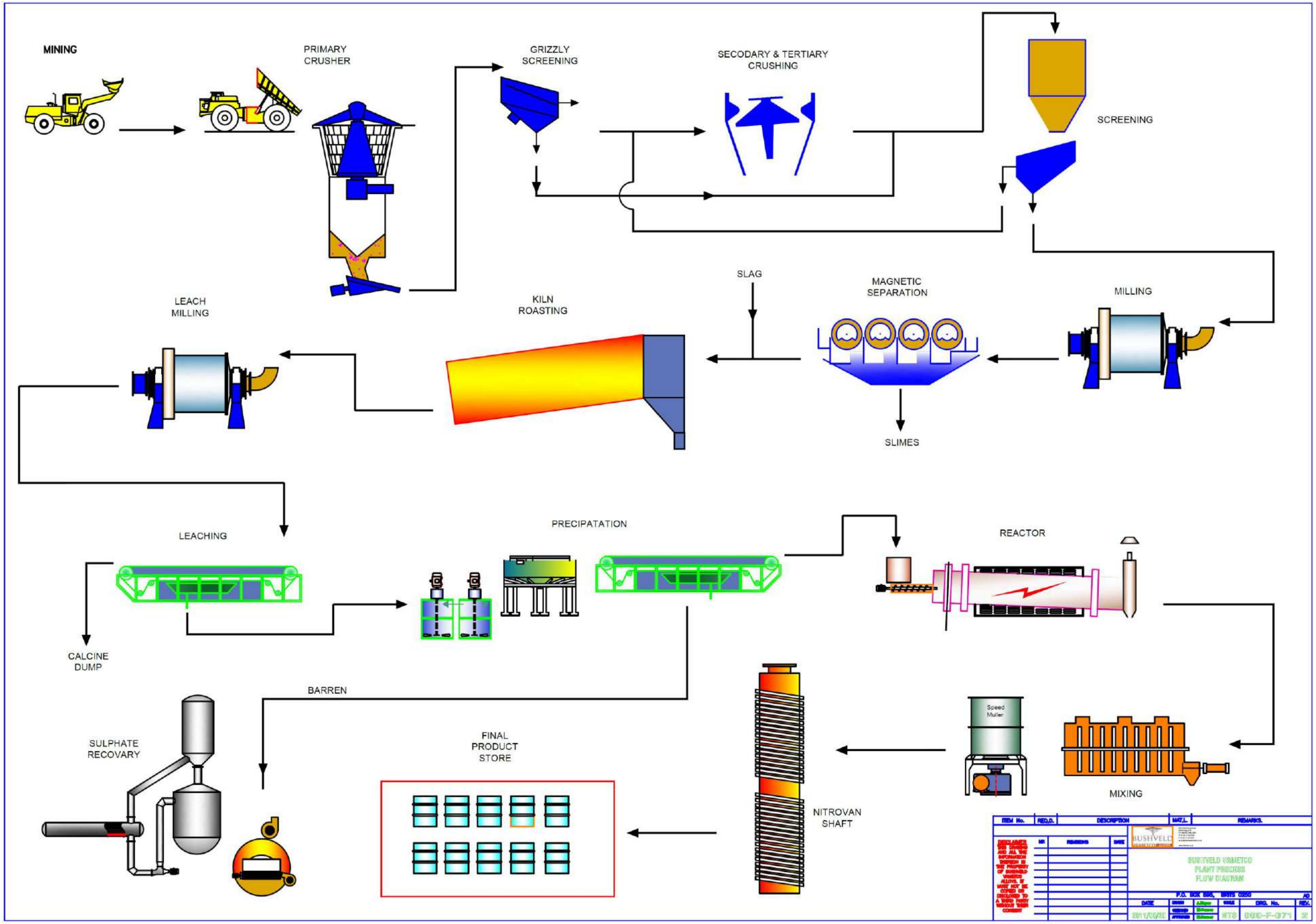
8.2.5.6 Processing recovery

The Vametco beneficiation process involves the following sequential sections as shown in Figure 8-8 which is described in more detail in Section 8.3:

- crushing
- milling and concentrator
- roasting
- leach
- precipitation and production of Modified Vanadium Oxide ("MVO")
- Nitrovan^{TM} furnaces

An overall processing recovery of 71 % was used for the pit optimisation process based on the 2019 budget parameters.

Figure 8-8
Overview of the Vametco Mine beneficiation process



Source: *Vametco (2019)*

8.2.5.7 *Whittle input parameters*

The cost and revenue input parameters tabulated in Table 8-5 were obtained from the Vametco 2019 budget and used for the whittle pit optimisation process to derive the optimal pit shell.

The mining drill and blast, load and haul costs are based on current mining contract rates for waste and ore. The mining fixed costs include Owner and environmental rehabilitation costs. The total processing costs is calculated from the Vametco 2019 budget based on RoM feed.

The selling costs include the transportation and distribution of the Nitrovan™ concentrate and sales commissions (royalty costs).

The G&A (General and Administration) and social costs include all the corporate and consulting costs and social expenses for trainees and medical expenses.

The 2019 budget utilised a vanadium selling price of 37.5 US$/kg V and an exchange rate of ZAR 14 per US$ for the pit optimisation and long-term planning. A nominal discount rate of 10 per cent was used for valuation purposes.

Table 8-5
Pit Optimisation Parameters

Parameter	Unit	Value
Drill and blast cost	ZAR/t mined	5.90
Load and haul costs	ZAR/t mined	19.73
Mining fixed costs	ZAR/t mined	8.40
Processing costs	ZAR/t processed	443.4
Selling cost (including royalty)	ZAR/t V (Nitrovan™) sold	60,290
Leases, Insurance	ZAR million p.a fixed	23.33
G&A and Social	ZAR/t processed	94.5
Selling Price	US$/kg V	37.50
Exchange Rate	ZAR/US$	14.0
Selling Price	ZAR/ t V	525 000
Overall processing recovery (crushing to final product)	%	71.0
Discount rate	%	10

8.2.5.8 *Capital costs and taxation*

Except for mining mobile equipment and mining facilities, which were applied as an operating cost, no capital costs or taxation costs were included for the pit optimisation process.

8.2.5.9 *Cut-off grades*

Vanadium-bearing rock is classified as mineralised material. There are three main seams in which the mineralised material is present:

- Upper Seam ("US");
- Intermediate Seam ("IS"); and

- Lower Seam ("LS").

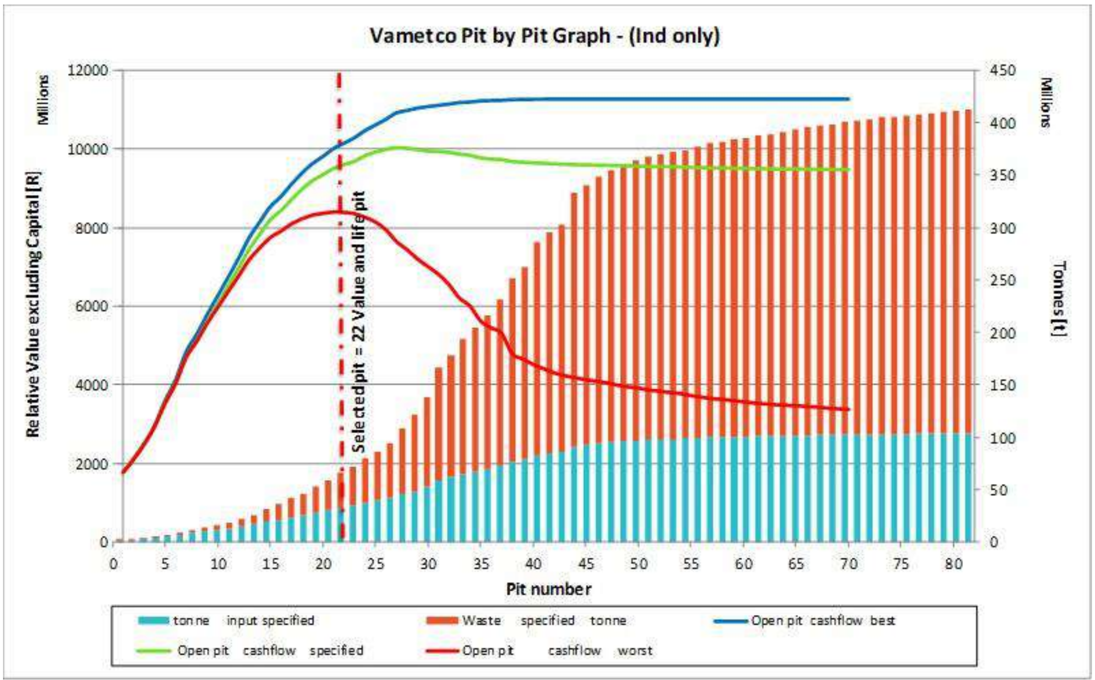
All the mineralised material is treated on site and classified as ore (traditionally the IS and LS have been the main focus of exploitation at the Vametco mine). No prescribed cut-off grades were used in the pit optimisation. Whittle was used to formulate the optimal pit shell using the pit optimisation parameters described in Table 8-5.

8.2.5.10 Base results

The Whittle pit optimisation output is shown in Figure 8-9. The pit shell 22 (revenue factor = 0.71) was chosen for the pit design for the following reasons:

- average pit depth to be kept less than 100 m pending additional geotechnical work;
- the pit achieves 96 % of the maximum net present value ("NPV") with a minimal waste to ore strip ratio;
- waste stripping aligned with the Vametco partial backfilling strategy approved by the DMR; and
- Pit 22 has approximately 40 Mt of LS ore material compared with Pit 80 which has 104 Mt of LS ore material at a significantly higher strip ratio. The Indicated Mineral Resource tonnes for LS ore is estimated as 109 Mt in the Mineral Resource statement (Section 7.9) which was estimated to a depth of 150m below surface. This highlights the optionality to deepen the Vametco open pit at a higher vanadium price.

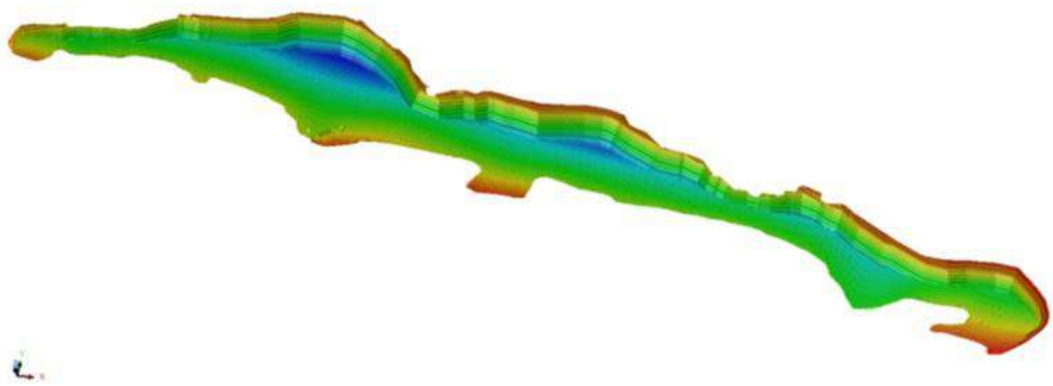
Figure 8-9
Whittle Pit optimisation output



8.2.6 Pit design

Using the pit 22 shell from the whittle pit optimisation, the pit design shown in Figure 8-10 was formulated using the geotechnical parameters in Section 8.1.4. The bench heights were set at 10 m aligned with the current design. A 9 m catch bench was added on the 5th bench and the average pit depth was kept within the 100 m geotechnical guideline.

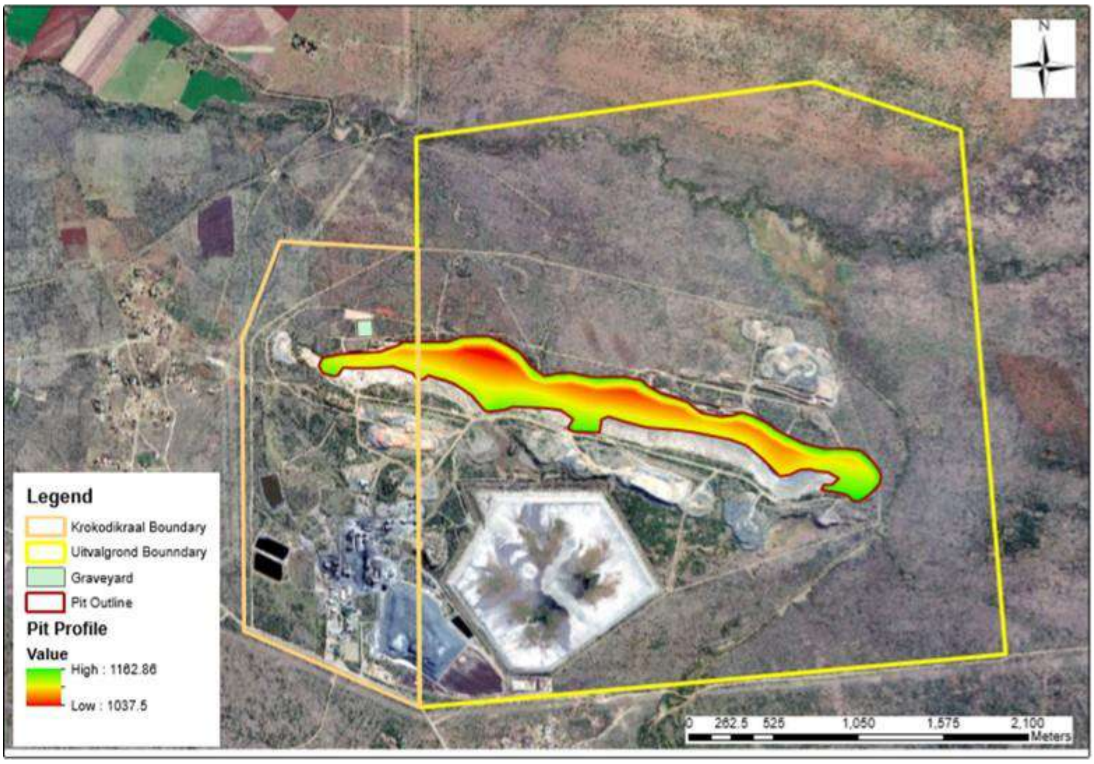
Figure 8-10
Schematic of the Vametco Mine pit design



The final pit design superimposed on the current mine layout including licence boundaries is shown in Figure 8-11. The key points are as follows:

- there is potential to deepen the pit to the North within the Uitvalgrond licence boundary pending additional geotechnical work and improved vanadium pricing; and
- the position of the graveyard affects the deepening of the pit on Krokodilkraal.

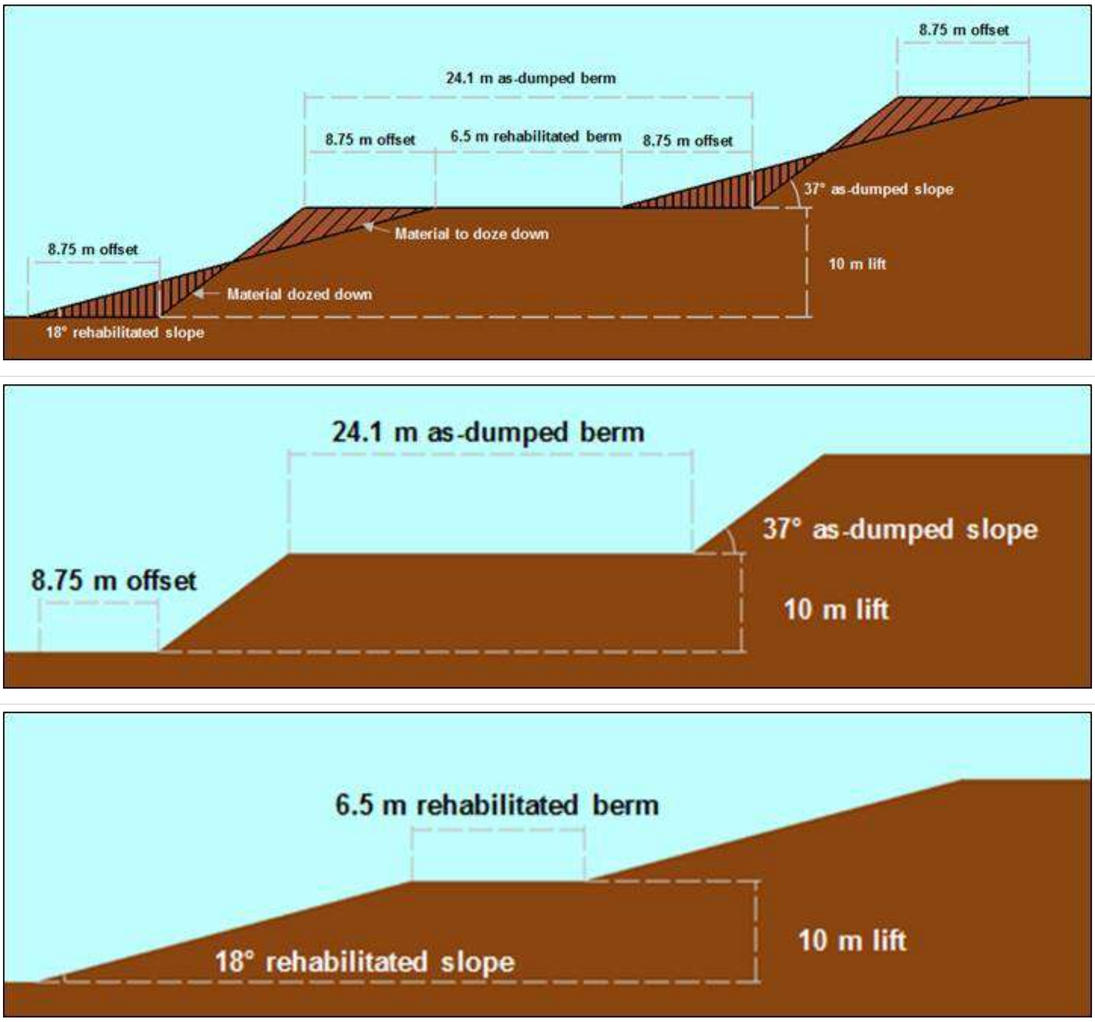
Figure 8-11
Schematic of the Vametco Mine pit design superimposed on mine layout



8.2.7 Waste Rock Designs

The following design criteria guidelines shown in Figure 8-12 (not to scale) was used for the waste rock dump designs assuming a compacted swell of 25 %. The overall final slope angle from the mine design was approximately 16 degrees with an average height of 50 m.

Figure 8-12
Waste rock profile



8.2.8 Haul roads

Temporary haul roads were used for the current pit design. The haul ramp and road design parameters are based on the largest equipment size which is the 45 t Bell trucks currently used on site, with running width allowances of 3.5 times the vehicle width for dual lane ramps and 2.0 times the vehicle width for single lane ramps. If a different equipment size is used, then these parameters will need to be adjusted and modifications made to all designs.

8.2.9 Bunds

Pit perimeter bunds will be constructed around the open pit and are intended to prevent inadvertent access to the pit crest. They will be set back from the pit crest 10 m to allow any pit crest cracks to be observed. These can be constructed from any waste material and should be of sufficient height and width to prevent entry with a light vehicle.

8.2.10 Water Management

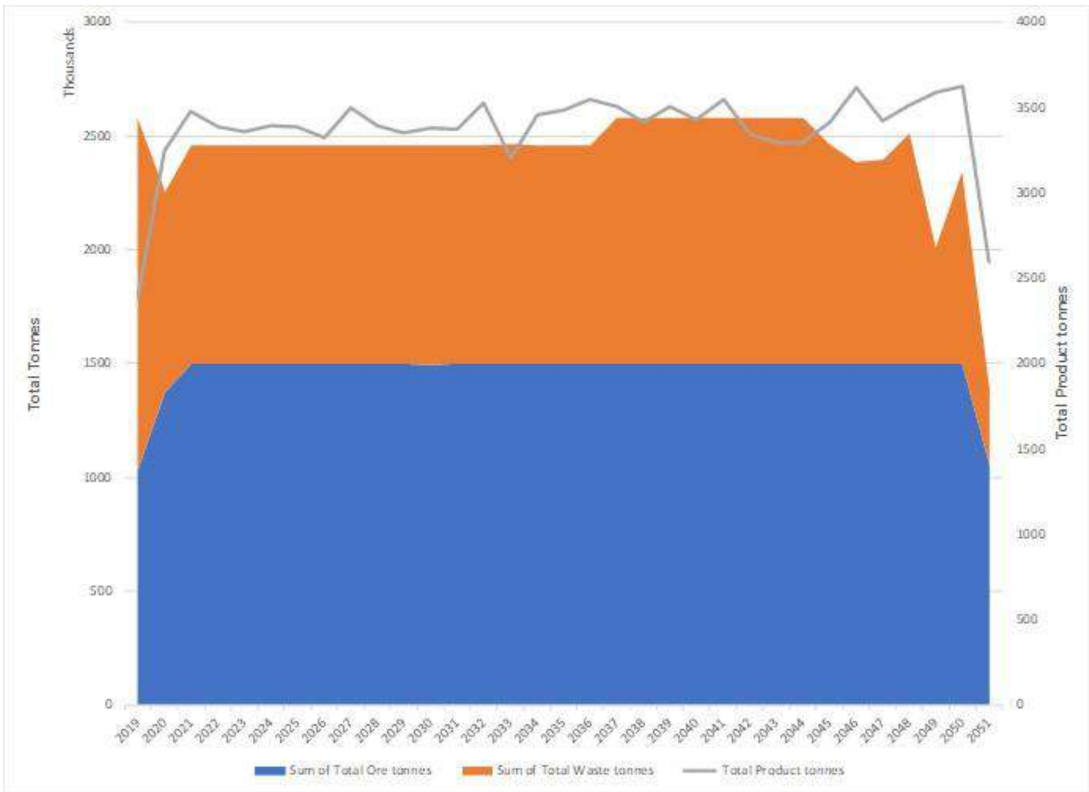
Settling ponds should be constructed at regular intervals (~300 m) along haul roads and Waste Rock Dump edges to collect run-off.

Water is sprayed on haul roads as required for dust suppression. A dust suppression additive should be considered to reduce water usage for dust suppression.

8.2.11 Production Schedule

From the site visit it was understood that mining is not a constraint and that the key constraint to the annual production of Nitrovan™ is the processing plant and in particular the kiln production. MSA have the view that the current plant is able to build up to approximately 3,400 mtV p.a. of Nitrovan™ per annum. The mine production schedule was done using the XPAC mine planning and scheduling software based on the Surpac design. Figure 8-13 is the output of the production and product profile underpinning the Ore Reserves.

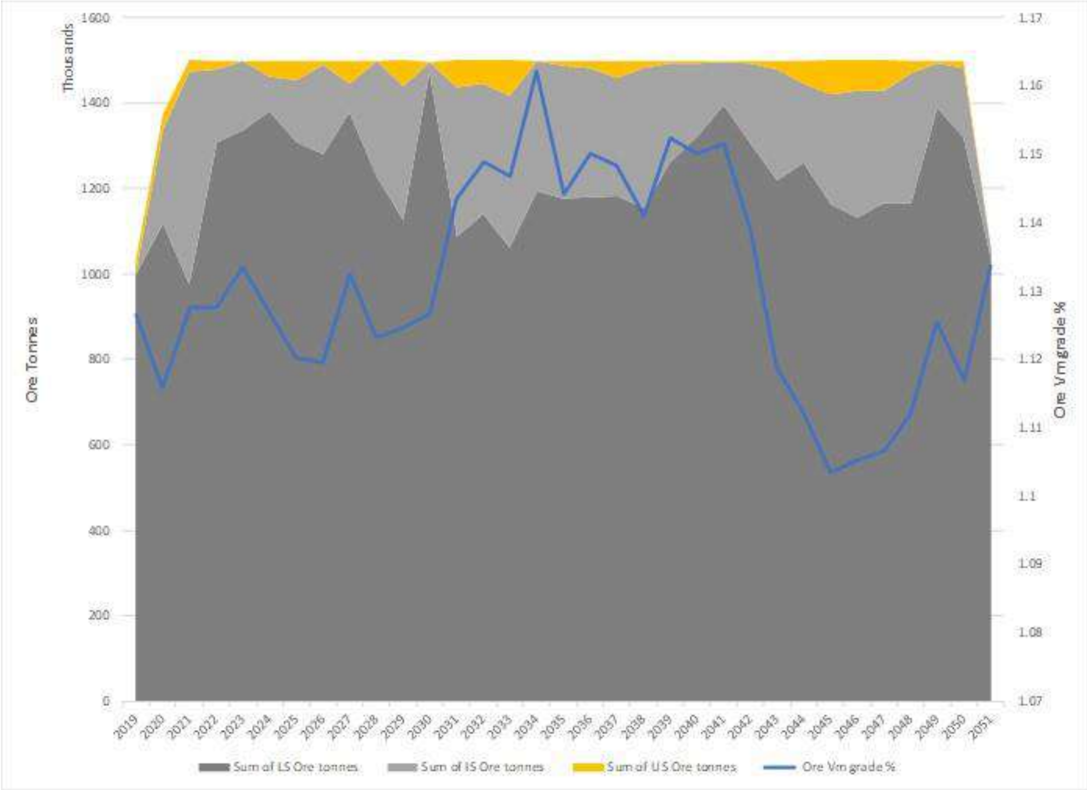
Figure 8-13
Vametco Mine life of mine production and product profile



The main production is from the LS which is >30 m thick compared with the IS which is <10 m and the US which is <2 m. The LS has higher vanadium content compared to the US and IS tonnes and is the main focus of the production as shown in Figure 8-14. The IS and US are important for blending purposes being lower in SiO_2 compared to the LS and therefore important for increased processing throughput.

Figure 8-14

Vametco Mine life of mine ore and vanadium grade



The magnetite grades are relatively consistent throughout the life of mine plan ranging between 28 % and 29 % magnetite (Figure 8-15).

The agreement with the DMR is to partially backfill the waste into the pit. The most practical solution is to backfill the areas where the pit has been mined to the final high-wall. For this reason, the western portion of the pit near the graveyard has been backfilled first to comply with the partial backfill scenario. Approximately 30 % of the waste produced will be backfilled into the pit based on this production schedule as shown in Figure 8-16.

Figure 8-15

Vametco Mine life of mine ore and magnetite grade

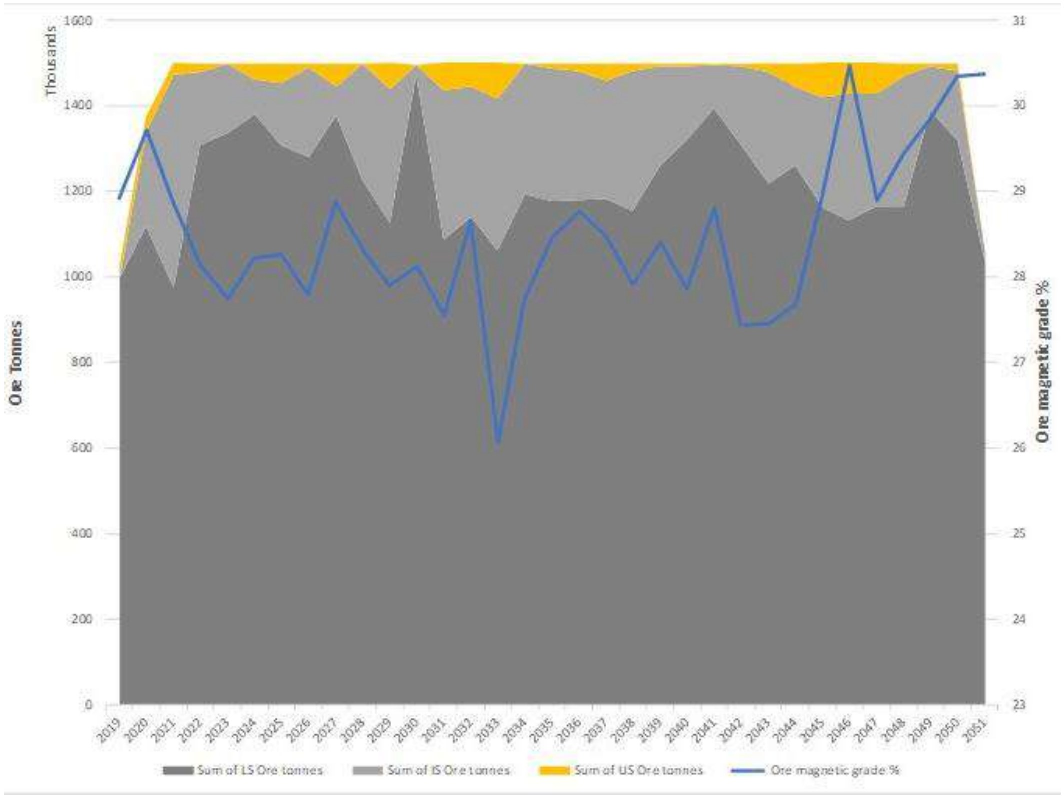
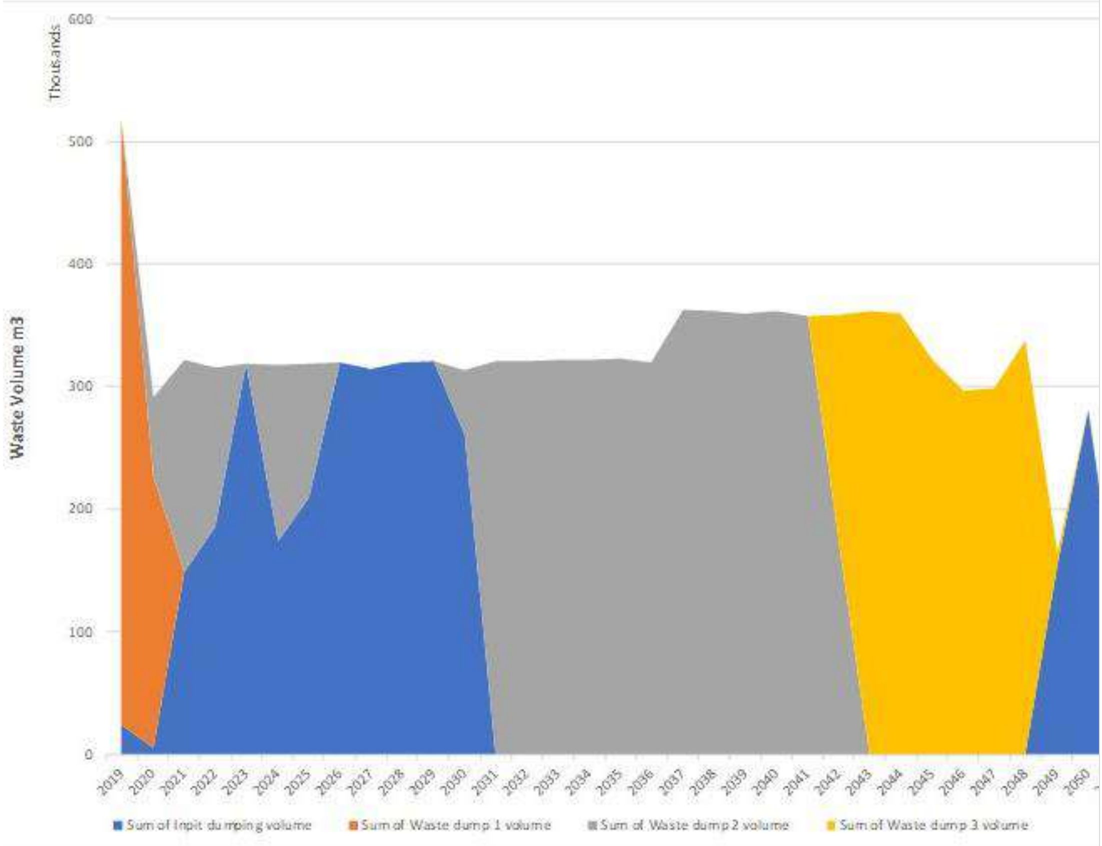


Figure 8-16
Vametco Mine waste dump schedule and pit backfilling



8.3 Metallurgical (Processing / Recovery)

The Vametco Mine processing plant receives ore from the co-located open pit mine. The metallurgical process is well-tested in a steady state ongoing operation. No metallurgical testwork is required.

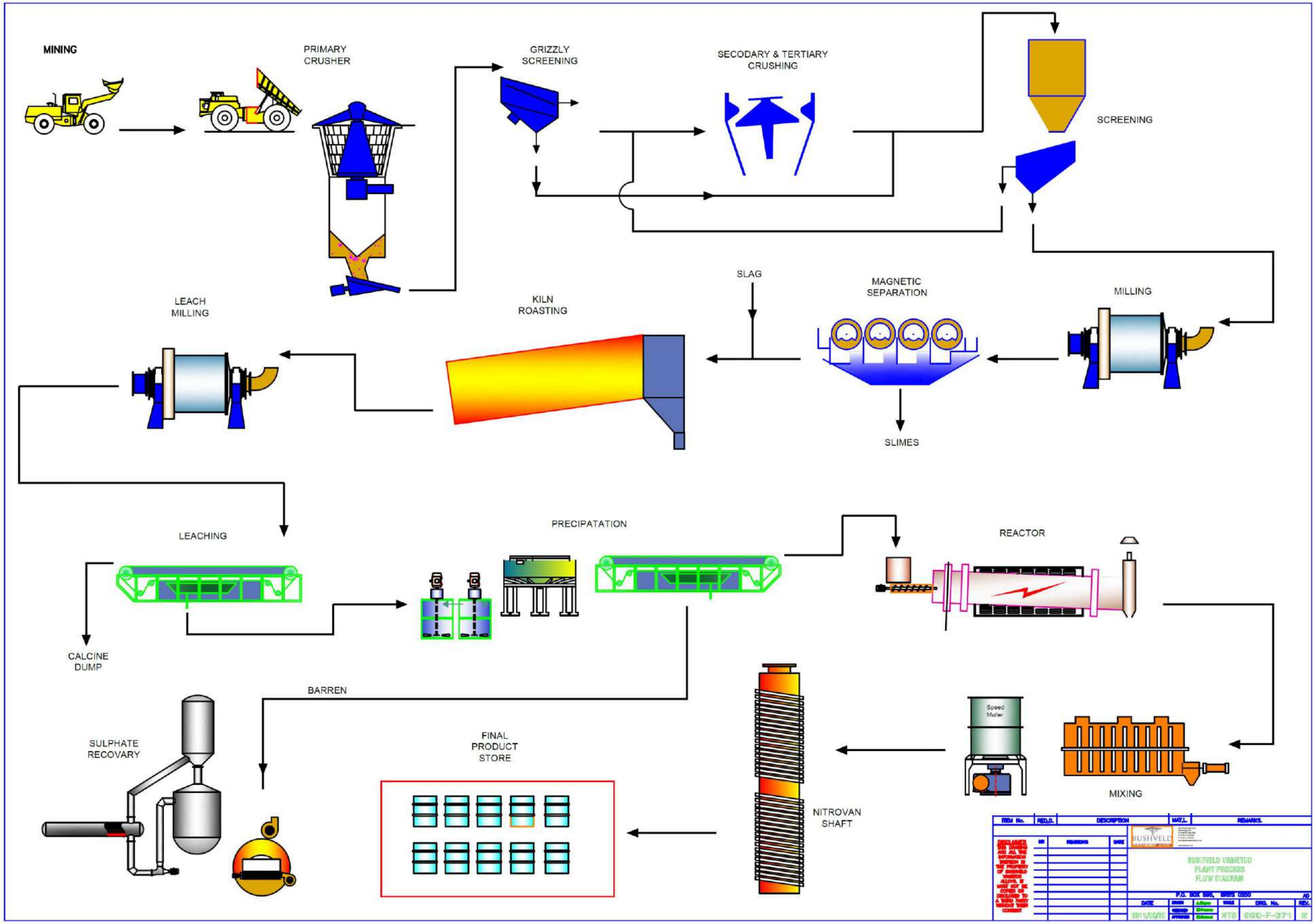
Bushveld. Vametco are currently (2019) investigating the potential to increase the kiln feed rate. Until such time as this Pre-Feasibility / Feasibility level of study work (which is currently underway) has been completed (Phase 3 plant expansion), MSA have the view that the current plant is able to build up to the targeted steady state production of 3,400 mtV p.a. of Nitrovan^{TM} in 2021.

8.3.1 Process Summary

The overall Vametco Project process flow diagram indicating operational components is shown in Figure 8-17 and is discussed below.

Figure 8-17

Simplified overall process flow diagram for the Vametco Project indicating the operational components



Source: *Vametco (2019)*

8.3.2 Concentrator

8.3.2.1 Crushing

The primary crusher operates on an eleven shift fortnight basis, whilst the remainder of the plant is operated on a 24/7 basis. RoM ore is delivered by tipper truck either directly to the oscillatory cone primary crusher, or to a RoM stockpile from where it is reclaimed to the primary crusher by an excavator and dump trucks. A stockpile of approximately 130,000 t was evident during the site inspection (27-28 May 2019), representing approximately 30 days of throughput at present (2019) treatment rates.

The primary crusher reduces the ore top size from 1,000 mm to 150 mm. The crusher discharge grizzly cuts the stream at 40 mm, with the coarse fraction being transferred to the secondary crusher feed stockpile (approximately 70,000 t). The sub- 40 mm fraction is combined with the output of the secondary and tertiary crushers and is transferred to the tertiary crusher screen feed bins.

The oversize material is drawn from the secondary crusher feed stockpile by three vibratory feeders and is transferred to a single secondary Simons cone crusher where it is reduced to a nominal top size of 38 mm before being combined with the primary crusher undersize and transferred into five screen bins. The crushed material is drawn from the bins by vibratory feeders to five polydeck vibrating screens where it is screened at 10 mm. The oversize from the five screens proceeds to the two tertiary crusher feed bins, each bin feeding a tertiary Simons crusher via a vibrating feeder. The material is crushed to 10 mm before being returned to the five screen bins. The sub- 10 mm screen undersize is directed to two silos ahead of the primary ball mill circuit.

8.3.2.2 Milling

The primary milling circuit consists of three ball mills which reduce the particle size to 70 % < 150 µm.

The mills are operated in closed circuit with cyclones with magnetic separators on the cyclone overflow streams. The combined primary mill magnetic fractions are directed to the single secondary mill. The primary mill non-magnetic fractions are cycloned, with the cyclone overflow being directed to the tailings thickener. The cyclone underflow is magnetically scavenged.

The secondary mill is operated in closed circuit with a cyclone to produce a grind of 80 % < 106 µm. The cyclone overflow is directed to the secondary magnetic separator. Separator non-magnetics are transferred to the scavenger magnetic circuit whilst the magnetic concentrate is pumped to a belt filter. The target moisture in the filter cake is 11 %. The filtered magnetite concentrate containing the vanadium oxides is transferred to a storage facility at the roasting plant (stockpile full). Typical impurities include Si, Ca and Al.

The tailings thickener underflow is pumped to the sand tailings dam, overflow being returned to the plant as process water.

8.3.2.3 *Roasting*

The magnetite concentrate is stockpiled in a covered facility by travelling tipper. The concentrate is recovered through two reclaim points to allow for a degree of blending and may also be reclaimed by front end loader ("FEL").

The magnetite concentrate is mixed with Na_2CO_3 and Na_2SO_4 and the resultant blend is fed to a 4.2 m diameter, 90 m long rotary kiln. The kiln is coal-fired, the coal being introduced with draft air at the calcine discharge end of the kiln in a counter current flow to the incoming concentrate blend.

In the kiln, at temperatures of 1,100 °C and in the presence of the sodium salts, the vanadium oxides are converted to soluble sodium vanadate. Some secondary reactions also occur including the conversion of Si to silicates, which at significant levels can affect the operability of the kiln as a result of glass accumulations which cause a restriction within the kiln. This requires a kiln stoppage in order to remove the accumulations.

The plant target for SiO_2 in magnetite concentrate is <2.8 %; however the plant has handled monthly averaged Si in excess of 3 % in the last 36 months without incurring a build-up. Plant staff have noted that high Si scavenges Na to form sodium silicates which may be "sticky" in the kiln hot zone and aggregate, whilst the reduced sodium available leads to a lesser degree of V conversion and hence lower V recoveries. Adding excessive sodium salts to compensate under these conditions aggravates the build-up of glass accumulations as well as increasing the sodium load on the leach and salt recovery plant ("SRP"). Glass accumulation may also be influenced by the temperature profiles and other conditions within the kiln.

Bushveld Vametco staff have reported that since the third primary mill has been commissioned, the Si levels have been handled through the kiln without major problems, suggesting that better Si/magnetite liberation in the mills is leading to better Si rejection in the primary and secondary magseps.

Kiln off-gasses are directed through a lime scrubber to remove dust and SO_2 prior to release to atmosphere. At the time of site inspection by MSA (28-29 May 2019), the scrubber and stack were undergoing an upgrade to ensure emissions complied with environmental standards.

Calcine is discharged from the kiln at 900 °C into an air-cooled rotary cooler and the resultant hot air is fed back into the kiln as an energy recovery measure.

8.3.2.4 *Extraction*

The calcine from the cooler is transferred by a steel bucket type elevator to a wet ball mill where it is milled with recovered process water during which the leaching of the water-soluble sodium vanadate is initiated.

Further leaching occurs in a three-stage leach circuit, with the final slurry reporting to a thickener where flocculent and $AlSO_4$ is added to precipitate co leached silica and clarify the pregnant leach liquor solution. The clarified thickener overflow is pumped to the ammonium metavanadate precipitation circuit.

Thickener underflow is pumped to a wash circuit where multiple counter current stage washing on a belt filter reduces the entrained soluble vanadate in the leached calcine tailings. The wash solutions from the filter are returned to the leach solution stream (stream target 30 g/L).

The calcine tailings cake from the belt filter is conveyed to the calcine tailings dam (magnetite dump).

8.3.2.5 Precipitation

The pregnant liquor solution is treated with an ammonium sulphate solution in a multistage precipitation circuit, resulting in the precipitation of ammonium metavanadate ("AMV") (NH_4VO_3).

The resultant slurry is transferred to a thickener, and the thickened underflow filtered on a belt filter to produce an AMV cake which is dried in an oil fired calciner before being pneumatically transferred to the modified vanadium oxide reactors. The thickener overflow solution containing residual ammonium sulphate and sodium sulphate produced by the exchange reaction during the precipitation is forwarded to the barren dam at SRP.

8.3.2.6 MVO

The AMV cake is treated in two parallel kilns operating at 900°C. The AMV decomposes to modified vanadium oxide ("MVO") (V_2O_3) in a reducing atmosphere caused by the decomposition of the released ammonia to nitrogen and hydrogen. The MVO is discharged from the kiln into drums for transfer to the Nitrovan™ plant.

Kiln gasses are extracted to a scrubber where fugitive ammonia is captured as ammonium sulphate for return to the precipitation section.

8.3.3 Nitrovan™ Plant

MVO is blended with starch and carbon in a two-stage dry–ball mill mixing process with current planning to replace this with a single stage process. The resultant blend is briquetted and the briquettes fed to four nitrogen-purged inductive shaft furnaces to produce the final Nitrovan™ product.

8.3.4 Salt Recovery Plant

The SRP receives solutions containing residual ammonium sulphate and sodium sulphate from the precipitation section.

The solutions are concentrated in two separate evaporator streams, resulting in the crystallisation of the sodium sulphate and the concentration of residual ammonium sulphate. Steam for the evaporative duty is generated by three boilers. The sodium sulphate is recovered by belt filter and returned to the kiln for magnetite roasting. Excess sodium sulphate does not meet sales specification and is currently stockpiled. The remaining concentrated mother liquor solution containing the ammonium sulphate is returned to the AMV precipitation section.

8.3.5 General Specifications including costs and process consumable usage rates

8.3.5.1 Coal

The kiln consumes on average around 1,900 tpm of semi-soft coking coal at a budgeted monthly cost of approximately ZAR 2.4 million or around 1.9 % of the total cost. Coal costs are ZAR 9.69/kg V out of a total consumable cost of around ZAR 61/kg V. As a comparison, the boilers consume an monthly average of approximately 1,050 tonnes of pea coal at a cost of ZAR 1.4 million. Table 8-6 breaks down the operations energy requirements, these being 12.12 % of the total operational cost. Coal is not a significant cost to the operation.

Table 8-6
Energy requirements and costs for the Vametco Operation

Energy:	Unit	Quantity	Monthly cost (ZAR)	Per cent of total cost (%)	ZAR/kg V
Electricity	kWh	7,577,587	7,122,543	5.76	29.15
Diesel	Litres	251,999	3,125,285	2.53	12.79
Burner oil	Litres	58,517	433,734	0.35	1.78
LP gas	Kg	16,864	266,425	0.22	1.09
Pea coal	tonnes	1,134	1,445,598	1.17	5.92
Semi soft coking coal	tonnes	1,878	2,368,053	1.92	9.69
Workshop energy			224,829	0.18	0.92
Total			**14,986,466**	**12.12**	**61.34**

8.3.5.2 Consumables

The major consumables are detailed in Table 8-7. Soda ash (sodium carbonate) is the major consumable used as a blending agent to promote V conversion in the kiln and constitutes 6.87 % of the total operations cost. The crusher and mill liners constitute 2.15 % and mill steel ball constitute 1.12 % of the total cost respectively. All other consumables are individually less than 1 % of the total cost.

Table 8-7
Costs for the major consumables, Vametco plant

Consumables	Unit	Quantity	Monthly cost (ZAR)	Per cent of total cost (%)	R/kg V
Soda ash	tonnes	2,071	8,488,981	6.87	34.74
Liners	ea	53	2,653,580	2.15	10.86
Milling balls	tonnes	100	1,381,752	1.12	5.66
Explosives	tonnes	127	1,107,358	0.90	4.53
Ammonium sulphate	tonnes	339	1,015,044	0.82	4.15
MS carbon	kg	97,620	802,662	0.65	3.29
Pre-heater liner	ea	22	556,627	0.45	2.28
Susceptors	ea	11	556,428	0.45	2.28
Nitrogen	kg	551,862	553,909	0.45	2.27

Consumables	Unit	Quantity	Monthly cost (ZAR)	Per cent of total cost (%)	R/kg V
Allum Sulphate (Liq)	tonnes	211	412,842	0.33	1.69
Starch Binder	kg	31,049	181,980	0.15	0.74
Sulphuric Acid	kg	113,116	173,394	0.14	0.71
Sodium Hydroxide	Mt	14	173,278	0.14	0.71
Drums 160 Litre	ea	352	161,208	0.13	0.66
Filtercloth	ea	3	102,468	0.08	0.42
Water	m^3	61,876	82,283	0.07	0.34
Minor consumables			342,644	0.28	1.40
Total			**18,298,746**	**15.17**	**76.72**

8.3.6 Plant Performance

8.3.6.1 Throughputs, recoveries and availabilities

The recovery performance by section for 2017, 2018 and 2019 to end of April are shown in Table 8-8.

Table 8-8
Annualised recoveries 2017 - 2019

Recoveries	Unit	2017	2018	2019 to April
Crushing and milling	%	89.91	90.24	93.81
Kiln	%	81.54	80.39	83.83
Leaching	%	94.23	92.53	88.79
Precipitation	%	95.85	96.40	96.18
Dry AMV	%	100.00	100.00	100.00
MVO	%	98.50	98.50	98.50
Overall recovery (kiln-MVO)	**%**	**73.33**	**72.08**	**71.00**
Mix	%	98.50	98.50	98.50
Nitrovan™	%	99.00	99.00	99.00
Overall processing recovery (kiln to Nitrovan™)	**%**	**71.51**	**70.29**	**69.24**

The increase in the crushing and milling recovery to the magnetite concentrate may be ascribed to the better liberation achieved after the commissioning of the third primary mill, cyclone and magnetic separation train in June 2018.

It is noted that the leach recovery has shown a decline over the period of measurement which is not currently explained. The leach recovery for January and February 2019 was 79.68% and 88.34 % respectively. Over these months, numerous problems were experienced with the calcine mill which may have affected the liberation characteristics (grind) and leach continuity, and various issues with the belt filters which may affected the wash efficiencies, i.e. pregnant solution losses.

As at the end of May 2019, annualised leach recovery had improved to 90.85 %. The improvement in kiln recovery is a result of improved kiln availabilities (steady state conditions) over a low January availability. The overall recovery to MVO follows the leach trend.

The MVO and NV recoveries are historically very constant.

The major section availabilities/utilisations for the same period are indicated in Table 8-9. It is noted that in any given year the sectional availabilities are reasonably in balance.

Table 8-9
Annualised utilisation / availabilities

Section Availability	Unit	2017	2018	2019 to April
Secondary Crusher	%	**77.55**	**73.51**	**73.68**
Tertiary Crusher 1	%	79.88	75.41	74.22
Tertiary Crusher 2	%	79.54	73.23	73.52
Average Tertiary Crusher	%	**79.71**	**74.32**	**73.87**
Primary Mill 1	%	83.78	70.31	72.59
Primary Mill 2	%	83.03	69.85	76.01
Primary Mill 3	%		59.77	70.19
Average Primary Mill	%	**83.41**	**67.75**	**72.93**
Secondary Mill	%	**87.15**	**77.63**	**82.31**
Kiln	%	**73.30**	**69.33**	**76.34**
Kiln Off-gas	%	**72.19**	**69.47**	**76.34**
Leach Mill	%	71.39	68.72	78.37
Leach Filter	%	71.39	68.72	78.37
Average Leach	%	**71.39**	**68.72**	**78.37**
Precipitation Dryer	**%**	**77.656**	**77.257**	**81.289**
West MVO Reactor	%	50.21	52.41	62.01
East MVO Reactor	%	79.24	75.73	68.47
Average MVO Reactor	%	**64.72**	**64.07**	**65.24**
Boiler 1	%	64.42	79.99	89.10
Boiler 2	%	75.06	82.99	93.44
Boiler 3	%	75.42	88.32	64.76
Average Boiler	%	**71.63**	**83.77**	**82.43**
West SRP	%	81.38	80.42	83.82
East SRP	%	87.13	86.14	91.53
Average SRP	%	**84.25**	**83.28**	**87.67**

The drop in primary mill availability/utilisation in the 2018/2019 years is due to the commissioning of the third primary mill in June 2018.

In 2018, the kiln had planned shutdowns in January (73.37 %), June (30.65 %) and October/November (72.41 %/51.39 %) and extended industrial action in September (33.95 %); these contributed to the lower kin availability in 2018. From January to end April 2019, the kiln had planned maintenance in January (70.89 %) and March (72.26 %). Most other downtime is due to diverse reasons including various equipment chokes, belt tears and trip-outs.

8.3.6.2 *Maintenance philosophies and procedures*

Maintenance is performed on a planned shutdown basis. The maintenance work is largely performed in-house although some repairs are contracted out to be performed either on or off site. This maintenance philosophy is common through much of the SA mining industry.

The kiln is due for annual shutdown from 15th July 2019. The kiln is shutdown on an annual basis for a period of approximately 20 days during which the kiln refractories are inspected, repaired or replaced as required. The critical path of the shutdown largely comprises this maintenance. Other mechanical and electrical repair and construction work to the kiln and ancillary systems is undertaken during this period. Specialist work (*e.g.* specialist equipment maintenance. refractories, rubber lining, belt splicing etc.) is performed by contractors on site. Replacement structure and equipment assemblies may be constructed offsite by external service providers for installation during the shutdown.

Major maintenance on other sections is on a planned basis with opportunity maintenance undertaken when the plant becomes available for upstream issues or during the kiln maintenance. Detailed maintenance records are kept for all sections. Major maintenance issues at the concentrator are largely related to conveyors and liners,

Unplanned shutdowns are only implemented to correct a condition which would ultimately lead to a breakdown. The possibility of a breakdown or unplanned stoppage is covered by applying the factor for availability. The availability factor would be the allowance. It is worth noting that a cement kiln working under very similar mechanical and thermal loads is expected to have a mean time between stoppages of approximately 750 hours; i.e. about once a month. Even if stopped for 24 hours, the availability would still be around 96.5 % which is vastly in excess of Vametco's current kiln availability.

Individual stoppages are recorded in the monthly management report. Daily and monthly running times are recorded in various reports and in the monthly metallurgical balance report as a running time and per cent availability.

The instrument shop and two of the general workshops were briefly inspected during the site inspection and found to be reasonably equipped and fit for purpose.

8.3.6.3 *Capacity bottlenecks*

Bushveld Vametco intends to increase plant throughput pending results of current studies.

Work is ongoing to determine where the process is likely to be constrained as increasing the plant vanadium output would imply either increasing the magnetite tonnage to the mills, or increasing the V grade in magnetite and/or increasing the vanadium recovery.

Increasing feed tonnage would imply some compromise between increasing the equipment hourly feed rates and/or increasing the equipment availability.

8.3.6.4 *Sectional throughput and capacities*

Upper end hourly throughputs for each plant section have been extracted from the 2017 - 2019 monthly metallurgical balance figures and the annual indicated maximum capacity for each plant section has been calculated on the basis of 100 % plant availability over an 8,746 hour year. The maximum indicated annual throughput figures are shown in Table 8-10.

Table 8-10
Hourly throughputs

Section	Material	Recent maximum throughput (tonnes per hour)	Indicated capacity at 100 % availability (tonnes per annum)
Secondary crusher	RoM	250	2,184,000
Tertiary crusher and screens	RoM	225	1,965,600
Primary mill	RoM	240	2,096,640
Secondary mill	magnetite	55	480,480
Kiln	magnetite	66	576,576
Off-gas scrubber	magnetite	66	576,576
Leach mill	calcine	61	532,896
Leach filter	calcine residue	61	532,896
Precipitation dryer	mtV	0.41	3,582
MVO reactors	mtV	0.50	4,368
SRP	mtV	0.41	3,582
Boilers	mtV	0.45	3,931

8.3.6.5 *Planned throughput increase*

Table 8-11 shows the hourly throughputs and availability requirements to meet a target of 3,400 mtV p.a. Nitrovan™. At 2018 sectional hourly throughputs, the precipitation, SRP and boiler sections will potentially limit the production of Nitrovan™ (see yellow highlights). At the maximum hourly sectional throughput, the precipitation and SRP sections would be close to 100 % utilisation (highlighted in green), allowing no margin for maintenance or breakdowns. Generally plants will operate at better than 90 % availability.

A simplified basic vanadium mass balance for the plant, indicating the mass flows per section and based on the 2018 annual recovery profile, for a RoM feed of 1.5 Mtpa and targeted production of 3,400 mtV p.a. Nitrovan™ is shown in Table 8-12.

Table 8-11
Increased tonnage mass balance

Section	2018 annual plant availability (%)	2018 annual plant throughput (tph)	Required availability to achieve 3,400 mtV p.a. Nitrovan™ at 2018 annual sectional throughput (%)	Maximum sectional throughput 2017-2019 (tph)	Required availability to achieve 3,400 mtV p.a. Nitrovan™ at maximum sectional throughput (tonnes per annum)
Secondary crusher	73.50	196.2	87.51	250	68.68
Tertiary crusher and screens	74.32	198	86.72	225	76.31
Primary Mill	67.75	240	71.54	240	71.54
Secondary Mill	77.63	52.74	86.58	55	83.99
Kiln	69.33	56.96	80.17	66	69.99
Off-gas scrubber	69.47	56.96	80.17	66	69.99
Leach Mill	68.72	57.47	79.46	61	75.73
Leach Filter	68.72	57.47	79.46	61	75.73
Precipitation Dryer	77.26	0.387	104.43	0.41	99.72
MVO Reactors	64.07	0.45	86.67	0.5	78.91
SRP	83.28	0.36 (eq)	112.26	0.41 (eq)	99.72
Boilers	83.77	0.36 (eq)	112.26	0.45 (eq)	90.86

Note: *Yellow cells - at 2018 sectional hourly throughputs, these sections will potentially limit the production of 3,400 mtV p.a. Nitrovan™;*

Table 8-12
Simplified vanadium mass balance for the plant

Section	Material	Monthly Feed	Magnetite			Vanadium		
		(tpm)	Grade (%)	Tonnes per annum (tpa)	Recovery (%)	Grade (%)	Production (mtV p.a.)	Recovery (%)
Secondary crusher	RoM	1,500,000						
Tertiary crusher and screens	RoM	1,500,000						
Primary Mill	RoM	1,500,000	28.00	420,000		1.13	4,746	
Secondary Mill magseps	magnetite			413,448	98.44	1.13	4,672	98.44
Non-magnetic tailings	waste	1,086,552	0.60	6,552		0.007	74	
Kiln	magnetite			413,448		1.13	4,672	83.50
Leach Mill	calcine	413,448					3,901	
Leach Filter	residue	409,789					3,659	93.80
Precipitation Dryer	AMV						3,531	96.50
MVO Reactors	MVO						3,478	98.50
Nitrovan^{TM} Reactors	NV						3,443	99.00
							Overall Recovery	**73.70**

Note: *The mass balance is calculated based on the 2018 annual recovery profile, and has been calculated for a RoM feed of 1.5 Mtpa and targeted production of 3,400 mtV p.a. NitrovanTM*

The secondary mill is close to indicated maximum capacity and would require an availability of around 98 % to achieve the required duty. Industry mill availabilities are generally in the low 90 % range. There is no significant storage capacity between the primary and secondary mills and thus it is likely that the hourly feed rate to the secondary mill would have to be increased to allow the availability to be aligned to the primary mills. This would normally result in a coarsening of the secondary grind, resulting in decreased rejection of waste in the secondary magnetic separators, lower V grade and increased impurities in the magnetite concentrate. The knock-on effect of this might be the reduction of conversion in the kiln and the impairment of kiln availability due to silicate agglomeration.

The installation of a second secondary crusher is planned. The installation of the second secondary crusher would allow for the crusher close side settings to be reduced, resulting in a finer product which would reduce the required duties on the tertiary crusher, primary and secondary mills. This may to some extent redress the issues associated with an increased feed to the secondary mill.

Although not approaching maximum availability, increasing the kiln availability is likely to be the major constraint should bushveld Vametco increase the overall plant output. Table 8-9 indicates that the annual kiln availability has not exceeded 76 % over the last three years, although individual months have achieved up to 90 %. The problem appears to be related to achieving consistent availability over an annual period.

Even at current throughput, the identified bottlenecking by the kiln is supported by the site inspection (J Derbyshire, 27-28 May 2019) which indicates substantial stockpiles ahead of all units prior to the kiln, but limited in-process stockpiles after the kiln.

If kiln availability cannot be substantially increased, it may be possible to increase the hourly throughput from the 66 tph envisioned in the mass balance (Table 8-11). During the site inspection (27-28 May 2019) it was stated that the nameplate capacity of the kiln was 95 wtph (~85 dtph) however this could not been confirmed nor has it been achieved in the observed history of the plant. No engineered solutions to achieve this were presented other than a comment that it would be achieved with the same equipment at increased efficiencies, and that downstream plant bottlenecks would be engineered out as required, It was noted by the kiln plant staff that limited periods of up 75 tph have been achieved, notably during December 2018.

Bushveld Vametco have commissioned a process and mechanical audit of the salt roast kiln and cooler system.

8.3.6.6 Plant Labour

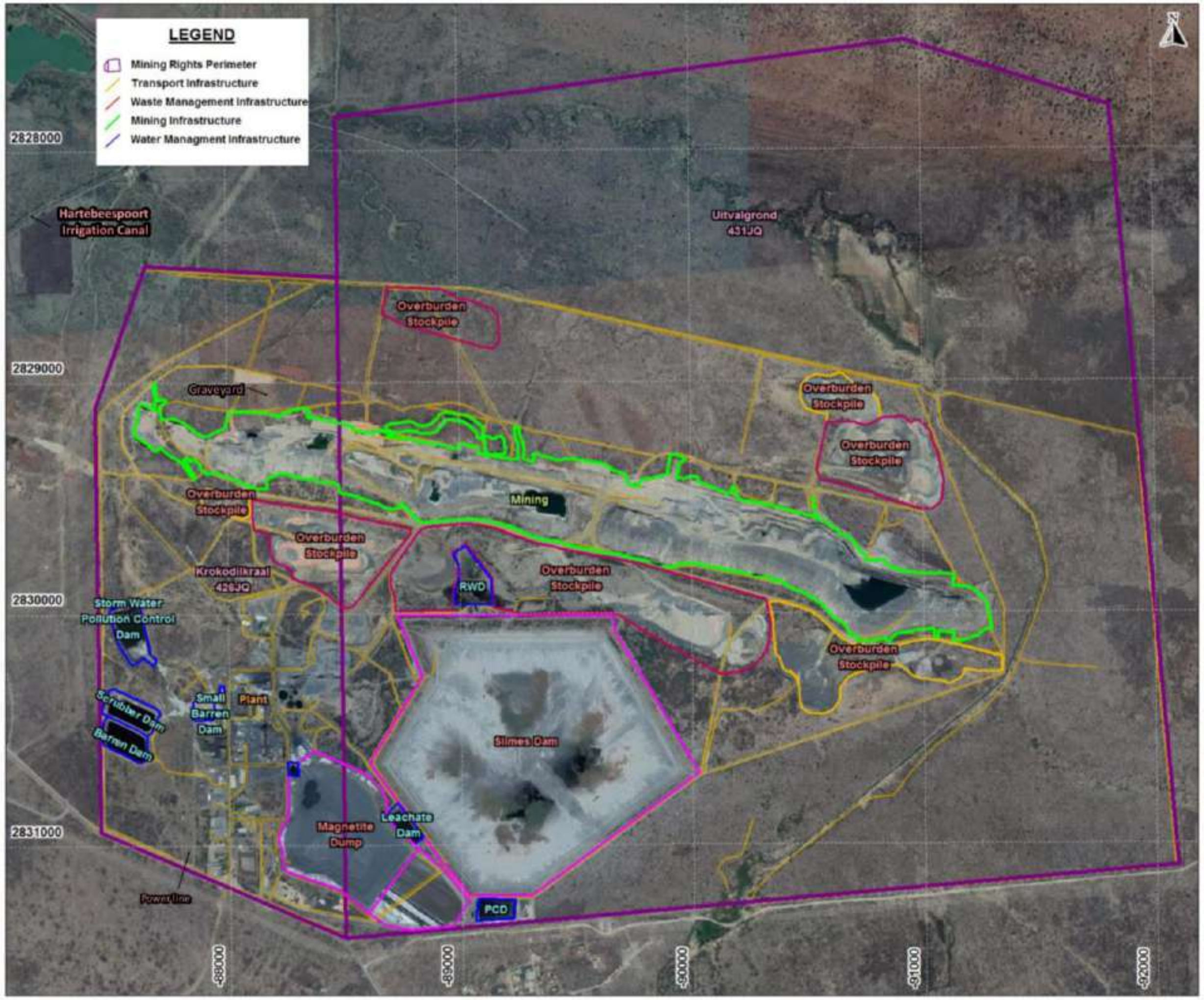
The plant currently has a trained workforce capable of operating the plant at baseline levels. There is no additional equipment requirement for the 3,400 mtV p.a. Nitrovan™ and hence in theory there should be no additional manpower requirements, merely an increase in the feed rate and/or a requirement to improve the running time.

8.4 Infrastructure

Infrastructure for the Vametco mine and plant is well established as the mine has been in operation from 1968. The overall design is considered appropriate to support the life of mine plan. The current mine layout for Vametco is shown in Figure 8-18.

Figure 8-18

Generalised Vametco mine layout and infrastructure



Source: *JMA (2018)*

8.4.1 Water

Water for the operations is obtained from:

- dewatering of the open pit;
- pumping of water from the canals of the Hartbeespoort irrigation system;
- boreholes;
- direct rain; and
- process area terrain run-off.

Water supply is currently only sourced from the Hartbeespoort Besproeiingsraad / Water Scheme. Raw water is pumped to the raw water UCAR Reservoir before being treated to potable water standards and distributed to the mine and plant. The current mine water balance results in a positive water balance at high rainfall periods. Any excess water is stored in the respective dams/impoundments on the Property and used during the dry season. There is sufficient water for the current operations. The budgeted water requirement is ~62,000 m^3 p.a., purchased from the Hartbeespoort irrigation system. If required, water from the boreholes can be pumped first to a reservoir close to the boreholes and then to a reservoir close to the plant via pipelines.

In the case of a water cut there are temporary water tanks (10 x 10,000 L JoJo Tanks) installed to store vehicle delivered water and feed this to the operations.

All mine dewatering is managed through an in-pit water reticulation system that moves water from the pit extremities to a central pit void. Water from here is pumped into the operational plant areas where contaminated water can be used without compromising equipment integrity. This includes a contaminated reticulation system that includes dams such as the scrubber dam and barren dam, semi-barren dam, return water dam, storm water dam and the pollution control dam ("PCD") and leachate dam associated with the magnetite dump and slimes dam. Water from the PCD and in the mining pit dam is used for both plant processing water and for site dust suppression.

Water consumption at the Vametco Mine is in compliance with the approved Integrated Water Use Licence ("IWUL")

8.4.2 Electricity

A 22 kV overhead Eskom line enters the Vametco Mine property from the south and connects to the mine's substation. The electricity requirement is budgeted at 7,577,587 kWh (7,577 MWh). The electricity supply is sufficient for the current (2019) operations.

Load shedding has been experienced by the plant. Power outages are addressed by stopping the high power consumption crushing and milling section and running the remainder of the plant on the stockpile of magnetite concentrate ahead of the kiln. The crushing and milling section has a catch up capacity. As such, load shedding has not disrupted production.

8.4.3 Accommodation

All employees are privately housed in Madibeng (Brits), Mothutlung or Rankotia, with no housing or compound provided on the property. Recreation facilities are provided by the Vametco Club 2000 facility.

8.4.4 Site layout

Figure 8-18 shows the current Vametco site layout which includes the following:

- open pit mining area including haul roads and roads connecting the pit to the beneficiation facilities;
- waste rock dumps and ore stockpile facilities;
- processing/beneficiation plant area;
- workshops, fuel storage, stores and office buildings;
- security;
- process water dams and slimes deposition facilities; and
- slag dump (magnetite / calcine dump).

A number of internal dirt and tarred roads service the Vametco Mine property, providing access to the various sections of the operations. The main administrative block is located to the south of the plant in the southwestern part of the Vametco MRA. The workshops and the administrative building for the mining operations are located to the north of the plant.

There is a graveyard on the northwestern side of the open pit that is currently excluded from all Ore Reserve calculations.

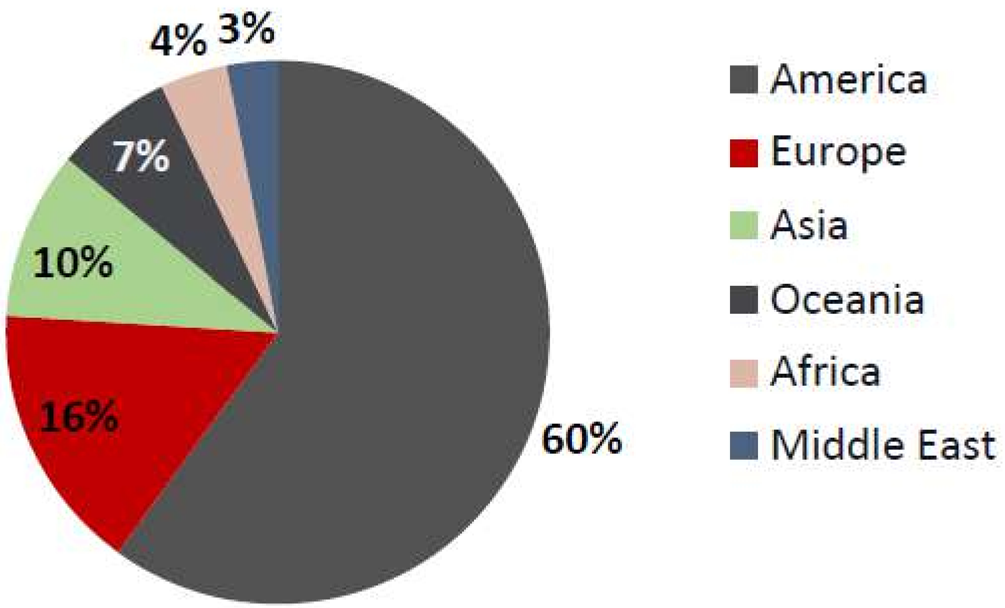
The largest current waste rock dumps are located to the south of the pit and will not be a constraint to any of the mining activities going forward, as the orebody dips to the north and mining will take place in a northerly direction. There are some small overburden stockpiles to the north of the pit, but these are very small and are not considered a constraint to any of the future mining activities.

The positioning of major infrastructure on the mine does not constrain the open pit operation

8.4.5 Logistics

Bushveld Vametco sells Nitrovan™ to steel mills globally. The global customer base based on 2018 sales is shown in Figure 8-19.

Figure 8-19
Bushveld Vametco's global customer base (CY2018 sales)



Source: *Vametco (2019)*

The Nitrovan™ bags are packed into containers and transported by container truck and trailer from the Vametco Mine Nitrovan™ Warehouse on site to the Inter Africa Warehouse, located in Johannesburg. From the warehouse, the Nitrovan™ is transported by road, by container truck and trailer, to the port at either Cape Town or Durban from where the containers are shipped to China, the United States of America, Rotterdam and other destinations. The logistics and distribution network for the Nitrovan™ product is well established.

8.5 Environmental and Social

The legislative framework, environmental and social compliance status and environmental liability are discussed in Sections 2.4.1, 2.4.6, and 2.4.7 respectively.

8.5.1 Environmental Aspects and Management Practices

A site visit was conducted on 28 May 2019 and included the following:

- a briefing and discussion with Vametco management;
- an inspection of the Vametco site and all operational components of the mine; and
- a review of all relevant documentation, inclusive of licences, internal and external audits and mitigation measures currently being undertaken at site.

Potential environmental impacts have been identified as part of the environmental permitting application processes in consultation with Interested and Affected Parties ("IAPs"), regulatory authorities and specialist consultants. A range of environmental issues were considered and are reported in the EMPr. More detail regarding the environmental permits for Vametco can be found in Table 2-3.

A combination of the EMPr, Waste Management Licence, Atmospheric Emissions Licence and Water Use Licence defines the management programmes for the operation. There are several performance and compliance auditing or assessment scopes and frequencies for Bushveld Vametco that verify compliance with these programs and commitments. Currently, the 1998 EMPr, remains the main authorisation for the operation. A new authorisation update (for the EMPr, WUL, Waste Management Licence and supporting document) is currently in process to update all the authorisations to meet the new operational parameters with the Phase 3 increase in production.

Aspects which require monitoring and have established management and monitoring programs include:

- hazardous excavations and structures (open pits, water dams, shafts and dams);
- physical destruction and general disturbance of biodiversity (vegetation);
- contamination of groundwater;
- pollution of surface water;
- air pollution (dust and atmospheric emissions from various sources);
- Waste disposal (hazardous – including the magnetite dump, domestic waste, and recyclables); and
- Heritage / Cultural aspects (graveyard).

The site management has conducted a 3rd party EMPr Performance Assessment Audit, on the approved EMPr documents (Table 2-3), to assess operational compliance to the commitments determined by the EMPr (Cort & Fred Consulting Engineers (Pty) Ltd June 2018). A Water Use Licence Audit has also been undertaken by ESCON Consulting (Pty) Ltd in February 2019 on the consolidated WUL No. 27/2/2/A921/20/1. No audit of the Waste Management Licence or the Atmospheric Emissions Licence was noted during the time of this report although there were monitoring reports on their performance.

During the operational phases of the Vametco mining operations, these audits are to be conducted on a regular basis as defined by the regulations and conditions within the authorisations. The audit findings are documented for record keeping purposes, regulatory reporting and informing site continual improvement.

The following compliance audits and reports are required to be submitted to the relevant authorities:

- EMP performance assessment, to be submitted by 7th June 2019 to the DMR as per written request;
- Updated closure and rehabilitation cost estimate, submitted annually to the DMR (also submitted by 7th June 2019 to the DMR as per written request);
- WUL Compliance Audit, February 2019; and
- Groundwater Flow Model and Remediation Progress Report, submitted to DWA as per IWUL (although there were noted reporting discrepancies including lack of an updated Integrated Waste and Water Management Plan);

- Bi-annual Air Emissions Monitoring Reports submitted to the Municipal Air Quality Officer (Although no evidence of these submissions was noted at the time of this report); and
- Social and Labour Plan Performance Report and Action Plan submitted to DMR in April 2019.

Current material environmental operational challenges on site that were noted include:

- air emissions compliance for the rotary kiln and other emissions processes where varied performance and compliance was noted through time;
- implementation and monitoring of ground water monitoring and remediation programs, and the effectiveness of this in addressing ground water contamination for the operation is a significant area of exposure and risk to the operation;
- Social/Heritage management of the grave site on Krokodilkraal on the far northwestern edge of the pit which is sterilising future mining. Future relocation of this facility and the decision to do so (or not to) needs to be made;
- partial backfill during operations as required by the DMR has several safety and pit mining implications and/or challenges that need to be addressed;
- water abstraction from the Hartbeespoort Besproeiingsraad/Water Scheme and the potential doubling of this volume has been catered for already by a second PVC pipeline. A section of this pipeline has not been buried and could be damaged in the annual winter veld fires that may occur. This could affect water supply and production;
- management of excess water on the mine does require discharge through the Flume 2 v-notch into the Rosespruit. Meeting the water quality objectives of this catchment will become more difficult in the future with the potential need to treat water. The mine water balance needs to be refined to ensure that discharges are not required;
- the management and disposal of ash material from the coal-based heating operations is becoming an issue with the historical ash offtake by an external 3rd party having stopped. An offtake agreement with a local brickmaker is being investigated;
- rehabilitation of the magnetite dump is an ongoing challenge as the steep slopes, growth medium, water and wind protection all play a role. Establishing a stable and sustainable cover on this facility is paramount and will significantly influence the future mine closure liability and risk;
- hazardous waste management - hydrocarbon contamination and hazardous waste skips around the plant and scrapyard/recovery yard are required to be stored in contained areas and suitable management needs to be implemented to prevent further ground water contamination; and
- water management infrastructure repair and maintenance – clean and dirty storm water systems at the plant generally need to be cleaned out and the storage of loose products/materials needs to be contained to prevent silting up of these systems.

8.5.2 Material Environmental Factors

8.5.2.1 Stormwater and polluted ground water management

Following the historical pollution of the ground water at the Vametco Mine, a system to abstract and address the contaminated water in the aquifer was approved and implemented as per the approved Vametco IWUL. Monitoring of this system and the ground water qualities has indicated a poor ground water response with little to no change in the quality of the water. Recommendations to improve the system and its implementation have been made in the recent update of the ground water model and monitoring report.

To this end, Bushveld Vametco needs to assess the implications and application of the proposed ground water quality improvement system and decide on an implementation strategy. A full technical inspection of the integrity of the contaminated water dams at the plant and around the waste facilities is also recommended.

The process of updating the IWWMP and associated operational systems (i.e. the Water balance) should be done as an optimisation process to ensure that the mine remains water neutral and contains (and re-uses) its contaminated water while seeking to reduce this through good clean and dirty water separation. Maintenance of drains and the containment of contaminating materials to reduce spillages and further ground water contamination is critical.

8.5.2.2 Environmental monitoring and reporting

Several monitoring and reporting conditions within the EMPr, IWUL and Waste Management Licence and Atmospheric Emissions Licence exist. These include biomonitoring of rivers, surface and ground water quality, reticulation flow monitoring, bi-annual stack emissions and dust monitoring, waste placement and facility management reports. These reports are to be submitted to the relevant regulatory authority. 2018 compliance auditing found several non-compliances in this area and it was uncertain if all monitoring and other reporting requirements had been met. The failure by Vametco to adhere to the authorisation commitments and conditions could jeopardise the issued authorisations or result in directives from the respective authorities which could have significant cost and operational continuity implications.

8.5.2.3 Hazardous waste – magnetite dump

With the Vametco Mine being categorised as a Class A hazardous waste generator and the waste management licensing of the magnetite waste facility, Bushveld Vametco need to adhere to several key operating conditions. These include the correct appointments, reporting and monitoring requirements as stipulated in the conditions.

Bushveld Vametco also need to establish sustained rehabilitation on the waste facilities. This is proving to be difficult with significant costs and resources being applied to initiate this, with mixed success. A re-evaluation of the rehabilitation approach (species used, growth medium, etc.) to ensure that a sustainable closure option can be implemented during life of mine is required.

The current extension of the magnetite dump facility to cater for an additional five years of waste production is nearing completion. Clarity on the capacity in terms of the proposed increases in production from the Phase 3 project (post Pre-Feasibility and/or Feasibility studies on the plant) were unclear although it was indicated that further expansion of the facility would be required. No planned timing for this was provided at the time of the independent review. A LoM schedule connected to production planning is required to ensure timely disposal capacity increases in the future.

8.5.2.4 Possible relocation of the Krokodilkraal Graveyard

With the location of the Krokodilkraal Community Graveyard on the northwestern extent of the Vametco open pit, a significant amount of future Ore Reserves have been sterilised. No clear decision on a possible relocation of the graveyard had been made.

8.5.2.5 Waste and material management

The management of stockpiled materials within the plant and kiln area is critical for ongoing operations and reduced loss or contamination of product. Within the plant area, several stockpile areas were noted that require containment for optimal material storage and management. This would reduce the sediment loading on the clean/dirty water management systems.

The management of ash waste accumulating within the plant to the north of the SRP is a growing concern. The volume of accumulating ash could become problematic as the third-party that used to collect the ash has stopped doing so. Currently the stockpile of ash material is encroaching on the magnetite stockpile and is causing significant sedimentation in the containment trenches. There are currently no planned disposal areas demarcated for this material; however, it can be placed on the magnetite dump (calcine dump), which is lined, if required.

8.5.3 Social Aspects and Management Practices

8.5.3.1 Social and Labour Plan

The Social and Labour Plan ("SLP") for the Vametco MRA was developed and approved in 2013 in terms of Sections 40 to 46 of the MPRDA. The development and submission of an SLP is a requirement of the MPRDA and sets out the social and labour programmes that need to be in place for the life of mine. This SLP for the Vametco Project expired at the end of 2017. It was recognised that the mine had not met the obligations of the SLP at the end of the SLP period and a remediation plan was agreed and implemented. Subsequently, Bushveld Vametco have received a Section 93 directive from the DMR relating to the implementation of the remediation plan. This issue needs to be addressed as a matter of priority by Bushveld Vametco.

The current SLP 2018 to 2022 is under final review and is expected to be submitted to the DMR in July 2019.

Bushveld Vametco has committed to the transformation of the South African Economy and have a strong focus on people development within their organisation. The financial commitments for the SLP external development projects, relating to the Social and Labour plan social upliftment commitments, are not clearly defined in the discounted cash flow model. These include:

- high mast lighting (ZAR 3 million);
- roads and storm water management structures (ZAR 3 million); and
- a cluster sports facility (ZAR 3 million).

8.5.3.2 Socio-economic impacts

An overall net positive socio-economic impact is expected from Bushveld Vametco's operations with the ongoing employment of personnel to mine, maintain and manage the operations from the local communities. The generation of revenue by the operation will have local spend and will continue to contribute to the local economic and socio-economic wellbeing of the surrounding communities.

8.6 Market Studies and Economic Criteria

Vanadium is a grey, soft and ductile metal that is valued for its high strength-to-weight ratio, corrosion resistance and weldability. Marketable forms are typically ferrovanadium (an alloy of iron and vanadium) and vanadium pentoxide (V_2O_5) concentrate ('flakes').

Vanadium is used mainly in the steel industry as an alloy component in the manufacturing of enhanced strength steel. Secondary uses include non-ferrous alloys, chemicals and power storage (batteries).

This review is partially informed by bespoke and confidential market research reports by BMO Global Commodities Research (BMO, 2019), Macquarie Capital (Europe) Limited and Macquarie Capital Limited (collectively Macquarie, 2019), and Roskill (Roskill, 2019). Information and data from these confidential sources cannot be quoted directly and are used in a generic fashion, together with other public sources, to give a view on the overall consensus of the state of the vanadium market.

8.6.1 Vanadium Market Summary

8.6.1.1 Supply

Over recent years, China has been the predominant producer and consumer of vanadium to the world market. During 2016 China is estimated to have produced some 57 % of the world total (SP Angel, 2018), with Russia contributing approximately 11 % and South Africa 10 %. Global production over the period 2011 to 2017 varied within a range of approximately 70,000 t and 90,000 t.

Global reserves of vanadium are also dominated by China, amounting to nearly 50 % of total reserves. Russia holds approximately 25 %, and South Africa nearly 20 %.

Approximately 73 % of vanadium production is derived from co-production in the form of steel slag as a result of blast furnace smelting of vanadium-bearing titaniferous magnetite ores. This supply is seen as fairly inelastic.

Continued tightening of environmental regulations in China could results in significant pressure being placed on the more polluting magnetite operations. Economic pressures associated with mining and processing of low-grade magnetite ores, relative to high-grade hematite ores, caused many vanadium-titanium-magnetite operations to close. It is considered that these conditions have diminished the likelihood of significant growth of vanadium from such sources.

Only some 17 % of vanadium supply is from primary vanadium ores, with approximately 10% coming from secondary sources.

The general consensus is that vanadium supply will be constrained for the foreseeable future.

Since China is tightening environmental regulations and many operations are closing, the resultant decrease in supply may well be offset by increased production in South Africa.

8.6.1.2 Uses and demand

Vanadium consumption largely mirrors global steel production, since the steel industry accounts for more than 90 % of total vanadium use. Other uses include non-ferrous alloys, chemicals and energy storage.

Global crude steel production has been relatively flat since 2013 with annual growth in the region of approximately 1.2 % per annum. Uptake of vanadium for energy storage, mainly in the form of vanadium redox flow batteries (VRFBs) has potential for significant growth but is unlikely to have significant impact in the next decade.

Vanadium consumption in the steel industry is dominated by high-strength, low-alloy ("HSLA") steel (approximately 48 % of total steel use) and full alloy steel (approximately 35 % of total steel use).

Changes in Chinese steel specifications for structural use, which propose elimination of 335 MPa rebar and replacing it with 600 MPa strength rebar caused a rapid rise in vanadium prices through 2016. This rapid increase ushered in a period of "tolerance" in the Chinese industry which allowed vanadium prices to cool down and retract to levels closer to the long-term average. Nonetheless, it is likely that pressure will remain to increase the vanadium content of Chinese rebar.

Production of HSLA outside of China has remained fairly static since 2012, varying between approximately 55 Mt and 60 Mt per annum. In contrast, Chinese production saw a steep increase from approximately 60 Mt in 2010 to approximately 180 Mt in 2014. Between 2014 and 2018, Chinese production of HSLA varied between approximately 170 Mt and 195 Mt per annum.

Both manganese and niobium pose substitution challenges to vanadium. There are no readily available substitutions for vanadium in non-ferrous and chemical applications, but it can be replaced by niobium and manganese in some steel applications. Niobium and vanadium are not direct substitutes, since switching requires operational adjustments to the steel plants to ensure product quality. Various analyses of the operational cost of substitution indicate that sustained ferrovanadium prices of more than approximately 55 % of the price of ferroniobium may bring substitution pressure to bear on vanadium use in steel production.

A consensus view of vanadium demand prospects forecasts growth over the next six years to increase by approximately 2.75 % per annum.

8.6.1.3 Market outlook

The market outlook for Vanadium products (ferrovanadium and vanadium pentoxide) varies between different analysts, especially for the short to medium term. Vametco has access to forecast data from seven industry sources. The specific forecast information is confidential to the relevant sources and may not be disclosed here. MSA's interpretation of consensus forecasting in real terms is as follows:

- 2020: USD 41.58 /kg FeV,
- 2021: USD 44.13 /kg FeV,
- 2022: USD 46.06 /kg FeV,
- 2023: USD 43.64 /kg FeV,
- 2024: USD 44.00 /kg FeV,
- 2025: USD 44.00 /kg FeV,
- Long term: USD 40.00 /kg FeV.

Research by Roskill (2019) has shown that there is a very strong linear relationship between ferrovanadium and V_2O_5 prices, indicating that one product may be used as a proxy for the other when analysing price data.

From inspecting various production cost curves, it appears that Vametco is comfortably within the lower half of the cost curve and should be able to maintain or improve this position going forward.

8.7 Economic Evaluation

A detailed discounted cash flow model ("DCF Model") was constructed to evaluate the economics of the Vametco Mine operations as a production entity.

The cash flow model is based on real money terms. Taxes, royalties and capital expenditure redemption were evaluated in nominal terms to ensure better accuracy of these cost lines. The tax rate used is based on the South African Corporate Tax rate of 28 %.

In accordance with the requirements of *Appendix 2 - CONTENT OF CPR* of AIM Note for Mining, Oil and Gas Companies (LSE, June 2009), a real discount factor of 10 % was used to estimate the real NPV from the post-tax cash flows on an annual basis.

8.7.1 Technical input parameters

The technical input parameters, e.g. run-of-mine production, processing recoveries and yields, etc. were all reviewed during the process of estimating the Ore Reserves currently available to the Vametco operations, since these parameters are the Modifying Factors required for conversion of Mineral Resources to Ore Reserves. The basis for accepting the modifying factors is rooted in reviewing the actual operations and verifying actual efficiencies and costs.

The Mineral Resource base as at 31 March 2019 is summarised in Section 7.9.

The Ore Reserve base as at 31 March 2019 is summarised in Section 9. For the cash flow analysis this Ore Reserve was depleted to reflect the status as at 01 January 2020.

Other technical input parameters are summarised in Table 8-13.

Table 8-13
Summary of technical input to DCF model

Parameter	Value	Unit
ZAR / USD exchange rate	14.25	R/$ (real, long term)
FeV price (per kg contained V – 80 % product)	41.58 44.13 46.06 43.64 44.00 40.00	$/kg (real, 2020) $/kg (real, 2021) $/kg (real, 2022) $/kg (real, 2023) $/kg (real, 2024-2025) $/kg (real, long term)
Effective V_2O_5 price	19.61	$/kg (real, long term)
Life of Mine (Ore Reserves depleted in 2050)	32	years
Total ROM product mined	46,910	kt
Total Waste mined	30,168	kt
Stripping ratio (LOM)	0.64	waste : ore
Vanadium in Crushed Ore	1.13	%
Magnetite recovery (concentrator)	98.44	%
Kiln recovery (of vanadium)	83.50	%
Leach recovery (of vanadium)	93.80	%
Precipitation recovery (of vanadium)	96.50	%
Modified Vanadium Oxide recovery (of vanadium)	98.50	%
Nitrovan™ furnace recovery (of vanadium)	99.00	%

Notes: *ZAR or R denotes South African Rands; $ or USD denotes United States Dollars*

The ZAR:USD exchange rate was informed by a consensus analysis of six sets of forecasts from banks and brokers. A constant real exchange rate ZAR 14.25 per USD was used for the entire life of the mine.

The ferrovanadium price was informed by outlooks from seven different sources. The consensus prices as detailed in Section 0 were used in the model.

8.7.2 Capital expenditure

The mine has allowed equal amounts of ZAR 5 million for 2020 and 2021. No capital was allocated after this. The production rate for 2020 is planned at 3,200 mtV p.a. Nitrovan™, reaching a steady state of approximately 3,400 mtV p.a. Nitrovan™ in 2021. The capital allocation is considered adequate for this marginal increase in production, with no major constructions required.

The current slimes facility is insufficient to cater for the Ore Reserves and the long-term plan from 2038 onwards. No additional capital has been allocated for this in the Discounted Cash Flow Model.

The budget for stay in business capital in the mine's long-term plan equates to approximately 5.4 % of working costs. To the sustain the infrastructure through the life of mine, this is considered to be on the low side by MSA, based on benchmarking with other local mining operations. MSA consider a more reasonable figure to be around 8 % for a mechanised operation with contract mining. This higher amount has been implemented in the cash flow model.

The current budget considers no major new plant or equipment to be implemented or commissioned during LoM. As an operating mine, with no major capital projects budgeted for, working capital requirements are minimal. However, allowances are made for seasonal variations in production, as well as the time delays inherent to realising sales.

Since Vametco is an operating mine, equipment is only needed for replacement units as existing units wear out. The need for such replacements are covered in the stay-in-business capital allowance.

8.7.3 Operating costs

Cost are based on actual historically achieved results and are accepted as relevant and reasonable. As an active operation, all current contractual arrangements are in place. These may be extended, or reviewed and altered, as the mine management see fit over time (Table 8-14)

Table 8-14
Summary of costs as at 01 April 2019

Parameter	Value	Unit
Mining Costs Fixed	36.20	R million p.a. (ave)
Mining Costs Variable	30.02	R/t mined
Concentrator Costs Fixed	98.90	R million p.a. (ave)
Concentrator Costs Variable	149.00	R/t concentrate
Evaporator and Extraction Fixed	150.43	R million p.a. (ave)
Evaporator and Extraction Variable	452.66	R/t concentrate
AMV and MVO Costs Fixed	34.16	R million p.a. (ave)
AMV and MVO Costs Variable	35.41	R/t concentrate
Mixing and Nitrovan™ Costs Fixed	71.82	R million p.a. (ave)
Mixing and Nitrovan™ Costs Variable	27.87	R/kg vanadium
Sales Costs	159.73	R million p.a. (ave)
General and Administration	105.95	R million p.a. (ave)
Social Expenditure	22.69	R million p.a. (ave)

Notes: *AMV – Ammonium Meta-Vanadate; MVO – Modified Vanadium Oxide*

Vametco's exposure to the ZAR:USD exchange rate is seen to be largely in its favour, since most costs are in ZAR and revenue is in USD.

A global cost curve for vanadium producers has been produced by Roskill (April 2019). The Roskill report is confidential, but the curve shows that Vametco locates well within the lower half of the cost curve, which means that Vametco should be able to weather adverse market conditions better than most of current producers. At present there is only one other fully vertically integrated producer like Vametco in South Africa, being Glencore's Rhovan operation. Vanchem Vanadium Products also produces saleable vanadium products, but buys in ore from external suppliers.

8.7.4 Discount rate

AIM-listed companies are instructed by the exchange to base financial evaluations of mineral assets on a real model with a discount factor of 10 % as a base case.

8.7.5 Discounted cash flow analysis

The base case cash flow model calculated a real NPV of USD 371.0 million at a discount rate of 10 % per annum. The model is reflects a 100 % interest in Vametco. The NPV is not considered to be a true reflection of market value. A simplified version of the DCF model is presented in Appendix 4.

With no up-front investment to consider, the entirely positive cash flows over life of mine make calculating an Internal Rate of Return ("IRR") for the Vametco operation meaningless.

8.7.5.1 Sensitivity Analyses

Four potentially material economic influencers were assessed, as described in the paragraphs below. The results obtained from the various discounted cash flow analyses are summarised in Table 8-15.

Commodity price / revenue

The FeV prices forecast were reduced by 15 %, resulting in lowering the base case NPV by 30 % to USD 258.7 million. This parameter has the strongest impact on the Vametco economics.

Capital expenditure

Since the capital expenditure budget is very modest, typical overruns that may be expected should have minimal effect on the economics of the Vametco operation.

Operating costs

A 15 % increase in operating costs has a moderate effect on the economics of the mine, reducing the base NPV by 17 % to USD 306.3 million.

Exchange rate exposure

Since most Vametco's costs are ZAR-denominated and the revenue is USD-denominated, a stronger ZAR should have a negative effect on the NPV. Strengthening the ZAR by 15 % against the USD results in a lowering of the NPV by 14 %. This indicates that the Vametco operation is only slightly sensitive to foreign exchange fluctuations.

Table 8-15
Summary of discounted cash flow analyses

Scenario	Change	NPV (real)
Base Case (10 % discount rate)	-	USD 371.0 million
Decreased Revenue (-15 % FeV price)	-30 %	USD 258.7 million
Increased Production Costs (+15 % production costs)	-17 %	USD 306.3 million
Stronger South African Rand (+15 % appreciation against USD)	-14 %	USD 319.1 million

It is clear from the base case and sensitivity analyses of the discounted cash flows projected for the Vametco operation, that expected financial performance is very robust. This resonates well with Vametco's position on the lower half of the cumulative cost curve for vanadium producers.

8.8 Risk Analysis

Apart from the project specific risks identified and discussed below, Bushveld Vametco's assets are inherently exposed to normal operational risks associated with exploration, development and production projects in general, and in South Africa in particular. The success of the Vametco Project depends largely on successful prospecting and development programmes and competent management. Profitability and asset values can be affected by unforeseen changes in operating circumstances and technical or economic issues.

BMN's other vanadium assets are located in South Africa. BMN is therefore significantly exposed to the South African economy in general and the South African mining industry in particular. Factors such as social, political and industrial disruption, regulatory change, currency fluctuation and interest rates could have an impact on Bushveld Vametco's future operations, both operating costs and potential revenue streams can be affected by these factors.

8.8.1 Geology and Mineral Resources

MSA considers the Mineral Resources at Vametco to be of low to medium risk. The majority of the Mineral Resource is classified as Indicated, although there are Inferred Mineral Resources at the eastern and western extremities for both the Upper and Lower Seams as a result of lack of drilling. These could easily be upgraded to Indicated Mineral Resources by drilling approximately ten diamond drillholes for a total length of approximately 1,200 m.

The thick, generally geologically continuous, tabular Mineral Resource is of low variability and by its very nature can be considered a robust deposit. The Mineral Resource has been mined for several tens of years and is predictable.

The Mineral Resource has been reported to a maximum depth of 150 m where drilling information allows. Pit optimisation as part of the Mineral Resource to Ore Reserve conversion process, generated a number of economic pit shells that demonstrated that a 150 m pit depth is economically feasible, which would provide a source of feed to the plant for in excess of 50 years at anticipated production rates.

8.8.2 Mining and Ore Reserves

There is limited risk with the mining production profile which is in line with the 2019 budget of 1.5 Mpta RoM feed to the plant. The current plant is able to build up to around 3,400 mtV p.a. of Nitrovan^{TM} per annum based on historical performance and realistic interventions.

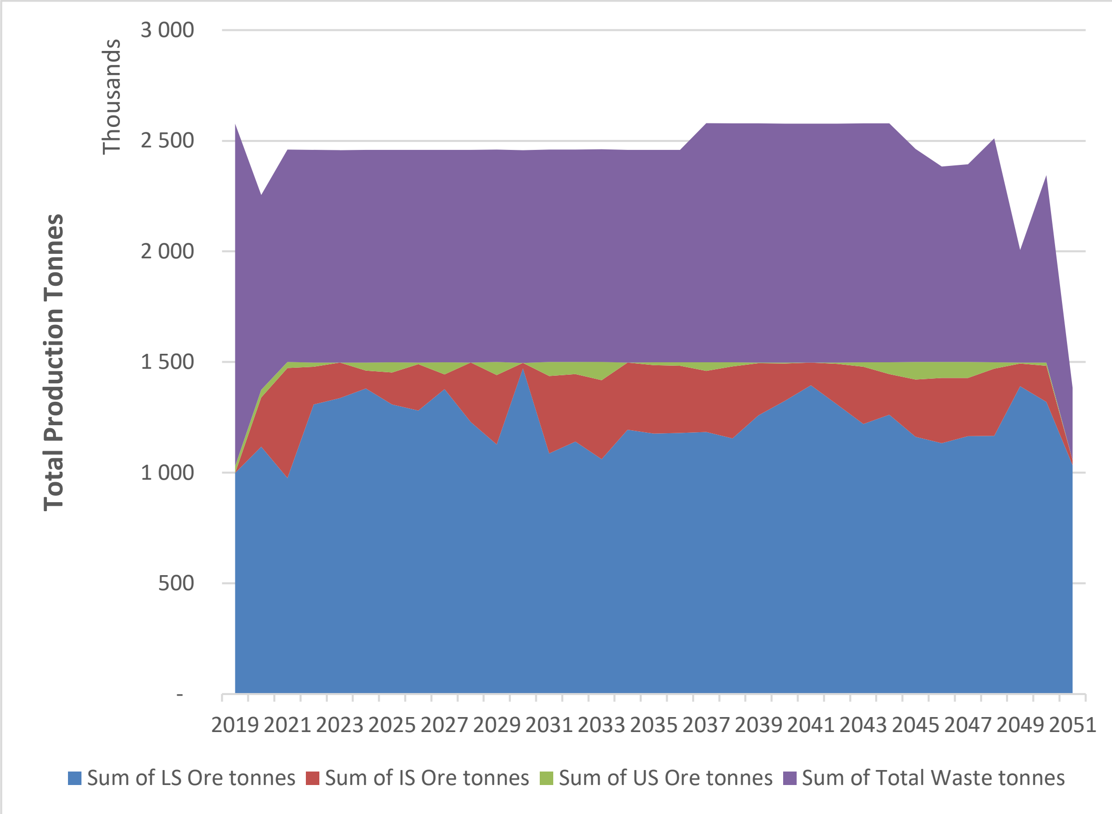
MSA have identified the following mining area risks and potential mitigating factors which may impact on the potential to deliver the 3,400 mtV p.a. of Nitrovan^{TM} in the production profile. As mitigating factors have been identified and the risks are able to be managed, the risks are considered to be low:

- Whilst the magnetic separation process removes a certain amount of SiO_2, not all SiO_2 is removed by the magnetic separation. Excessive SiO_2, which occurs in the LS ore, can cause problems in the plant. In the kiln, at temperatures of 1,100°C and in the presence of the sodium salts, the vanadium oxides are converted to soluble sodium vanadate. Some secondary reactions also occur including the conversion of Si to silicates; the silicates scavenge sodium to form glass. As the sodium is required for the conversion of the vanadium oxides to soluble sodium vanadate, scavenging of the sodium by silicates impacts recoveries of vanadium. In order to mitigate this, IS ore which has a lower SiO_2 content, has been used in the production schedule to blend with the LS ore to reduce the overall SiO_2 and improve the plant throughput. The IS constitutes 15 % of the life of mine and Ore Reserve ore tonnage:
    - To mitigate this risk further, optimisation work is recommended to investigate the proportion of SiO_2 in the long term plan and the availability of IS for blending. Stockpiling of IS can be used to assist blending.
- The vanadium content in the magnetite of the Mineral Resources appears to be higher than the historical average performance. The result is that a relatively conservative production of 1.5 Mtpa RoM feed to the plant is required. Should the vanadium content be lower than expected, the annual Nitrovan™ product production will be affected:
    - To mitigate this risk the RoM feed from mining could be increased to offset the product shortfall. The current milling circuit is able to handle additional tonnage. The risk in the processing plant is the kiln.
- Excessive dilution above plan would result in a reduction in the magnetite grade affecting the RoM throughput:
    - It is suggested that a Reverse Circulation ("RC") drilling based grade control programme be considered, instead of the current blast hole sampling, in order to improve orebody understanding, mine planning and dilution control. A trade-off study comparing the costs and benefits of RC drilling with blast hole sampling is recommended for consideration.

The current mining equipment is adequate to achieve the production plan capacity. The modifying factors and geotechnical assumptions were considered appropriate as the average pit depth was kept below 100 m.

The mining fixed costs and rates in the financial model provided for review are in line with the 2019 Vametco Mine budget which was based on a sound cost estimation methodology. The mining costs are considered comparable with those of related mining companies. The overall mining costs are lower due to the reduced waste to ore strip ratio in the production plan. The reason for the lower strip ratio was related to impact of additional Intermediate seam (IS) ore from the Mineral Resource model as shown in Figure 8-20.

Figure 8-20
Vametco life of mine ore profile



Vametco uses contract mining and a potential weaker Rand currency scenario could affect the costs of replacing mining equipment, diesel and consumables which would inflate the contract mining costs.

8.8.3 Metallurgy and Processing Risks

The processing plant has been operated successfully since 1968 and in 2004 produced in excess of 3,400 mtV p.a. Nitrovan^{TM}. No fatal flaws relating to the processing plant for the short-term expansion targets were noted. Some risks relating to achieving these targets were however identified.

8.8.3.1 Precipitation

The AMV precipitation and drier section boilers have been identified as having a limited output of approximately 3,600 mtV equivalent. From this study it is unclear as to whether the entire section contributes to the limited output, or whether individual equipment items within the section (residence times, pumps, belt filter, centrifuge etc) limit the throughput. It is suggested that the limiting factor be established and that capacity be increased in line with expansion output targets. Some capital expenditure would be required. The **risk** associated with meeting the short-term expansion targets is relatively **low** providing plant availability can be maintained. The risk to the operation is **low**.

8.8.3.2 *Salt Recovery Plant*

The SRP evaporators and boilers have been identified as having a limited output of approximately 3,600 mtV equivalent. The evaporators and crystallisers are constructed of stainless steel which is susceptible to chloride corrosion. Chlorides arising from the leach and precipitation circuits are concentrated through this circuit and may result in accelerated corrosion issues. It is likely however that to significantly exceed 3,600 mtV equivalent, a third evaporator crystalliser plant and additional boiler capacity would have to be installed. Alternatively, a leach vat operation could be considered or a waste salt crystalliser installed to remove the chlorides. The risks are associated with maintaining adequate plant availability at close to the throughput limit to achieve the expansion throughput. Corrosion issues could conceivably, due to the dual streams, take 50 % of the plant offline for extended periods. Under the circumstance what is presently a **moderate risk** may be mitigated by equipment monitoring and maintenance measures. The risk to the operation is **medium**.

8.8.3.3 *Kiln*

Whereas many of the sections of the plant have dual processing streams, the kiln, being a single stream operation, represents the greatest operational risk to achieving an increased plant throughput. A **high risk** profile is indicated in this regard.

Although in theory the kiln has the indicated capacity to meet the expansion target, the risk at this stage is seen as not achieving the required annual kiln availability to meet the proposed increased throughput targets. The required availability has been regularly achieved on a monthly basis, but lacks the required consistency to achieve this on an annual basis. Feed consistency, whilst not the only determining factor in kiln availability, is important. The more consistent the feed and the operating conditions within the kiln, the better the chances of optimising the conversion process and limiting factors causing process-related downtimes, particularly spinelling. To mitigate this risk, factors affecting hourly throughput and downtimes should be addressed.

In light of information provided on site by plant personnel that the kiln had a 95 wtph capacity as designed, it is suggested that a detailed engineering audit, mass and energy balance be conducted to identify any deviations or constraints that exist against the specified design parameters for the original kiln supply.

Any measure to improve the operational efficiency of the kiln, either by increasing the throughput or improving the availability/ utilisation of the kiln system should be seen to be paramount.

Some measures that may improve the kiln throughput include those which increase the thermal efficiency and temperature profile of the kiln. These could include inter alia:

- reducing the magnetite concentrate moisture from the current 11 % (pressure filtration, or pre-drying the concentrate);
- preheating the kiln feed; and
- ensuring the feed coal is dry.

Any increase in the V grade in the kiln feed magnetite would be "free carry" through the crushing, milling and kiln sections.

Measures to reduce kiln downtime include:

- more intensive proactive monitoring and preventative maintenance of the kiln lining, drive, feed and discharge systems;
- control of silica in the magnetite concentrates to <3 % to limit accretion formation; and
- accurate control of the temperature profile in the kiln to limit the formation of siliceous glass phases.

As of the date of this CPR, the kiln scrubber and stack were being upgraded. This is primarily to comply with the emissions permit requirements rather than improved throughput, but may improve coal combustibility, kiln temperature profile and hence possible kiln throughput. This possible improvement has yet to be quantified. In addition, Bushveld Vametco have commissioned a process and mechanical audit of the salt roast kiln and cooler system.

8.8.3.4 Nitrovan™ Plant

An additional shaft furnace has been purchased to augment the four units currently in operation. The furnace is on site and awaiting installation. The installation of this unit would mitigate any expansion throughput risk associated with this section.

8.8.4 Infrastructure

Infrastructure for the Vametco Mine is well established, as the mine has been in operation from 1968. The supply of water and electricity is adequate and available to sustain the long-term plan. The surface facilities (offices, maintenance, storage, laboratories, workshops, changes houses, fire protection systems) are all in place and well maintained. No risks are identified associated with the general Vametco Mine infrastructure.

8.8.5 Economic Risks

The economic evaluation of Vametco shows a robust operation that is not very sensitive to an increase in operating costs, and somewhat more sensitive to lower sales revenue. This analysis implies that Vametco may be expected to weather adverse operating and trading conditions well. Given the economic base case represents a currently successfully operating mine and processing plant, with only incremental increases in production planned, there are no additional sensitivities to be investigated, apart from those already discussed in section 8.7.

8.8.6 Environmental and Social Risk

Material social and environmental risks identified which could impact on the Vametco Project include:

- ground water contamination and the effectiveness of the containment initiatives underway;
- the required backfill strategy and the related mining and financial implications thereof;
- compliance with WUL, Waste Management and Atmospheric Emissions authorisation conditions for monitoring and reporting;

- closure of the DMR Section 93 Directive relating to the completion of the 2013-2018 SLP Action plan deliverables;
- confirmation of the Mine Closure Liability provisioning meeting the new 2018 assessment values; and
- confirmation of the scope of the possible Phase 3 expansion such that the new authorisations are applied for in good time before implementation and do not become a delay for the Project.

Bushveld Vametco requires that its various mineral licences and environmental authorisations are maintained in good order and that they remain in compliance with various pieces of minerals, environmental and social related legislation. While Bushveld Vametco has demonstrated the ability to successfully obtain and maintain the Mining Right, the Company will be reliant on the establishment and continued maintenance of such rights going forward.

Bushveld Vametco relies on good relationships with the private landowners to provide access for prospecting and future development on the Krokodikraal and Uitvalgrond farms.

8.8.7 Vametco Risk Assessments

In addition to the risk analysis for the Vametco Project (Sections 8.8.1 to 8.8.6), Bushveld Vametco follows a mature risk management approach. A risk matrix is held and updated regularly. Table 8-16 summarises the risks as identified by Bushveld Vametco.

Table 8-16

Bushveld Vametco Risk Register

#	Inherent Risk	Residual risk	Risk Area and Description of the risk	Risk owner	Causes of risk	Related internal controls description
1	Likely	Possible	Political - Stakeholder Management	COO SLM	Inter-community (and intra-community) factions may result in mine and/or production stoppages. Significant loss of reputation / bad-press resulting from negative community interactions.	Compliance with requirements of mining right conversion. Ongoing interactions with the DMR and Communities
2	Almost certain	Possible	LT Supply / Demand - Global Industry cyclicity	COO	Nitrovan™ is a niche product in the market which competes with Ferrovanadium. Economic premium of Nitrovan™ may be eroded due to poor economic climate and or low FeV prices. Product heavily dependent on the steel market. Supply / demand economics may adversely affect the operations where margins are eroded by vanadium price on the open market and exchange rates.	Maintaining client requirements within demand in order to ensure clients are retained. Ongoing marketing and promotion of Nitrovan™ to customers and the market through customer visits, Vanitec membership and various conferences.
3	Likely	Possible	Cost - Cost position vs. competitors.	COO CFO	Inflated production costs due to increased electricity and fuel costs, combined with increased prices of key raw materials such as coal, carbon products and Sulphuric Acid, Soda Ash etc.	Raw materials prices are reviewed on a monthly basis. Where possible, use more than one supplier on database to ensure continuity of supply and competitive pricing. Extra-ordinary / non-critical costs are being eliminated to limit the impact on operational costs.
4	Likely	Possible	Operational - Environmental Compliance (Operational Responsibility)	SHEQ	Significant environmental liability due to regulated environmental requirements. Sale, transfer, re-work or addition to dumps may affect the ability of the organisation to operate effectively. Non-compliance to legislative / regulatory requirement and licence conditions such as point emissions at stacks may result in fines or operational stoppages. Inadequate monitoring and reporting of emissions and ambient air quality is performed. Air pollution controls and off-gas systems are not adequate as required within the Ambient Air Licence. Inadequate monitoring and recording of all emission forms. Fugitive emissions (dumps and tailings) not determined resulting in possible non-compliance. No measurement, monitoring or inventory of asbestos or	Ground water quality is monitored at 65 points. Water discharges are controlled, monitored, measured and reported accordingly. All systems are controlled and monitored in accordance with licensing or permit conditions. Controls actively monitored by the H&S Department. PPE is supplied and maintained by the company. Regular risk assessments and inspections performed. COP's are in place as required by legislation and reviewed according to specific regulated requirements. Monthly surveys are performed at high risk areas. Contractor management program in place which is audited quarterly. Retaining wall with monitoring systems installed around the dump. Other exposures treated as identified. New Kiln-offgas system to be commissioned in 2019.

#	Inherent Risk	Residual risk	Risk Area and Description of the risk	Risk owner	Causes of risk	Related internal controls description
					other fibre (Plant and residential property owned by Vametco). Possible project failure or closure by the Green Scorpions due to non-compliance. Limitations on production capacity due to limited size of disposal facility. Ground water pollution plume pollutes underground water of greater community. Environmental liability of dump and dump lining not in conformance with current standards pose risks to business. Possible pollution of clean water system. Possible tax on discharges may result in financial loss. Waste management system may not be adequate in order to mitigate related risks.	Calcines dump extension project, in excess of R75mil to be completed in Q2'2019.
5	Likely	Possible	Operational - Business Continuity	DE	Lack of / deficient business continuity plan / planning in place in the event of a disaster or loss of critical IT infrastructure or resource. Lack of Business continuity risk assessment and stress testing. Lack of adequate fail-over.	Documented disaster recovery plan in place; Back-up UPS and generator. Back-up tapes are stored in a fireproof safe.
6	Likely	Possible	Operational - Sourcing and Supply of Raw Materials and Energy	SVM	Availability and supply of raw materials (vanadium bearing slag and ore; electricity; coal; ammonium sulphate; nitrogen; soda ash; chemicals; etc.t). Quality of raw materials received and settlement. Cost of raw materials - cost inflation management. Long term supply agreements may not be viable or are not in place in order to adequately protect the interest of the company or meet requirements. Supply continuity (electricity; water and other raw materials). Alternate Nitrogen suppliers not willing to deliver into the current Air Products tanks or lines due to safety concerns.	No alternative electricity supplier other than Eskom. Implementation of multi sourcing arrangements for raw materials. Vametco controls supply of ore (dependant on licence). Materials in short supply (i.e. soda ash, graphite materials) affects pricing. Where certificates are not received with delivery, tests are conducted in the Lab.
7	Almost Certain	Possible	HR - Leadership in key functional roles.	COO HR	Availability of management skills and competencies. Effect of skills shortage and skill drain.	Recruitment practices are focused on and include head hunting from other similar industries.

#	Inherent Risk	Residual risk	Risk Area and Description of the risk	Risk owner	Causes of risk	Related internal controls description
					Increasing cost of available resources. Management competencies in key positions. Skills and knowledge - centralised with IT manager and one other IT resource.	Vanadium skills and competencies will receive a premium. Scarcity allowance is paid for trades. Cross training and transfer of skill and knowledge. IT support services sourced from the market per requirements.
8	Almost Certain	Possible	External Compliance - Labour law	HR	Possible non-compliance to BCEA and other relevant legislation (including transformation objectives). Extended and extension of employment contract results in exposures to the company (Labour Relations Act).	Various controls. Compliance to legislation is monitored on an ongoing basis. Overtime is being monitored on an ongoing basis and controls are in place for identifying and monitoring excessive overtime. Fixed term contractors to be reduced and current contractors will be appointed in permanent positions, where possible.
9	Almost Certain	Possible	Reputational - Corporate / Social Responsibility	COO SLM	Possible penalties or plant stoppages due to non-compliance to Social & Labour Plan and Mining Charter.	SLP implemented and actively managed.
10	Likely	Possible	Operational - Fraud and Ethics	COO	Individual or collective Fraud and/or Corruption committed against the company or by officials acting in capacity as Vametco employees. Lack of appropriate governance structures to support ethical environment and compliance with respective regulations / legislation. Application of governance principals. Ethical environment; management philosophy; etc. Management structures not supportive of tone at the top and governance structures. Perception of governance / ethical climate (own and business). Industry standards and norms; acceptable business practices.	Governance structures are being developed and implemented. Governance / ethical climate and "Bushveld way" is communicated on an ongoing basis. Fraud Hotline rolled out to all employees.
11	Likely	Possible	Operational - Maintenance Risk	COO WM	Possibility that capital plant is not maintained / not maintained in accordance with specification resulting in breakdowns, production stoppages and financial loss. Breakdowns or stoppages preventable by routine maintenance not performed.	Maintenance program is established and operational. Efficient and effective maintenance department and management team.
12	Likely	Possible	Political - Nationalisation of assets (mines)	COO SLM	Possible nationalisation of assets (mine) by the incumbent government.	Active member of the Chamber of Mines in RSA which review proposed government policy.
13	Likely	Likely	Financial - Currency risk; Exchange Rate Risk	CFO	Vametco's exposure to exchange rate fluctuations may affect profitability / margins. Risk-averse markets may	Hedging or other currency instruments are not utilised for sales or purchases.

#	Inherent Risk	Residual risk	Risk Area and Description of the risk	Risk owner	Causes of risk	Related internal controls description
					result in stronger US Dollar and reduced demand, resulting in exaggerated effects on margins.	
14	Almost certain	Unlikely	Health and Safety	SHEQ	Possible injury, harm or death of an employee / contractor. Consequential harm / damage to an employee's health. Production stoppages; closure; fines or other intervention by regulatory authorities resulting in financial loss and production losses. Possible harm to H&S of community and surrounding population. Possible non-compliance to the Mine Health and Safety Act. Nature / state of ageing plant and heightened rate of corrosion of plant (particularly leach plant) may result in safety hazardous to employees. Possible explosions, chemical spills or other operational failure resulting in health and safety exposures. Possible exposures to safety inherent to operation including, mining operations (side walls; trackless machinery and other). Magnetite dump side wall slides and other. Lack of appropriate skills and competence relating to health and safety training may result in H&S exposures to employees and affect business continuity. Technical aspects of safety may not be adequately addressed in order to ensure safety of workforce.	Various controls monitored by the H&S Department and officials. All appropriate PPE is supplied and maintained. Medical surveillance operational. Occupational hygienist appointed highlighting occupational deviations for rectification. Regular risk assessments and inspections performed. COP's are implemented. Monthly surveys are performed at high risk areas. Contractor management program in place which is Audited quarterly. Respective safety measures in mining area adequately mitigating the risk. Retaining wall monitoring system implemented around calcine dump. Other exposures treated as identified.

Note: *COO – Chief Operating Officer; WM – Works Manager; CFO – Chief Financial Officer; ITM – IT Manager; SHEQ – SHEQ Manager; HRM – HR Manager; PRM – Procurement Manager; SVM – Services Manager; SLM – Stakeholder Relationship Manager*

Source: *Modified from Vametco BVA Risk Register (2019)*

9 ORE RESERVE ESTIMATES

On behalf of Bushveld Vametco, MSA has completed an updated Ore Reserve estimate for the Vametco open pit Vanadium Mine, located near to the town of Brits in the North West Province of South Africa.

Vanadium is not an exchange-traded commodity, pricing is instead negotiated by contract between supplier and customer (often through an intermediary trader). Vametco produces a saleable product (Nitrovan^{TM}) on site, which is Vametco's trademark vanadium nitride product and is sold globally to steel mills where it is used as a micro-alloying additive to strengthen steel.

The Ore Reserve estimate is based on the Mineral Resource model and estimate for Vametco completed by Mr Jeremy C. Witley (MSA, Section 7.9).

The Ore Reserve is reported in accordance with the 2012 edition of the Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves, The JORC Code and is classified into the Probable category as shown in Table 9-1 (gross basis) and Table 9-2 (attributable basis) and based on Indicated Mineral Resources only. The Mineral Resources are reported inclusive of Ore Reserves.

MSA has undertaken a mining study and mine plan for Vametco to convert the Mineral Resources to Ore Reserves. The mine plan is deemed to be technically achievable and economically viable. Material modifying factors have been considered in the formulation of the mine plan. The Ore Reserve estimation is derived from a combination of Geovia mine planning products including Whittle, Surpac and mine scheduling software. The Whittle Pit Optimisation software was used to determine the most preferable economically viable pit shell. The pit design was then completed in Surpac taking into consideration all the planning and geotechnical assumptions.

The modifying factors and assumptions considered in the estimation of the Ore Reserves include:

- cost assumptions aligned with the Bushveld Vametco FY 2019 budget (Table 8-5);
- geotechnical parameters for weathered rock (37.8 degrees) and fresh rock (56.95 degrees) types;
- a mining dilution applied based on re blocking the Mineral Resource model to an SMU size of 10.0 mX by 10.0 mY by 5.0 mZ;
- a mining loss of 15% applied based on historical performance at the Vametco Project. Ore Reserve Estimation was done using a combination of Geovia mine planning products including Whittle, Surpac and RPMGlobal mine scheduling software; and
- the average pit depth is less than 100 m below surface.

The choice of pit shell from the Whittle optimisation has a revenue factor of 0.71 which is deemed conservative. There is potential to select a larger pit shell in the future with a higher revenue factor to increase the Ore Reserves post more technical study work. A key consideration for the Ore Reserves is to minimise the waste stripping but ensure sustainable production to align with the expiration of the mining lease in 2038.

9.1 Ore Reserve Statement

The Ore Reserve estimate as at 29 March 2019 is presented in Table 9-1 (gross basis). The Ore Reserve was prepared in accordance with the guidelines of the 2012 Edition of the JORC Code. The reference point for the Ore Reserves is the RoM pad feed to the processing plant before recovery.

The attributable Ore Reserve estimate based on the 74 % shareholding of Bushveld Minerals in Bushveld Vametco Alloys is presented in Table 9-2.

The Ore Reserve estimate was compiled under the direction of Mr. Jonathan Hudson (BSc Hons (Eng.)) who is a mining engineer with 30 years' experience in base and precious metals mining and Ore Reserve estimation and reporting. He is an Associate Principal Mining Engineer for The MSA Group (an independent consulting company), is a Fellow of the South African Institute of Mining and Metallurgy ("SAIMM") and is a Professional Mining Engineer for the Engineering Council of South Africa ("ECSA"). Mr. Hudson has the appropriate relevant qualifications and experience to be considered a "Competent Person" for the style and type of mineralisation and activity being undertaken as defined by the 2012 Edition of the JORC Code.

Table 9-1

Vametco Ore Reserves, 29 March 2019 – Gross Basis

Class	Seam Name	Tonnes	V_2O_5 grade of whole rock	Magnetite grade of whole rock	V_2O_5 grade in magnetite	Tonnes V_2O_5 in magnetite	Tonnes V in magnetite
		(Millions)	%	%	%	(Thousands)	(Thousands)
Probable	Upper	0.96	0.58	27.3	1.78	4.6	2.6
	Intermediate	7.23	0.53	23.7	1.89	32.3	18.1
	Lower	40.23	0.63	29.4	2.05	242.1	135.6
	Total	**48.43**	**0.62**	**28.5**	**2.02**	**279.1**	**156.3**

Notes:

1. *All tabulated data have been rounded and as a result minor computational errors may occur.*
2. *Ore Reserve tonnes and grades reported on dry ROM (plant feed) basis after mining modifying factors have been applied but before beneficiation down-stream recoveries/losses have been applied.*
3. *Reporting was prepared on a Mineral Resource model developed by MSA.*
4. *Reported on a Gross Basis. Bushveld Minerals shareholding in Vametco Alloys is 74 %.*
5. *Ore Reserve tonnes depleted as at 29 March 2019.*

Table 9-2

Vametco Ore Reserves, 29 March 2019 - Attributable Basis

Class	Seam Name	Tonnes	V_2O_5 grade of whole rock	Magnetite grade of whole rock	V_2O_5 grade in magnetite	Tonnes V_2O_5 in magnetite	Tonnes V in magnetite
		(Millions)	%	%	%	(Thousands)	(Thousands)
Probable	Upper	0.7	0.58	27.3	1.78	3.4	1.9
	Intermediate	5.4	0.53	23.7	1.89	23.9	13.4
	Lower	29.8	0.63	29.4	2.05	179.2	100.3
	Total	**35.8**	**0.62**	**28.5**	**2.02**	**206.5**	**115.6**

Notes:

1. *All tabulated data have been rounded and as a result minor computational errors may occur.*
2. *Ore Reserve tonnes and grades reported on dry ROM (plant feed) basis after mining modifying factors have been applied but before beneficiation down-stream recoveries/losses have been applied*
3. *Reporting was prepared on a Mineral Resource model developed by MSA*
4. *Reported on an Attributable Basis. Bushveld Minerals shareholding in Vametco Alloys is 74 %.*
5. *Ore Reserve tonnes depleted as at 29 March 2019.*

9.2 Previous Ore Reserve Estimates

The previous Minerals Reserve estimates are discussed in Section 4.4.

9.3 Comparison between MSA 2017 (06 October 2017) Ore Reserve estimate and the current estimate (29 March 2019)

The total Ore Reserve tonnes estimated is 48.4 Mt which is an increase of 22.31 Mt (85 % increase) in the Ore Reserve tonnage compared to the 2017 Ore Reserve (JORC 2012) declaration due to the following:

- the Mineral Resource definition work on the Intermediate and Upper seams resulted in reclassification to the Indicated Mineral Resource category. This resulted in the estimation of an additional 8.19 Mt of Probable Ore Reserves within the selected pit design;
- the additional 14.12 Mt Probable Ore Reserves from the Lower seam is due to the larger pit shell from the whittle pit optimisation based on the overall improved economics;
- a lower strip ratio (0.66) as a result of the Intermediate and Upper seams being classified as ore and not waste;
- an improved vanadium price from 28.5 to 37.5 US$/kg V;
- the magnetite grade increased from 26.8 % to 28.5 % as a result of the increased magnetite grade in the Mineral Resources; and
- the vanadium grade (V_2O_5 %) of magnetite has increased overall by 3 % mainly due to an increase in the Mineral Resource estimate of the Lower Seam

A comparison of the MSA 2017 and 2019 Mineral Resource estimates is summarised in Table 7-13.

Table 9-3
Comparison between MSA 2017 Ore Reserve and the MSA 2019 Ore Reserve (JORC 2012) estimates for Vametco (gross basis)

		MSA 2017			MSA 2019		
Class	**Seam Name**	**Tonnes (millions)**	**Magnetite grade of whole rock (%)**	**V_2O_5 grade of magnetite (%)**	**Tonnes (millions)**	**Magnetite grade of whole rock (%)**	**V_2O_5 grade of magnetite (%)**
Probable	Upper	-	-	-	0.96	27.3	1.78
	Intermediate	-	-	-	7.23	23.7	1.89
	Lower	26.12	26.79	1.96	40.23	29.4	2.05
	Total	**26.12**	**26.79**	**1.96**	**48.43**	**28.5**	**2.02**

Notes:

1. *All tabulated data has been rounded therefore minor computational errors may occur.*
2. *The Ore Reserves are inclusive of Mineral Resources.*

9.4 Assessment of Reporting Criteria

Criteria for assessing this Ore Reserve estimate are presented in Appendix 3, which includes the relevant aspects of Table 1 of the JORC Code (2012).

10 OTHER RELEVANT INFORMATION

10.1 Adjacent Properties

The Bushveld Minerals Brits Vanadium Project, comprising new order prospecting rights and a mining right application, is located immediately to the east of the Vametco MRA (Table 10-1).

Table 10-1
Brits Vanadium Project prospecting rights and mining right application

Farms	Mineral Rights
Portion 3 of Uitvalgrond 431 JQ	Prospecting right for vanadium (application to include iron ore and rutile granted by not yet executed)
Portion 2 of Uitvalgrond 431 JQ; Syferfontein 430 JQ	Mining right application
Remainder of Doornpoort 295JR	Prospecting right for vanadium, iron ore and rutile

The Brits vanadium project is a greenfield exploration project. Bushveld Minerals is in the process of securing regulatory approval in terms of Section 11 of the MPRDA for a change in control pursuant to Bushveld acquisition of the Project from Sable Metals and Mining Limited, a South African-based resources company.

The Brits vanadium Project is an extension along strike of the Vametco Project. As at the Vametco Project, the Upper, Intermediate and Lower seams outcrop over several kilometres.

11 INTERPRETATION AND CONCLUSIONS

Vametco Mine has been operating since 1967. The mining method and plant processes are well-understood and have delivered tangible result since mining started. The input factors into the financial model are well known and are based on actual cost and income generated by the mine.

11.1 Geology and Mineral Resources

The geology of the area is well understood. In the CP's opinion (Mr J Witley), the Mineral Resource reported herein has reasonable prospects for eventual economic extraction, given that it is an integrated operating mine and processing plant, with a market for the vanadium product.

11.2 Mining and Ore Reserves

MSA has undertaken a mining study and mine plan for Vametco to convert the Mineral Resources to Ore Reserves. The mine plan is deemed to be technically achievable and economically viable.

The total Ore Reserve tonnes estimated is 48.4 Mt which is an increase of 22.31 Mt (85 %) in Ore Reserve tonnage compared with the 2017 Ore Reserve (JORC 2012) declaration.

A build up to a process feed rate of 1.5 Mpta of run of mine to the plant was used by MSA. There is potential to increase the run of mine feed rate to the milling circuit. The key constraint in the process plant is the feed rate through the kiln. Vametco are investigating the potential to increase the kiln feed rate. Until this Pre-Feasibility / Feasibility level of study work has been proven and completed, MSA have the view that the current mine plan is able to support a build up to approximately 3,400 mtV p.a. of Nitrovan™.

There is limited risk with the mine design and production profile which is in line with the 2019 budget of 1.5 Mpta RoM feed to the plant. MSA have identified some mining risks which may affect the delivery of 3,400 mtV p.a. of Nitrovan™ but these are considered manageable and mitigation measures have been recommended and/or are already in place.

11.3 Metallurgical (Processing / Recovery)

The Vametco processing plant receives ore from the co-located open pit mine. The metallurgical process is well-tested in a steady state ongoing operation. No metallurgical testwork is required.

The processing plant has historically performed satisfactorily with a recent annual production history of around 2,600 mtV p.a. Nitrovan™. A study as to the current indicated sectional maximum throughputs indicates that some of the sections would become limiting at an annual tonnage throughput of 1.5 Mtpa for a production of around 3,400 mtV p.a. Nitrovan™.

Measures to increase the hourly throughput, improve thermal efficiencies and limit downtime in the kiln section are currently being considered.

As Bushveld Vametco have future plans to potentially increase production (Phase 3 plant expansion to >4,300 mtV p.a. Nitrovan™), a Pre-Feasibility / Feasibility level study is underway to determine the requirements and necessary changes to the process flow to attain the potential increased production.

11.4 Environmental and Social

Some material social and environmental risks have been identified that could impact on the resource or its continued extraction. These include:

- ground water contamination and the effectiveness of the containment initiatives underway;
- the required backfill strategy and the related mining and financial implications thereof;
- compliance with WUL, Waste Management and Atmospheric Emissions authorisation conditions for monitoring and reporting;
- closure of the DMR Section 93 Directive relating to the completion of the 2013-2018 SLP Action plan deliverables;
- submission of the 2018 to 2022 SLP;
- confirmation of the Mine Closure Liability provisioning meeting the new 2018 assessment values;
- the management and disposal of ash material from the coal-based heating operations requires monitoring as the historical ash offtake by an external 3rd party is no longer in effect. There is currently no planned disposal area for the ash; in the interim, the ash can be disposed of on the magnetite (calcine) dump which is lined however this is not ideal; and
- confirmation of the scope of the possible Phase 3 expansion such that the new authorisations are applied for in good time before implementation and do not become a delay for the Project.

11.5 Market Outlook

The market outlook for Vanadium products (ferrovanadium and vanadium pentoxide) varies between different analysts, especially for the short to medium term. Long term forecasts vary from USD 33 to USD 50 /kg FeV, from which a consensus price of USD 40 /kg FeV is selected. Short to medium term forecasts may be as high as USD 54 to as low as USD 21 /kg FeV. MSA's consensus prices vary between USD 41.58 /kg FeV (2020) and USD 46.06 /kg FeV (2022).

Research by Roskill (2019) has shown that there is a very strong linear relationship between ferrovanadium and V_2O_5 prices, indicating that one product may be used as a proxy for the other when analysing price data.

From inspecting various production cost curves, it appears that Vametco is comfortably within the lower half of the cost curve and should be able to maintain a position or improve this position going forward.

11.6 Economic Evaluation

A detailed discounted cash flow model was constructed to evaluate in real money terms the economics of the Vametco Mine operations as a production entity. Taxes, royalties and capital expenditure redemption were evaluated in nominal terms to ensure better accuracy of these cost lines. Operating costs are based on actual achieved results.

The base case real NPV of USD 371.0 million is based on a 10 % discount rate. Sensitivity analyses indicate that the operation is most sensitive to revenue, with a 15 % decrease in FeV prices causing the NPV to reduce by 30 %. The operation is moderately sensitive to operating costs, with a 15 %

increase in costs triggering a 17 % drop in NPV. Sensitivity to exchange fluctuations is modest, with a 15 % strengthening of ZAR vs USD resulting in only a 14 % reduction in NPV.

This analysis implies that Vametco may be expected to weather adverse operating and trading conditions well.

12 RECOMMENDATIONS

There is potential to deepen the open pit in excess of 100 m and extend the life of mine and Ore Reserves post additional Geotechnical feasibility and scenario planning work. It is recommended that this Geotechnical work be completed and additional pit design scenarios run to compare the economic impact of a deepened pit with the current mine plan.

It is suggested that a Reverse Circulation ("RC") drilling based grade control programme be considered, instead of the current blast hole sampling, in order to improve orebody understanding, mine planning and dilution control. A trade-off study comparing the costs and benefits of RC drilling with blast hole sampling is recommended for consideration.

Capacity bottlenecks in the plant for the 2019 to 2020 ramp-up have been identified on a section basis. Work is ongoing to determine where the process is likely to be constrained as increasing the plant vanadium output would imply increasing the magnetite tonnage to the mills, increasing the V grade in magnetite and/or increasing the vanadium recovery.

It has been noted that the leach recovery has shown a decline from 2017 to 2019. The cause of this is currently unknown and requires investigation. Although not approaching maximum availability, increasing the kiln availability from the current 69 % to 82 % is likely to be the major constraint to increasing the overall plant output. If kiln availability cannot be substantially increased, it may not be possible to increase the hourly throughput from the 66 tph envisioned in the mass balance. No engineered solutions to achieve this are currently in place; however Bushveld Vametco have indicated that availability could be increased using the same equipment at increased efficiencies or with relatively modest changes to the kiln setup, and that downstream plant bottlenecks would be engineered out as required. Bushveld Vametco have commissioned a process and mechanical audit of the salt roast kiln and cooler system in order to address the above.

Should Bushveld Vametco commence work on the planned plant expansion, the relevant environmental and related permitting will need to be in place before the expansion plans can be effected. It is critical that the timing of the environmental and related authorisations be considered in the expansion planning and scheduling.

The stay in business capital was calculated as 5.4% of working costs which equated to ZAR 39.6M in 2019 and ZAR 56.25M in 2020. MSA proposes that 8% of the working capital will be more appropriate.

13 QUALIFICATIONS OF COMPETENT PERSONS', COMPETENT VALUATOR AND DATE AND SIGNATURE PAGE

This report titled "Competent Persons' Report on the Vametco Vanadium Mine, North West Province, South Africa" with a Mineral Resource and Ore Reserve effective date of 29 March 2019, prepared by MSA on behalf of Bushveld Minerals Limited (BMN) and Bushveld Vametco Alloys (Pty) Ltd dated 10 January 2010 was prepared and signed by the Competent Persons:

"Signed"

Dated at Johannesburg, South Africa
10 January 2010

Jeremy Charles Witley
B.Sc. Hons. (Mining Geology); M.Sc. (Eng.).
Pr.Sci.Nat., FGSSA
Head of Department – Mineral Resources
The MSA Group (Pty) Ltd

"Signed"

Dated at Johannesburg, South Africa
10 January 2010

Jonathan Hudson
B.Eng. Hons. (Mining Engineering); MBA
Pr.Eng., FSAIMM
Associate Principal Mining Engineer
The MSA Group (Pty) Ltd

"Signed"

Dated at Johannesburg, South Africa
10 January 2010

Trevor Rangasamy
B.Sc. (App. Geol.), GDE (Mining), M.Sc. (Eng.)
Pr.Eng., FSAIMM
Associate Principal Geotechnical Engineer
The MSA Group (Pty) Ltd

"Signed"

Dated at Johannesburg, South Africa
10 January 2010

John Derbyshire
B.Sc. Eng. (Chem.)
Pr.Eng., FSAIMM
Associate Principal Metallurgical Consultant
The MSA Group (Pty) Ltd

"Signed"

Dated at Johannesburg, South Africa
10 January 2010

Richard David Garner
B.Sc., B.Sc. Hons. (Plant Ecology), M.Sc. (Ecology and Biodiversity)
Pr.Sci.Nat. (Botanical Science and Environmental Science)
Head of Department – Environmental Sciences
The MSA Group (Pty) Ltd

"Signed"

Dated at Johannesburg, South Africa
10 January 2010

André van der Merwe
B.Sc., B.Sc. Hons. (Geophysics), Grad. Dip. Engineering (Mining).
Pr.Sci.Nat., FGSSA, MAusIMM
Head of Department – Mining Studies
The MSA Group (Pty) Ltd

14 REFERENCES

BMO. (2019). BMO Global Commodities Research. Vanadium: Demand Reinforces Fundamental Outlook. 18 March 2019.

Bushveld Minerals, (2018). VAMETCO 5 YEAR OPEN PIT MINE - PROGRESSIVE BACKFILLING PLAN. Compiled by: Troth N. Saindi (Project Geologist). 10th September 2018.

Bushveld Vametco, (2017). Bushveld Vametco Holdings Social and Labour Plan, 2017 Annual Progress Report. DMR Ref: NW/30/5/1/2/5/2/08 SLP. 24pp.

Bushveld Vametco, (2019). Draft Social and Labour Plan. 5 Year Plan – Plan #2 2018 – 2022. **DRAFT 1.Bushveld Vametco Alloys**, (2019). Response Letter to Department of Mineral Resources: Instruction in terms of Sections 93 (1)(b)(i) of the Mineral and Petroleum Development Act, 2002 (Act 28): Bushveld Vametco Holdings (Pty) Limited. Detailed Action Plan by Bushveld Vametco Alloys Social and Labour Plant 2012-2016. Dated 24/05/2019.

Bushveld Vametco BVA Risk Register, (2019) BVA Risk Register. BVA Business Risk Register.xlsx, provided by Bushveld Vametco.

Cawthorn, R.G., Eales, H.V., Walraven, F., Uken, R. and **Watkeys, M.K.** (2006).The Bushveld Complex. In: Johnson. M.R., Anhaeusser, C.R. & Thomas, R.J. (eds.) The geology of South Africa, pp. 261-281. Geological Society of South Africa, Johannesburg & the Council for Geoscience, Pretoria.

Clay, A.N., Orford, T.C., Dyke, S., Myburgh, J.A., and **Mphahlele, K.,** (2014). Independent Competent Persons' Report on the Moeijelijk Chromite Mineral Asset prepared or Bauba Platinum Limited. 108 pp.

Cort & Fred Consulting Engineers (Pty) Ltd (2018). External Audit Report: Assessment of Compliance to the EMPr in Terms of Regulation 55 of Mining Regulations 527 (23/04/2004), Published Under the Mineral and Petroleum Resources Development Act (EMPr Performance Assessment Report). June 2018.

Governmental Gazette No. 42464. (May 2019). Proposed Regulations Pertaining to Financial Provisioning for the Rehabilitation and Remediation for Environmental Damage Caused by Reconnaissance, Prospecting, Exploration, Mining or Production Operations. Page 88 – 124

Bohlsen, M. (2018). A Brief Update On The Vanadium Boom. 3 December 2018.

BMN (2018). Bushveld Minerals – Annual Report and Financial Results 2018. 112 pp.

CIA Factbook (2019). The World Factbook: Africa – South Africa. Accessed April 2019 <https://www.cia.gov/library/publications/the-world-factbook/geos/sf.html>

Department of Mineral Resources. (2008). An Overview Of South Africa's Vanadium Industry During The Period 1997-2006. Report R55/2008.

Department of Mineral Resources, (2019). Letter: The SHE Manager Bushveld Minerals: Revised Quantum for Financial Provision for Remediation of Environmental Damage – Confirmation of Reports & issuance of EMPr PAR and MC Assessment. 5th April 2019.

Department of Water and Sanitation, (2017), Water Use License No. 04/A21J/ABCFGIJ/4669, File No. 27/2/2/A921/20/1 issued in terms of Chapter 4 of the National Water Act, 1998 (Act 36 0f 1998), 31 May 2017.

Ellis International Services, Inc. (2011). Market Valuation of the Fair Value of the Minerals Estate Interest held by Natural Resource Holdings Ltd, in the Suni Iron Property, Ontario, Canada. Compiled by Trevor R Ellis and Daniel L Collins. 7 April 2011, 88 pp.

ESCON Consulting (Pty) Ltd, (2019). Regulation GN. 704 Audit Report of Bushveld Vametco Alloys, File No. 27/2/2/A921/20/1. Issued February 2019.

ESCON Consulting (Pty) Ltd, (2019). Groundwater Flow Model and Remediation Progress Report 01 July 2017 to 31 December 2018 of Bushveld Vametco Alloys, File No. 27/2/2/A921/20/1. Issued March 2019.

ESCON Consulting (Pty) Ltd (2018): Annual Water Quality Monitoring Report (01 July 2017 to 30 June 2018). November 2018.

Glencore (2019). Mt Owen Mining Schematic. Accessed on <http://www.mtowencomplex.com.au/en/mining-infrastructure/Pages/mining-methods.aspx>, April 2019

GuardRisk Insurance Company Limited, (2019). Endorsement N. 01/19 issued in the name of Bushveld Vametco Holdings (Pty) Limited. Policy Amendment as at the 25th of February 2019.

GuardRisk Insurance Company Limited, (2019). Letter to the Regional Director of Department of Minerals and Energy: Financial Guarantee for the Rehabilitation of Land Disturbed by Mining. Ref. NW30/5/1/2/2/08(MR). 25th February 2019.

Haines, A. and Terbrugge, P. J. (1991). Preliminary estimation of rock slope stability using rock mass classification systems. Proc. 7th Int. Conf. Int. Soc. Roc Mech., Aachen, Germany, Volume 2, 1991, Balkema, pp 887 - 892.

IMF (2019) International Monetary Fund – World Economic Outlook Database, April 2019. Accessed April 2019 on <https://www.imf.org/external/pubs/ft/weo/2019/01/weodata/index.aspx>.

JMA (2015). Evraz Vametco Environmental Impact Assessment (EIA, compiled by JMA Consulting (Pty) Ltd. 547 pp. excluding appendices.

JMA (2015). Bushveld Vametco Alloys (Pty) Ltd Closure Cost Report. JMA Project: JMA/30035, JMA Report: Prj6170. JMA Consulting (Pty) Ltd Date: December 2018

JOAN Consulting (Pty) Ltd, (2019). Bushveld Vametco Alloys Environmental Performance Assessment (Audit) Report. Date: 14 May 2019.

JORC Code (2012). Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves, The JORC Code, 2012 Edition. 44pp. (http://www.jorc.org/docs/jorc_code2012.pdf)

Lawrence, M., (1994). An overview of valuation methods for exploration properties. Mineral Valuation Methodologies 1994 (VALMIN '94), pp. 205-223.

Low, A.B. and Rebelo, A.(T,)G., (1996). Vegetation of South Africa, Lesotho and Swaziland. A companion to the vegetation map of South Africa, Lesotho and Swaziland. Dept. of Environmental Affairs and Tourism, Pretoria.

LSE, (2009). AIM Note for Mining, Oil and Gas Companies, June 2009. London Stock Exchange. 16 pp. Accessed January 2020 on < https://www.londonstockexchange.com/companies-and-advisors/aim/advisers/rules/guidance-note.pdf >

Macquarie Capital, (2019). Vanadium Outlook: Strenghtened by China's Reforms. 13 March 2019.

Mining Weekly Online. (2016). Bushveld signs agreement to buy Vametco for $17.2m. 9 May 2019. Accessed May 2019 on <www.miningweekly.com>

MPRDA, (2002). Republic of South Africa. Mineral and Petroleum Resources Development Act No. 28 of 2002.

MSA (2011) The MSA Group: Integrated Water and Waste Management Plan. Project Code J2053. June 2011.

Mucina, L. and Rutherford, M.C. (eds.). 2006. The Vegetation of South Africa, Lesotho and Swaziland.

Municipal Air Quality Officer: Everaz Vametco Alloys (Pty) Ltd, (2015). Atmospheric Emission License in terms of Sections 47(1) of the National Environmental Management: Air Quality Act, 2004 (Act 39 of 2004). License Number: NWPG/VAMETCO/AEL 4.18/FEB13. Date: 31/03/2015.

National Department of Environmental Affairs, (2014). Certificate of Registration in terms of chapter 6 of the National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008). Ref Number D04401-01. Date of Registration: 2014-06-06.

National Department of Environmental Affairs (2016).: Waste Management License in terms of the National Environmental Management Act 59 of 2008. Recovery and Disposal of Hazardous Waste and the Construction of a Storage Facility. License Number 12/9/11/L44253/7, Date of issue 9/3/2016

National Environmental Management: Biodiversity Act, (2004). Republic of South Africa. National Environmental Management: Biodiversity Act No. 10 of 2004.

National Environmental Management: Protected Areas Act, (2003). Republic of South Africa. National Environmental Management: Protect Areas Act No. 57 of 2003.

NEMA, (1998). Republic of South Africa. National Environmental management Act No. 107 of 1998.

NEM:AQA, (2004). Republic of South Africa. National Environmental Management: Air Quality Act No. 39 of 2004.

NEM:WA, (2008). Republic of South Africa. National Environmental Management: Waste Act No. 59 of 2008

NWA, (1998). Republic of South Africa. National Water Act No. 36 of 1998.

SAMREC, (2009). SAMCODE – the South African Mineral Codes as amended July 2009. SAMREC - The South African Code for the Reporting of Exploration Results, Mineral Resources and Mineral Reserves (The SAMREC Code) 2007 Edition as amended July 2009 and SAMVAL – The South African Code for the Reporting of Mineral Asset Valuation (The SAMVAL Code) 2008 Edition, as amended July 2009, 64 pp (http://www.samcode.co.za/downloads/SAMREC2009.pdf)

Sam Mtileni E-mail: (Vametco SHE Manager) (2019). : Engineer Submission of Designs to DEA. 29th May 2019.

South African National Biodiversity Institute, Pretoria, South Africa. (808 pp with CD GIS-database)

PWC (2018) SA Mine 2018, 10th edition. Highlighting trends in the South African Mining Industry. PwC, 54 pp.

Roskill, (2019). Vanadium Outlook to 2028. 5 March 2019.

Rutherford, M.C. & R.H. Westfall. (1986). The biomes of Southern Africa – an objective categorisation. Memoirs of the Botanical Survey of South Africa 51: 1–98.

SP Angel (2018). Commodity Research Note. Vanadium. Q1 2018.

SRK Consulting, (2011). Tenement Valuations, Report Prepared for Legacy Iron Ore Limited. August 2011, 76 pp.

Vametco SLP Implementation Status, (November 2018).

Vametco Consolidated Integrated Water Use Licence (23 February 2016). Reference number 04/B12B/ACFGIJ/4115

Van der Merwe, A.J. and Erasmus, J.F., (2006). Ounces into pounds – how much is an *in situ* ounce of platinum worth? International Platinum Conference 'Platinum Surges Ahead', The Southern African Institute of Mining and Metallurgy. Pp 11-16

Viljoen M.J. and Schurman, L.W. (1998) Platinum-group metals. In: Wilson MGC and Anhaeusser CR (eds) The mineral resources of South Africa. Council for Geoscience, Pre loria, pp 532-568

WEAR Check Condition Monitoring Specialists (2018): Transformer Technical Summary and Analysis Reports. Dispatch notes: SW15645 & A – 16 & 12 & /11/2017 & SW16797B & C – 24 & 25/05/2018 & SW17849 - 17/12/2018

APPENDIX 1: UNITS OF MEASURE, ACRONYMS AND ABBREVIATIONS

Units of measure, acronyms and abbreviations

ADT	Articulated dump truck
AIM	Alternative Investment Market
ALS	ALS Global (Edenvale, Johannesburg, South Africa)
AMV	Ammonium Metavanadate
BBBEE	Broad Based Black Economic Empowerment
BMN	Bushveld Minerals Limited
Bushveld Vametco	Bushveld Vametco Alloys (Pty) Lt
CaO	Calcium
cm	centimetre
CP	Competent Person
CPIX	Consumer price index excluding mortgage costs
CPR	Competent Persons Report
CRM	Certified Reference Material
CV	Competent Valuator
DD	Diamond Drilling
DEA	Department of Environmental Affairs
DMR	Department of Mineral Resources
DTM	Digital terrain model
dtph	Dry tonnes per hour
DWS	Department of Water and Sanitation
EIA	Environmental Impact Assessment
EMPr	Environmental Management Programme
ESG	Environmental and Social Governance
EOH	End of Hole
FEL	Front end loader
ha	hectare
HDSA	Historically Disadvantaged South Africans
HSLA	high-strength, low-alloy
IAPs	Interested and Affected Parties
IRR	Internal Rate of Return
IS	Intermediate Seam
IWUL	Integrated Water Use Licence
kV	Kilovolt
JORC Code	Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves, The JORC Code, 2012 Edition.
JSE	Johannesburg Stock Exchange
LGS	Lebowa Granite Suite
LS	Lower Seam
LSE	London Stock Exchange
m	metre
Ma	Million years
magsep	Magnetic separation
MPa	Megapascal
MPRDA	Mineral and Petroleum Resources Development Act (Act 28 of 2002)

MRA	Mining Right Area
MSA	The MSA Group (Pty) Ltd
Mt	Million tonnes
mtV	Metric tonnes vanadium
Mtpa	Million tonnes per annum
MVO	Modified Vanadium Oxide
Nedbank	Nedbank Limited, acting through its Nedbank Corporate and Investment Banking Division
NEMA	National Environmental Management Act (Act 107 of 1998)
NEM:AQA	National Environmental Management: Air Quality Act (Act 39 of 2004)
NEM:WA	National Environmental Management: Waste Act (Act 59 of 2008)
NV	Nitrovan
NWA	National Water Act (Act 36 of 1998)
NWDEDET	North-West Department of Economic Development, Environment and Tourism
p.a.	Per annum
PAR	Performance Assessment Report
PCB	Poly-chlorinated by-phenols
PD	Percussion Drilling
PGM	Platinum Group Metals
Project Jock	Planned listing of BMN on the JSE
QAQC	Quality Assurance Quality Control
RC	Reverse Circulation
The Report	CPR or the Competent Persons Report
RGS	Rashoop Granophyre Suite
RLS	Rustenburg Layered Suite
RMB	First Rand Bank Limited, acting through its Rand Merchant Bank Division
ROD	Record of Decision
RoM	Run of Mine
Royalty Act	The Mineral and Petroleum Resources Royalty Act (2008)
RSIP	Rehabilitation Strategy and Improvement Plan
SAMREC Code	The South African Code for the Reporting of Exploration Results, Mineral Resources and Mineral Reserves (The SAMREC Code) 2007 Edition as amended July 2009
SANAS	South African National Accreditation System
SI	Système international (d'unités) or International System of Units
SiO_2	Silica
SLP	Social and Labour Plan
SMC	Strategic Minerals Corporation
SMU	Smallest Mining Unit
SRP	Salt Recovery Plant

SWMP	Storm Water Management Plan
t	tonnes
tpa	Tonnes per annum (metric)
The Company	Bushveld Vametco Alloys (Pty) Ltd
µm	Micrometre
UIS	UIS Analytical Services (Centurion, South Africa)
US	Upper Seam
WACC	Weighted average cost of capital
WRD	Waste Rock Dump
wtph	Wet tonnes per hour
XRF	X-ray fluorescence
ZAR	South African Rand

APPENDIX 2: A SUMMARY OF DRILLHOLE DATA FROM THE VAMETCO PROJECT

Appendix 2: a summary of drillhole data from the Vametco Project

Drillhole Name	Dip	Azimuth	Max Depth (m)	Drillhole Collar Coordinates (m) WGS84 LO29		
				X	Y	Z
KR1	-90	000	35.05	88268.9	-2829133.6	1147.7
KR10	-90	000	69.54	88151.0	-2829222.6	1147.0
KR11	-90	000	51.85	88069.6	-2829120.4	1145.4
KR12	-90	000	70.15	88265.9	-2829092.0	1146.3
KR7	-90	000	133.56	88423.9	-2829075.9	1150.3
KR8	-90	000	41.6	88269.9	-2829268.3	1149.4
KR9	-90	000	45	88026.2	-2829242.4	1146.4
UI1	-90	000	135.65	88903.2	-2829127.5	1149.5
UI10	-90	000	44.25	90381.6	-2829744.9	1156.8
UI13	-90	000	49.36	89230.0	-2829476.6	1152.8
UI14	-90	000	48.5	89818.1	-2829623.4	1157.1
UI15	-90	000	59.29	90622.0	-2829861.9	1156.9
UI16	-90	000	62.1	90110.1	-2829649.6	1157.1
UI17	-90	000	48.57	91058.0	-2829917.5	1159.5
UI18	-90	000	67.93	91309.9	-2829744.9	1160.5
UI2	-90	000	128.32	90429.9	-2829505.0	1149.5
UI20	-90	000	10.98	89259.4	-2829607.4	1153.8
UI21	-90	000	10.06	89180.8	-2829571.8	1153.0
UI22	-90	000	15.54	89473.3	-2829661.6	1155.5
UI23	-90	000	9.14	89566.1	-2829689.2	1156.5
UI24	-90	000	9.75	89645.9	-2829704.5	1157.4
UI25	-90	000	69.24	89381.6	-2829465.6	1152.6
UI27	-90	000	69.23	90562.5	-2829735.5	1155.9
UI28	-90	000	66.18	90895.5	-2829880.7	1158.4
UI29	-90	000	82.35	91202.2	-2829885.8	1160.3
UI30	-90	000	77.47	89069.3	-2829382.0	1152.5
UI31	-90	000	73.81	88758.0	-2829300.7	1151.7
UI32	-90	000	91.8	88483.7	-2829144.3	1147.1
UI33	-90	000	62.52	88683.5	-2829129.7	1147.0
UI35	-90	000	29.29	89185.3	-2829181.8	1150.3
UI36	-90	000	33.85	89356.9	-2829290.7	1150.9
UI37	-90	000	39.65	89588.3	-2829374.4	1152.7
UI38	-90	000	28.67	89886.5	-2829387.8	1153.8
UI39	-90	000	35.07	90151.1	-2829483.2	1154.7
UI40	-90	000	35.07	90451.4	-2829518.2	1154.1
UI41	-90	000	64.96	89095.8	-2829219.8	1150.6
UI42	-90	000	46.66	89232.4	-2829316.3	1150.7
UI43	-90	000	45.75	89473.6	-2829415.5	1152.6
UI44	-90	000	54.9	89759.6	-2829458.3	1154.7
UI45	-90	000	41.17	90134.4	-2829567.5	1155.9
UI46	-90	000	19.82	90383.0	-2829617.6	1155.2
UI5	-90	000	164.59	89609.0	-2829216.8	1151.9
UI6	-90	000	276.45	88593.9	-2828616.1	1143.8
UI7	-90	000	32.31	88492.8	-2829343.0	1151.9
UI8	-90	000	37.49	88911.7	-2829509.5	1155.0
UI9	-90	000	57.72	89525.5	-2829544.0	1154.4
VA1	-90	000	135.08	89289.6	-2829238.7	1151.4
VA2	-90	000	142.06	89486.0	-2829271.2	1151.6
VA3	-90	000	138.22	89675.6	-2829308.5	1152.9
VA4	-90	000	138.66	89918.2	-2829371.2	1149.6
VA5	-90	000	134.98	90147.8	-2829419.4	1153.9
VA6	-90	000	133.95	90382.0	-2829471.0	1155.2
VM001	-90	000	90.35	91228.5	-2829897.3	1158.1
VM002	-90	000	97.86	91060.5	-2829773.1	1158.8
VM003	-90	000	120.34	90758.3	-2829694.4	1157.0
VM004	-90	000	117.88	90223.5	-2829488.2	1154.3
VM005	-90	000	125.01	89917.2	-2829404.8	1149.3
VM006	-90	000	160.78	90654.1	-2829536.8	1155.9
VM007	-90	000	75.79	89626.6	-2829290.4	1151.8

Drillhole Name	Dip	Azimuth	Max Depth (m)	Drillhole Collar Coordinates (m) WGS84 LO29		
				X	Y	Z
VM008	-90	000	118.86	89347.6	-2829291.4	1150.8
VM009	-90	000	133.94	89170.0	-2829199.2	1150.5
VM010	-90	000	146.62	88939.5	-2829107.0	1148.3
VM011	-90	000	103.52	88596.1	-2829148.0	1147.6
VM012	-90	000	108.36	88379.4	-2829112.8	1146.7
VM013	-90	000	107.04	90953.2	-2829726.8	1158.1

APPENDIX 3: JORC CODE 2012, TABLE 1

Section 1 Sampling Techniques and Data

(Criteria in this section apply to all succeeding sections.)

Criteria	JORC Code explanation	Commentary
Sampling techniques	• *Nature and quality of sampling (e.g. cut channels, random chips, or specific specialised industry standard measurement tools appropriate to the minerals under investigation, such as down hole gamma sondes, or handheld XRF instruments, etc). These examples should not be taken as limiting the broad meaning of sampling.* • *Include reference to measures taken to ensure sample representivity and the appropriate calibration of any measurement tools or systems used.* • *Aspects of the determination of mineralisation that are Material to the Public Report.* • *In cases where 'industry standard' work has been done this would be relatively simple (e.g. 'reverse circulation drilling was used to obtain 1 m samples from which 3 kg was pulverised to produce a 30 g charge for fire assay'). In other cases more explanation may be required, such as where there is coarse gold that has inherent sampling problems. Unusual commodities or mineralisation types (e.g. submarine nodules) may warrant disclosure of detailed information.*	**New Exploration Drillholes sampling techniques** • The mineralisation was sampled using diamond cored drillholes. 12 drillholes out of the 13 drillholes collared were used for the geological model for the three magnetite-rich layers on the property: the Upper, Intermediate and Lower Seam. One drillhole was excluded as it did not intersect mineralisation, it being incorrectly collared. • The sampling start and end positions were based on the lithological contacts and / or the occurrence of significant magnetite concentration. High grade zones (magnetite concentration >20 %) were identified and the sample interval was limited to a maximum interval of 0.5 m and minimum interval of 0.3 m and the low-grade zones (magnetite concentration <20 %) were sampled to a maximum of 1.0 m. Where the magnetite concentration fell below 10 %, the sample interval was increased to a maximum of 2.0 m. • 50 % of all samples taken were equal to or less than 0.50 m in length. The intervals were varied to respect geological boundaries. • Cores were cut longitudinally in half using a rotating diamond saw blade and one half was submitted for analysis. **Historical Drillholes sampling techniques** • The mineralisation was sampled using diamond cored drillholes. A total of 65 holes were drilled vertically or inclined downwards between 46° and 58° in a south-westerly direction. 52 drillholes had adequate information to use in the geological model and 37 were used for the Upper, Intermediate and Lower Seam grade estimate. 15 drillholes were excluded for a number of reasons such as: no magnetite concentrate assays or missing survey data. The positions of these excluded holes were

Criteria	JORC Code explanation	Commentary
		examined and they were found to be in close proximity to the holes that were accepted and so no impact on the overall drilling grid occurred. • The position where sampling of the core commenced and ended for each layer was based on the occurrence of significant magnetite concentration defined as greater that approximately 20%. Low grade zones (magnetite concentration <20 %) were identified and analysed for magnetite content but were not always assayed for V_2O_5, SiO_2 and CaO. • 50 % of all samples taken were equal to or less than 0.30 m in length. The intervals were varied to respect geological boundaries.
Drilling techniques	• *Drill type (e.g. core, reverse circulation, open-hole hammer, rotary air blast, auger, Bangka, sonic, etc) and details (e.g. core diameter, triple or standard tube, depth of diamond tails, face-sampling bit or other type, whether core is oriented and if so, by what method, etc).*	**New Exploration holes drilling techniques** • 12 diamond drillholes using NQ core size. No drillhole cores were oriented. **Historical holes drilling techniques** • 27 drillholes were diamond drill (core) and 38 holes were percussion holes. No information was available for drill core orientation**.**
Drill sample recovery	• *Method of recording and assessing core and chip sample recoveries and results assessed.* • *Measures taken to maximise sample recovery and ensure representative nature of the samples.* • *Whether a relationship exists between sample recovery and grade and whether sample bias may have occurred due to preferential loss/gain of fine/coarse material.*	• Drillhole core sample recoveries for new exploration drillholes included recording interval length, core recovered, total solid core, number of fractures, frequency of fractures and Rock Quality Designation (RQD). • No core recovery data were available for historical drillholes. • No discernible relationship exists between core recovery and grade.
Logging	• *Whether core and chip samples have been geologically and geotechnically logged to a level of detail to support appropriate Mineral Resource estimation, mining studies and metallurgical studies.* • *Whether logging is qualitative or quantitative in nature. Core (or costean, channel, etc) photography.* • *The total length and percentage of the relevant intersections logged.*	**New Exploration Drillhole logging** • All core has been logged for lithology, stratigraphy and seam units. • All cores were logged from the collar to end of hole (EOH). The total length of core in the 12 drillholes used for both the geological model and the estimate is 1385.66 m. • Core photography completed per core tray from collar to end of each drillhole **Historical Drillhole logging** • All core has been logged for lithology and seam unit.

Criteria	JORC Code explanation	Commentary
		• All data are stored in a relational drillhole database (Microsoft Access). • All cores were logged from the top of intersected magnetite-rich gabbro to the base of the intersected magnetite-rich gabbro. The total length of core in the 65 drillholes used for the geological model is 3,503.87 m and the total length of core in the 37 drillholes used for the estimate is 2,374.86 m.
Sub-sampling techniques and sample preparation	• *If core, whether cut or sawn and whether quarter, half or all core taken.* • *If non-core, whether riffled, tube sampled, rotary split, etc and whether sampled wet or dry.* • *For all sample types, the nature, quality and appropriateness of the sample preparation technique.* • *Quality control procedures adopted for all sub-sampling stages to maximise representivity of samples.* • *Measures taken to ensure that the sampling is representative of the in situ material collected, including for instance results for field duplicate/second-half sampling.* • *Whether sample sizes are appropriate to the grain size of the material being sampled.*	**New Exploration Drillholes** • Drillhole cores were sampled by splitting longitudinally in half using diamond saw splitter. • Drillhole cores were sampled dry. • Fractured portions aligned and buffing tape used to ensure core splitting lines are the same from start to end of samples. • Minimum and maximum core sample intervals of 0.30 m and 2.00 m respectively appropriate for the style of mineralisation. **Historical Drillholes** • It has been assumed that half cores were taken as is standard practice in the area. However, this has not been verified. • The disseminated and layered style of mineralisation is not sensitive to core sizes. The sample length is generally shorter than required, but samples were composited into longer lengths during estimation.
Quality of assay data and laboratory tests	• *The nature, quality and appropriateness of the assaying and laboratory procedures used and whether the technique is considered partial or total.* • *For geophysical tools, spectrometers, handheld XRF instruments, etc, the parameters used in determining the analysis including instrument make and model, reading times, calibrations factors applied and their derivation, etc.* • *Nature of quality control procedures adopted (e.g. standards, blanks, duplicates, external laboratory checks) and whether acceptable levels of accuracy (i.e. lack of bias) and precision have been established.*	**New Exploration Drillholes** • Primary laboratory was UIS Analytical Services in Centurion, South Africa. • X-ray fluorescence (XRF) spectroscopy using the fusion technique was used for analysis of whole rock and concentrate. Davis Tube wet magnetic separation used to separate the magnetic portion (concentrate) from the head sample. • Blanks and standards inserted in the sample stream for quality assurance and quality control • 5 % of samples (duplicates) using different sample IDs assayed as duplicated by the primary laboratory.

Criteria	JORC Code explanation	Commentary
		• QAQC plots completed on assay results received to ensure they are acceptable. **Historical Drillholes** • Davies Tube was used to determine the magnetite content. Assays of the magnetite concentrate were carried out for V_2O_5, SiO_2 and CaO. • QAQC was not performed on any of the historical drilling. However, mining operations indicate that actual mined vanadium values are consistent with those determined from drilling. •
Verification of sampling and assaying	• *The verification of significant intersections by either independent or alternative company personnel.* • *The use of twinned holes.* • *Documentation of primary data, data entry procedures, data verification, data storage (physical and electronic) protocols.* • *Discuss any adjustment to assay data.*	**New Exploration Drillhole sampling and assaying** • No twin drillholes have been drilled. • Assays were confirmed by a second laboratory (ALS Global – Johannesburg). • All recent data are stored in a Microsoft Excel database. • No statistical adjustments to data have been applied. **Historical Drillholes sampling and assaying** • Historical data were captured from hard copies. • No verification work of significant intersections has been completed. • No twin holes have been drilled, however the results of the drilling are broadly consistent with the recent drilling and mining operations indicate that actual mined vanadium values are consistent with those determined from drilling. • All data are stored in a Microsoft Access database. • No statistical adjustments to data have been applied.
Location of data points	• *Accuracy and quality of surveys used to locate drill holes (collar and down-hole surveys), trenches, mine workings and other locations used in Mineral Resource estimation.* • *Specification of the grid system used.* • *Quality and adequacy of topographic control.*	• All of the recent drillhole collars were surveyed by the Vametco mine surveyor using differential global positioning system (DGPS) survey equipment. • Two of the historical drillholes were located in the field and surveyed by the Vametco mine surveyor using DGPS.

Criteria	JORC Code explanation	Commentary
		• The coordinates of the historical drillholes were derived from information on historical plans combined with the verified surveys of two historical holes. • All holes were drilled vertically or inclined downwards. The depths ranged between 75 m and 161 m (for the new exploration drillholes) and between 5 m and 271 m (for the historical drillholes). No down-hole surveys were conducted and all holes were assumed as being as collared for their entire length. • The grid system for the Project is WGS84, LO27. • The high-resolution topography digital terrain model (DTM) was completed by Bushveld Vametco for the mine area. This includes an open pit survey (29 March 2019).
Data spacing and distribution	• *Data spacing for reporting of Exploration Results.* • *Whether the data spacing and distribution is sufficient to establish the degree of geological and grade continuity appropriate for the Mineral Resource and Ore Reserve estimation procedure(s) and classifications applied.* • *Whether sample compositing has been applied.*	• The historical drillholes were spaced at an average of 150 m apart on strike and 200 m on dip, while the new exploration drillholes were spaced at an average of 100 m to 400 m apart on strike, and these acted as infill to the historical grid. • The drillhole spacing is sufficient to assume and/or confirm geological and grade continuity for this type of mineralisation, which is highly continuous. • Exploration results not reported. 2m composites applied during estimation.
Orientation of data in relation to geological structure	• *Whether the orientation of sampling achieves unbiased sampling of possible structures and the extent to which this is known, considering the deposit type.* • *If the relationship between the drilling orientation and the orientation of key mineralised structures is considered to have introduced a sampling bias, this should be assessed and reported if material.*	• Recent drillholes were drilled vertically into the 19° dipping layer. • Historical holes were drilled vertically. • No sampling bias due to drilling orientation is expected.
Sample security	• *The measures taken to ensure sample security.*	**New Exploration Drillhole Samples** • Chain of custody used in the whole sample handling process from the sample preparation point to and from the laboratory. • Sample bags properly sealed in small bags and again placed in a sealed big bag containing a number of samples.

Criteria	JORC Code explanation	Commentary
		Historical Drillhole Samples • Unknown for historical drillholes.
Audits or reviews	• *The results of any audits or reviews of sampling techniques and data.*	**New Exploration Drillhole Data** • QAQC Plots conducted on the assay data reviewed internally and externally reviewed by MSA **Historical Drillhole Data** • None.

Section 2 Reporting of Exploration Results

(Criteria listed in the preceding section also apply to this section.)

Criteria	JORC Code explanation	Commentary
Mineral tenement and land tenure status	• *Type, reference name/number, location and ownership including agreements or material issues with third parties such as joint ventures, partnerships, overriding royalties, native title interests, historical sites, wilderness or national park and environmental settings.* • *The security of the tenure held at the time of reporting along with any known impediments to obtaining a licence to operate in the area.*	• Mining Right, No: 59/2013, which consists of portions of the farms Krokodilkraal 426 JQ Portion 1 and Uitvalgrond 431 JQ portion 1. • The mining right is valid for a period of 25 years and has an expiry date of 23 April 2038.
Exploration done by other parties	• *Acknowledgment and appraisal of exploration by other parties.*	• The KO, KR, UI and UO series historical holes were drilled by Union Carbide Exploration from the 1965 until 1982. • The VA series holes (VA1 to VA6) were drilled by Evraz Vametco in 2006.
Geology	• *Deposit type, geological setting and style of mineralisation.*	• The deposit occurs within the Rustenburg Layered Suite of the Bushveld Complex, which is a layered mafic intrusion. Magnetite- rich gabbro

Criteria	JORC Code explanation	Commentary
		occurs in layers in the Upper Zone. Locally these are known as the Upper Seam, Intermediate Seam and Lower Seam. • Mineralisation occurs in the form of vanadiferous magnetite-rich layers.
Drill hole Information	• *A summary of all information material to the understanding of the exploration results including a tabulation of the following information for all Material drill holes:* – *easting and northing of the drill hole collar* – *elevation or RL (Reduced Level – elevation above sea level in metres) of the drill hole collar* – *dip and azimuth of the hole* – *down hole length and interception depth* – *hole length.* • *If the exclusion of this information is justified on the basis that the information is not Material and this exclusion does not detract from the understanding of the report, the Competent Person should clearly explain why this is the case.*	• The majority of the drillholes are orientated vertically. • Intersection thicknesses described for the Mineral Resource.
Data aggregation methods	• *In reporting Exploration Results, weighting averaging techniques, maximum and/or minimum grade truncations (e.g. cutting of high grades) and cut-off grades are usually Material and should be stated.* • *Where aggregate intercepts incorporate short lengths of high grade results and longer lengths of low grade results, the procedure used for such aggregation should be stated and some typical examples of such aggregations should be shown in detail.* • *The assumptions used for any reporting of metal equivalent values should be clearly stated.*	• Exploration results not being reported
Relationship between mineralisation widths and intercept lengths	• *These relationships are particularly important in the reporting of Exploration Results.* • *If the geometry of the mineralisation with respect to the drill hole angle is known, its nature should be reported.* • *If it is not known and only the down hole lengths are reported, there should be a clear statement to this effect (e.g. 'down hole length, true width not known').*	• Holes were drilled vertically into the layers that have a near constant dip of 19°. The Upper Seam is narrow (approximately 2 m thick) and consists of a massive magnetite layer. The thicker Intermediate and Lower Seams are lower grade as they comprise magnetite layers within zones of magnetite disseminated in gabbro.

Criteria	JORC Code explanation	Commentary
Diagrams	• *Appropriate maps and sections (with scales) and tabulations of intercepts should be included for any significant discovery being reported These should include, but not be limited to a plan view of drill hole collar locations and appropriate sectional views.*	• Exploration results not being reported
Balanced reporting	• *Where comprehensive reporting of all Exploration Results is not practicable, representative reporting of both low and high grades and/or widths should be practiced to avoid misleading reporting of Exploration Results.*	• Exploration results not being reported
Other substantive exploration data	• *Other exploration data, if meaningful and material, should be reported including (but not limited to): geological observations; geophysical survey results; geochemical survey results; bulk samples – size and method of treatment; metallurgical test results; bulk density, groundwater, geotechnical and rock characteristics; potential deleterious or contaminating substances.*	• There is no other exploration information considered material to this estimate.
Further work	• *The nature and scale of planned further work (e.g. tests for lateral extensions or depth extensions or large-scale step-out drilling).* • *Diagrams clearly highlighting the areas of possible extensions, including the main geological interpretations and future drilling areas, provided this information is not commercially sensitive.*	• No further exploration work is planned on the property

Section 3 Estimation and Reporting of Mineral Resources

(Criteria listed in section 1, and where relevant in section 2, also apply to this section.)

Criteria	JORC Code explanation	Commentary
Database integrity	• *Measures taken to ensure that data has not been corrupted by, for example, transcription or keying errors, between its initial collection and its use for Mineral Resource estimation purposes.* • *Data validation procedures used.*	• The database is managed by Bushveld Vametco Alloys Ltd, and has undergone the procedures below: – data checks procedures built in Microsoft Excel to prevent key in errors • The validation process consisted of:

Criteria	JORC Code explanation	Commentary
		– Examining the sample assay, collar survey and geology data to ensure that the data were complete for all drillholes, – examining the de-surveyed data in three dimensions to check for spatial errors, – examining the assay data to ascertain whether they were within expected ranges, – examining the whole rock versus concentrate assays and yield to ensure values were in expected ranges, – checks for "From-To" errors, to ensure that the sample data did not overlap one another or that there were no unexplained gaps between samples, – statistical checks to validate the generations of data.
Site visits	• *Comment on any site visits undertaken by the Competent Person and the outcome of those visits.* • *If no site visits have been undertaken indicate why this is the case.*	• A site visit was undertaken by Jeremy Witley on 31 August 2017 to examine the mineralisation in the open pit. The recent drilling was examined during a site visit on 28 May 2019.
Geological interpretation	• *Confidence in (or conversely, the uncertainty of) the geological interpretation of the mineral deposit.* • *Nature of the data used and of any assumptions made.* • *The effect, if any, of alternative interpretations on Mineral Resource estimation.* • *The use of geology in guiding and controlling Mineral Resource estimation.* • *The factors affecting continuity both of grade and geology.*	• The confidence in the geological interpretation of the Upper, Intermediate and Lower Seam is considered good. Bushveld Complex layered deposits are highly continuous. • Diamond drilling and percussion data was used. No other data, such as geophysics was available. • Minor faults and dykes occur as well as local slumps in the layering. • No alternative interpretations exist from the new exploration drilling coupled with the well understood local stratigraphy, which has been confirmed by nearly 50 years of mining. • The three magnetite-rich layers intersected in drillhole core are clearly discernible. The Lower Seam is separated into an upper and lower unit by a visible anorthosite layer. The magnetite-rich layers are host to V_2O_5 mineralisation.
Dimensions	• *The extent and variability of the Mineral Resource expressed as length (along strike or otherwise), plan width, and depth below surface to the upper and lower limits of the Mineral Resource.*	• The area defined as the Upper Seam Mineral Resource extends approximately 3,200 m in the strike direction and for approximately 550 m in the dip direction. The Upper Seam Mineral Resource varies generally from approximately 1.0 m to 3.0 m. • The area defined as the Intermediate Seam Mineral Resource extends approximately 2,400 m in the strike direction and for approximately 640

Criteria	JORC Code explanation	Commentary
		m in the dip direction and is less continuous than the Upper and Lower Seams. The Intermediate Seam Mineral Resource varies generally between approximately 6 m and 10 m thick and pinches out in places. • The area defined as the Lower Seam Mineral Resource extends approximately 4,000 m in the strike direction and for approximately 650 m in the dip direction. The Lower Seam is generally between 25 m and 30 m thick (excluding the 5 m thick anorthosite parting) • The mineralisation has been demonstrated by a drillhole to continue at depth, although this estimate has been constrained to 140 m below surface.

Estimation and modelling techniques	• *The nature and appropriateness of the estimation technique(s) applied and key assumptions, including treatment of extreme grade values, domaining, interpolation parameters and maximum distance of extrapolation from data points. If a computer assisted estimation method was chosen include a description of computer software and parameters used.*
	• *The availability of check estimates, previous estimates and/or mine production records and whether the Mineral Resource estimate takes appropriate account of such data.*
	• *The assumptions made regarding recovery of by-products.*
	• *Estimation of deleterious elements or other non-grade variables of economic significance (e.g. sulphur for acid mine drainage characterisation).*
	• *In the case of block model interpolation, the block size in relation to the average sample spacing and the search employed.*
	• *Any assumptions behind modelling of selective mining units.*
	• *Any assumptions about correlation between variables.*
	• *Description of how the geological interpretation was used to control the resource estimates.*
	• *Discussion of basis for using or not using grade cutting or capping.*
	• *The process of validation, the checking process used, the comparison of model data to drill hole data, and use of reconciliation data if available.*
		• Block model estimates were completed using Datamine RM.
		  • 20 mX by 20 mY by 5 mRL block models.
		  • Coefficients of variation are low.
		  • The estimates were completed using Inverse Distance Squared.
		  • A search distance of 200 mX by 200 mY by 10 mRL was used to source between 6 and 10 two metre composites for estimation. Searches were expanded two and ten times to estimate the model cells. A maximum of four composites were allowed from a single hole.
		  • No density data were available for the historical drillholes. Density was assigned to the individual block model estimates using a 3rd order polynomial regression based on the magnetite content and the density measurements completed on the recent drillholes.
		  • The Davis Tube concentrate V_2O_5 grade of 2.80% for one composite was capped to 2.28% as it was significantly higher that the rest of the data.
		• The grade estimates are globally similar to the production records.
		• No by-products were estimated.
		• Both the whole rock and Davis Tube concentrate V_2O_5 grades were estimated.
		• 20 mX by 20 mY by 5 mRL block models. Drillholes generally between 50 m and 200 m apart. Block size more a function of layer orientation than drillhole spacing. CV is low which justifies a small block size.
		• No selective mining units modelled. Search ellipses aligned with dip and strike of layers. Estimates used hard boundaries between the seams

Criteria	JORC Code explanation	Commentary
		modelled. • Capping and cutting not necessary (except for one Davis Tube concentrate value of 2.8% V_2O_5. CVs are low and there are no outliers. • Model was validated by visual examination, swath plots and global averages of model versus the data.
Moisture	• *Whether the tonnages are estimated on a dry basis or with natural moisture, and the method of determination of the moisture content.*	• Tonnages were estimated on a dry basis.
Cut-off parameters	• *The basis of the adopted cut-off grade(s) or quality parameters applied.*	• A 20% magnetite cut-off grade was used for the Mineral Resource, which is slightly lower than the mining cut-off grade of 26%.
Mining factors or assumptions	• *Assumptions made regarding possible mining methods, minimum mining dimensions and internal (or, if applicable, external) mining dilution. It is always necessary as part of the process of determining reasonable prospects for eventual economic extraction to consider potential mining methods, but the assumptions made regarding mining methods and parameters when estimating Mineral Resources may not always be rigorous. Where this is the case, this should be reported with an explanation of the basis of the mining assumptions made.*	• Mining is by open-pit methods. • The Mineral Resource is reported to a depth of 150 m below surface. High level mining studies indicate that the potentially economic pit depth is greater than 140 m below surface.
Metallurgical factors or assumptions	• *The basis for assumptions or predictions regarding metallurgical amenability. It is always necessary as part of the process of determining reasonable prospects for eventual economic extraction to consider potential metallurgical methods, but the assumptions regarding metallurgical treatment processes and parameters made when reporting Mineral Resources may not always be rigorous. Where this is the case, this should be reported with an explanation of the basis of the metallurgical assumptions made.*	• Vametco is an operating mine and produces a saleable product on site.
Environmental factors or assumptions	• *Assumptions made regarding possible waste and process residue disposal options. It is always necessary as part of the process of determining reasonable prospects for eventual economic extraction to consider the potential environmental impacts of the mining and processing operation. While at this stage the determination of potential environmental impacts, particularly for a greenfields project, may not always be well advanced, the status of early*	• Vametco is an operating mine. It is assumed that all environmental permissions are in-place. • The CP is not aware of any environmental impediments.

Criteria	JORC Code explanation	Commentary
	consideration of these potential environmental impacts should be reported. Where these aspects have not been considered this should be reported with an explanation of the environmental assumptions made.	
Bulk density	• *Whether assumed or determined. If assumed, the basis for the assumptions. If determined, the method used, whether wet or dry, the frequency of the measurements, the nature, size and representativeness of the samples.* • *The bulk density for bulk material must have been measured by methods that adequately account for void spaces (vugs, porosity, etc), moisture and differences between rock and alteration zones within the deposit.* • *Discuss assumptions for bulk density estimates used in the evaluation process of the different materials.*	• No density data were available for the historical drillholes. Density was assigned to the individual block model estimates using a 3rd order polynomial regression based on the magnetite content and the density measurements completed on the recent drillholes. • 1,245 density measurements were available. • The density measurements were taken using a gas pycnometer which does not account for porosity. The fresh igneous rocks at Vametco are not porous.
Classification	• *The basis for the classification of the Mineral Resources into varying confidence categories.* • *Whether appropriate account has been taken of all relevant factors (i.e. relative confidence in tonnage/grade estimations, reliability of input data, confidence in continuity of geology and metal values, quality, quantity and distribution of the data).* • *Whether the result appropriately reflects the Competent Person's view of the deposit.*	• The Mineral Resources were classified as Indicated when they occur within an area drilled to better than 200 m spacing. Indicated Mineral Resources were extended 125 m along strike and down from the drillhole grid. • The Mineral Resources were classified as Inferred when they occur within the geological model but outside the area drilled to at least 200 m spacing. Inferred Resources are mostly extrapolated and to a maximum of 400 m along strike and 250 m down dip.
Audits or reviews	• *The results of any audits or reviews of Mineral Resource estimates.*	• The Mineral Resources have been internally reviewed by Vametco geologists. • No formal external audits have taken place.
Discussion of relative accuracy/ confidence	• *Where appropriate a statement of the relative accuracy and confidence level in the Mineral Resource estimate using an approach or procedure deemed appropriate by the Competent Person. For example, the application of statistical or geostatistical procedures to quantify the relative accuracy of the resource within stated confidence limits, or, if such an approach is not deemed appropriate, a qualitative discussion of the factors that could affect the relative accuracy and confidence of the estimate.* • *The statement should specify whether it relates to global or local*	• The Indicated Mineral Resources are considered to be of sufficient accuracy to allow for life of Mine planning. • Bushveld magnetite deposits are highly continuous and generally of relatively low risk. However, they are impacted by faulting which can affect mine planning. • Inferred Mineral Resource estimates should be considered global in nature. • Production data generally support the grade of the estimates, but

Criteria	JORC Code explanation	Commentary
	estimates, and, if local, state the relevant tonnages, which should be relevant to technical and economic evaluation. Documentation should include assumptions made and the procedures used. • *These statements of relative accuracy and confidence of the estimate should be compared with production data, where available.*	detailed comparisons have not been made.

Section 4 Estimation and Reporting of Ore Reserves

(Criteria of this section apply all succeeding sections.)

Criteria	JORC Code explanation	Commentary
Mineral Resource estimate for conversion to Ore Reserves	• *Description of the Mineral Resource estimate used as a basis for the conversion to an Ore Reserve.* • *Clear statement as to whether the Mineral Resources are reported additional to, or inclusive of, the Ore Reserves.*	• The Ore Reserve estimate compiled by MSA is based on the Mineral Resource model and estimate for Vametco completed by Mr Jeremy Witley (MSA) dated 29 March 2019. • The Mineral Resources are reported inclusive of Ore Reserves.
Site visits	• *Comment on any site visits undertaken by the Competent Person and the outcome of those visits.* • *If no site visits have been undertaken indicate why this is the case.*	• A site visit was undertaken by Mr Jon Hudson on 28 May 2019 to review the Vametco open pit mining operation and surface infrastructure.
Study status	• *The type and level of study undertaken to enable Mineral Resources to be converted to Ore Reserves.* • *The Code requires that a study to at least Pre-Feasibility Study level has been undertaken to convert Mineral Resources to Ore Reserves. Such studies will have been carried out and will have determined a mine plan that is technically achievable and economically viable, and that material Modifying Factors have been considered.*	• Vametco operates an open pit mine supplying ore to its vanadium processing plant located on the same properties. • MSA has undertaken a mining study and mine plan for Vametco to convert the Mineral Resources to Ore Reserves. The mine plan is deemed to be technically achievable and economically viable. Material modifying factors have been considered in the formulation of the mine plan.
Cut-off parameters	• *The basis of the cut-off grade(s) or quality parameters applied.*	• Whittle Pit Optimisation software was used to determine the most preferable economically viable pit shell.
Mining factors or assumptions	• *The method and assumptions used as reported in the Pre-Feasibility or Feasibility Study to convert the Mineral Resource to an Ore Reserve (i.e. either by application of appropriate factors by optimisation or by preliminary or detailed design).*	• The mining method used at Vametco is a conventional drill, blast, load and haul open pit mining operation with a bench height of 10m. • The choice of pit shell from the Whittle optimisation has a revenue factor of 0.71 which is deemed conservative and aligned to a potential drop in

Criteria	JORC Code explanation	Commentary
	• *The choice, nature and appropriateness of the selected mining method(s) and other mining parameters including associated design issues such as pre-strip, access, etc.* • *The assumptions made regarding geotechnical parameters (e.g. pit slopes, stope sizes, etc), grade control and pre-production drilling.* • *The major assumptions made and Mineral Resource model used for pit and stope optimisation (if appropriate).* • *The mining dilution factors used.* • *The mining recovery factors used.* • *Any minimum mining widths used.* • *The manner in which Inferred Mineral Resources are utilised in mining studies and the sensitivity of the outcome to their inclusion.* • *The infrastructure requirements of the selected mining methods.*	vanadium price. There is potential in the future to choose a bigger pit shell with a higher revenue factor to increase the Ore Reserves post more technical study work. • The pit shell is aligned with the mining lease which is due to expire in 2038. • The following slope angles used for the Whittle pit optimisation process were determined by Middindi and MSA. – weathered material (37.80 degrees) – fresh material (56.95 degrees) • A minimum mining width of 50m will be applied to the detailed pit designs and should be aimed for in practise. Although it is restrictive, this should be achievable with the mining method and equipment used (specifically the 40t ADT fleet). • The more detailed geotechnical parameters were developed by MSA for the weathered and fresh material in the pit design and shown in the table below. The pit design was based on temporary roadway access ramps being used from the footwall side of the pit. The overall slope stability of the pit was reduced with the use of a catch bench (every 5th bench) on the high wall. The final average pit depth was less than 100 m which resulted in the use of one catch bench only.

Material type	*Bench heights*	*Berm widths*	*Stack height*	*Bench face angle*	*Stack angle*	*Maximum depth*
Weathered	10	4.5	10	50	37.8	10
Fresh	10	4.5	90	75	54.32	60
Catch bench (every 5th bench)	**10**	**9**	**40**	**75**	**54.32**	**100**

- The following whittle input parameters derived from the Vametco 2019 budget and long-term forecasting were used to derive the Whittle pit shell;
  - drill and blast costs
  - load and haul costs
  - mining fixed costs
  - processing costs
  - selling costs
  - royalties
  - leases, insurance

Criteria	JORC Code explanation	Commentary
		– G&A and social – selling price – exchange rate – mining recovery – overall processing recovery • Given the bulk nature of the mineralisation, mining dilution was applied based on re-blocking the Mineral Resource model to an SMU size 5.0 mX by 5.0 mY by 5.0 mZ. This block size was determined after consideration of the size of the excavator bucket and expanded to mimic the mixing associated with blasting and loading. Mineral Resource classifications were assigned on the basis of majority representation within the SMU block. • A mining loss of 15% was applied to the ore based on historical actual performance at Vametco. • The waste to ore strip ratio for the pit was calculated to be 0.66. • There is a graveyard on the north-western end of the property that is currently excluded from all reserve calculations. A tentative boundary of approximately 100m has been put into the mine design around the graveyard to further constrain the ore reserves. The plan ensures that the current access to the graveyard in maintained.
Metallurgical factors or assumptions	• *The metallurgical process proposed and the appropriateness of that process to the style of mineralisation.* • *Whether the metallurgical process is well-tested technology or novel in nature.* • *The nature, amount and representativeness of metallurgical test work undertaken, the nature of the metallurgical domaining applied and the corresponding metallurgical recovery factors applied.* • *Any assumptions or allowances made for deleterious elements.* • *The existence of any bulk sample or pilot scale test work and the degree to which such samples are considered representative of the orebody as a whole.* • *For minerals that are defined by a specification, has the ore reserve estimation been based on the appropriate mineralogy to meet the specifications?*	• Vanadium is not an exchange-traded commodity, pricing is instead negotiated by contract between supplier and customer (often through an intermediary trader). Nitrovan^{TM} Vametco's trademark vanadium nitride product, is sold globally to steel mills where it is used as a micro-alloying additive to strengthen steel. • Vametco employs the standard salt roast and leach process to produce a trademark vanadium carbon nitride (VCN) product called Nitrovan^{TM}. • The process comprises the following stages: • **STEP 1:** Crushing, milling and magnetic separation to produce a magnetite concentrate with average grades of approximately 2.0 % V_2O_5; • **STEP 2:** Salt roasting of concentrate involving roasting of the concentrate with sodium salts in a kiln at approximately 1,200 ºC to form a water-soluble sodium vanadate material; • **STEP 3:** Leaching and purification involving dissolution of roasted vanadium concentrate in water, purification and precipitation of

Criteria	JORC Code explanation	Commentary
		vanadium through the addition of ammonium sulphate followed by drying and rotary calcining in a reducing environment to produce a modified vanadium oxide product; and • **STEP 4:** Nitrovan^{TM} production – the modified vanadium oxide is briquetted and fed into an induction shaft furnace under a nitrogen atmosphere to produce Nitrovan^{TM}. • An overall processing recovery of 71 % was assumed for the mine plan based on the 2019 budget.
Environmental	• *The status of studies of potential environmental impacts of the mining and processing operation. Details of waste rock characterisation and the consideration of potential sites, status of design options considered and, where applicable, the status of approvals for process residue storage and waste dumps should be reported.*	• The Vametco EMPR is in place and annual external audits have been conducted as per the requirements of South African legislation. The waste dumps are in place to cater the mine plan requirements. Partial backfilling of the pit waste will be undertaken as per the agreement with DMR. A study is underway to investigate an optimal backfilling strategy. • No environmental impediments are currently known. The mining licence has been maintained.
Infrastructure	• *The existence of appropriate infrastructure: availability of land for plant development, power, water, transportation (particularly for bulk commodities), labour, accommodation; or the ease with which the infrastructure can be provided, or accessed.*	• Infrastructure in the area around the mine and for the operations is well established, as the mine has been in operation from the mid 1970's. • The administrative offices, change houses, plant and workshops are all located to the south-western part of the property, close to the entrance. • A 22kV Eskom power line enters the property from the southern side of the property and provides the electricity required to sustain the day to day operations of the mine. • Water is extracted from six boreholes as well as a canal to supply the plant and other facilities with water. • An agricultural aqueduct from Hartebeespoort Dam passes 500m from the north-western corner of the property.
Costs	• *The derivation of, or assumptions made, regarding projected capital costs in the study.* • *The methodology used to estimate operating costs.* • *Allowances made for the content of deleterious elements.* • *The source of exchange rates used in the study.* • *Derivation of transportation charges.* • *The basis for forecasting or source of treatment and refining charges, penalties for failure to meet specification, etc.*	• The projected capital costs were received from Vametco and used in the Financial model. The capital plan makes provision for sustaining and legal compliance capital. • The operating cost methodology and estimation is based on the Vametco 2019 budget. • The financial model however calculates royalties payable to the state using the formula below, as prescribed in the Royalty Bill for unrefined mineral resources. The Royalty Rate is capped at 7 % for unrefined resources.

Criteria	JORC Code explanation	Commentary
	• *The allowances made for royalties payable, both Government and private.*	– 1. $Royalties = Gross\ Sales \times Royalty\ Rate$ – 2. $Royalty\ Rate = 0.5 + [EBIT \div (Gross\ Sales \times 9)] \times 100$ • No Royalties to Co-owners is included in the financial model.
Revenue factors	• *The derivation of, or assumptions made regarding revenue factors including head grade, metal or commodity price(s) exchange rates, transportation and treatment charges, penalties, net smelter returns, etc.* • *The derivation of assumptions made of metal or commodity price(s), for the principal metals, minerals and co-products.*	• The following long-term revenue factors were used based on the 2019 budget. – Vanadium selling price of US$/kg V (37.50) – Exchange rate of ZAR/US$ (14.00)
Market assessment	• *The demand, supply and stock situation for the particular commodity, consumption trends and factors likely to affect supply and demand into the future.* • *A customer and competitor analysis along with the identification of likely market windows for the product.* • *Price and volume forecasts and the basis for these forecasts.* • *For industrial minerals the customer specification, testing and acceptance requirements prior to a supply contract.*	• The vanadium price has been volatile over the past few years, rising by more than 400 % from lows of US$13.50 /kgV in December 2015 to highs of US$68 /kgV by May 2018. • The price increase is driven by a fundamental structural deficit in the vanadium market, arising from robust and growing demand underwritten by the steel sector amidst concentrated and constrained supply with limited new supply in the near future. Approximately 90 % of vanadium consumption is from the steel industry. The steel market is thus set to continue supporting robust vanadium demand, which is expected to grow at a CAGR of approximately two per cent over the next 10 years, supported by the increased intensity in use of steel in emerging markets, particularly in China, underpinned by the improved enforcement of regulations. • The use of the budget pricing for the long-term forecast is therefore considered appropriate by MSA.
Economic	• *The inputs to the economic analysis to produce the net present value (NPV) in the study, the source and confidence of these economic inputs including estimated inflation, discount rate, etc.* • *NPV ranges and sensitivity to variations in the significant assumptions and inputs.*	• Economic viability demonstrated by the current operating mine being profitable based on 2019 costs and pricing, as well as positive long-term outlook for vanadium prices.
Social	• *The status of agreements with key stakeholders and matters leading to social licence to operate.*	• A Social and Labour Plan (SLP) is in place for the Vametco operations. It covers the following focus areas: • Human Resources Development Programme • Local Economic Development Programme • Programme for Managing Downscaling and Retrenchments

Criteria	JORC Code explanation	Commentary
		• As part of the SLP, action plans are in place to assist the community in promoting economic growth and improve quality of life. LED (Local Economic Development) Project plans are developed in five-year increments and continually reviewed in line with the SLP.
Other	• *To the extent relevant, the impact of the following on the project and/or on the estimation and classification of the Ore Reserves:* • *Any identified material naturally occurring risks.* • *The status of material legal agreements and marketing arrangements.* • *The status of governmental agreements and approvals critical to the viability of the project, such as mineral tenement status, and government and statutory approvals. There must be reasonable grounds to expect that all necessary Government approvals will be received within the timeframes anticipated in the Pre-Feasibility or Feasibility study. Highlight and discuss the materiality of any unresolved matter that is dependent on a third party on which extraction of the reserve is contingent.*	• A new order mining right (No: NW 30/5/1/2/2/08 MR) is held by Vametco Holdings (Pty) Ltd, for the vanadium operations. The converted mining right replaced the old order mining right held by Vametco which consists of 75 % Strategic Minerals Corporation, 15 % Business Venture Investment Group no 973 and 10 % Business Venture Investment Group no 1833, representing community-based trusts and co-operations. The mining right is valid for a period of 25 years and has an expiry date of 23 April 2038.
Classification	• *The basis for the classification of the Ore Reserves into varying confidence categories.* • *Whether the result appropriately reflects the Competent Person's view of the deposit.* • *The proportion of Probable Ore Reserves that have been derived from Measured Mineral Resources (if any).*	• Ore Reserves are declared for open pits inclusive of Mineral Resources inside the LOM pit design (the optimised pit shell in this instance). Ore tonnes are reported as Run of Mine ("ROM") tonnes after mining modifying factors for mining losses and dilution have been applied and metal content before beneficiation plant recoveries have been applied. Ore Reserves are declared for in-situ tonnes in the pit and exclude any stockpiles. • There are no Measured Mineral Resources classified at Vametco Mine and therefore no resources were translated into Proved Ore Reserves. All Indicated Mineral Resources were considered for Probable Ore Reserves with none discounted to Ore Inventory. • Ore Reserves are reported in total and not discounted for ownership. Attributable value should be calculated on an ownership basis.
Audits or reviews	• *The results of any audits or reviews of Ore Reserve estimates.*	• The Project was previously reviewed by MSA and VBKOM. • No adverse findings were recorded.

Criteria	JORC Code explanation	Commentary
Discussion of relative accuracy/ confidence	• *Where appropriate a statement of the relative accuracy and confidence level in the Ore Reserve estimate using an approach or procedure deemed appropriate by the Competent Person. For example, the application of statistical or geostatistical procedures to quantify the relative accuracy of the reserve within stated confidence limits, or, if such an approach is not deemed appropriate, a qualitative discussion of the factors which could affect the relative accuracy and confidence of the estimate.* • *The statement should specify whether it relates to global or local estimates, and, if local, state the relevant tonnages, which should be relevant to technical and economic evaluation. Documentation should include assumptions made and the procedures used.* • *Accuracy and confidence discussions should extend to specific discussions of any applied Modifying Factors that may have a material impact on Ore Reserve viability, or for which there are remaining areas of uncertainty at the current study stage.* • *It is recognised that this may not be possible or appropriate in all circumstances. These statements of relative accuracy and confidence of the estimate should be compared with production data, where available.*	• The mine is an operational opencast vanadium mine, located in the Bojanala Platinum District within the North-West Province of the Republic of South Africa. • A detailed cash flow model was created using the pricing described above. The cash flow analysis demonstrated a positive return for the project. • A key risk for the project relates to long term supply and demand of the product. Nitrovan is a niche product in the market which competes with Ferrovanadium. Economic premium of Nitrovan may be eroded due to poor economic climate and or low FeV prices. Product heavily dependent on the steel market. Supply / demand economics may adversely affect the operations where margins are eroded by vanadium price on the open market and exchange rates. • Sensitivity analyses indicate that the operation is most sensitive to revenue, with a 15 % decrease in FeV prices causing the NPV to reduce by 30 %. • The operation is moderately sensitive to operating costs, with a 15 % increase in costs triggering a 17 % drop in NPV. • Sensitivity to exchange fluctuations is modest, with a 15 % strengthening of ZAR vs USD resulting in only a 14 % reduction in NPV. • There is limited risk with the mining production profile which is in line with the 2019 budget of 1.5 Mpta RoM feed to the plant. The current plant is able to build up to around 3,400 mtV p.a. of Nitrovan^{TM} per annum based on historical performance and realistic interventions.

APPENDIX 4: DISCOUNTED CASH FLOW MODEL SUMMARY

Discounted Cash Flow Model Summary

Financial Years to December	Units	Notes	Tot/Av	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051
Macro Economic Parameters				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
South African Inflation	%			5.60%	5.60%	5.80%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%
Inflation Factor				1.00	1.06	1.12	1.18	1.24	1.31	1.38	1.46	1.54	1.63	1.71	1.81	1.91	2.01	2.12	2.24	2.36	2.49	2.63	2.78	2.93	3.09	3.26	3.44	3.63	3.83	4.04	4.26	4.49	4.74	5.00	5.28
USA Inflation	%			2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%
Inflation Factor				1.00	1.02	1.04	1.06	1.08	1.10	1.13	1.15	1.17	1.20	1.22	1.24	1.27	1.29	1.32	1.35	1.37	1.40	1.43	1.46	1.49	1.52	1.55	1.58	1.61	1.64	1.67	1.71	1.74	1.78	1.81	1.85
Rand/US$ Exchange Rate	R/US$	real		14.25	14.25	14.25	14.25	14.25	14.25	14.25	14.25	14.25	14.25	14.25	14.25	14.25	14.25	14.25	14.25	14.25	14.25	14.25	14.25	14.25	14.25	14.25	14.25	14.25	14.25	14.25	14.25	14.25	14.25	14.25	14.25
FeV Price (per Kg contained V - 80% product)	US$/ton	real		41.58	44.13	46.06	43.64	44.00	44.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00
Production	**Units**	**Notes**	**Tot/Av**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**2051**
Mining																																			
ROM Product	kt		46,910	1374	1500	1498	1497	1498	1499	1498	1499	1498	1500	1497	1501	1500	1501	1498	1499	1499	1499	1499	1498	1498	1497	1498	1499	1499	1500	1500	1500	1499	1497	1498	571
Waste Mined	kt		30,168	880	960	960	960	960	960	960	960	960	960	960	960	960	960	960	960	960	1080	1080	1080	1080	1080	1080	1080	1080	963	884	894	1011	509	846	177
Magnetite in Crushed Ore	%			29.72%	28.89%	28.13%	27.75%	28.22%	28.26%	27.79%	28.88%	28.32%	27.90%	28.12%	27.55%	28.65%	26.08%	27.73%	28.47%	28.77%	28.49%	27.91%	28.41%	27.86%	28.81%	27.44%	27.46%	27.67%	28.93%	30.47%	28.90%	29.44%	29.86%	30.35%	30.37%
V in Crushed Ore	%	1.13%		1.12%	1.13%	1.13%	1.13%	1.13%	1.12%	1.12%	1.13%	1.12%	1.12%	1.13%	1.14%	1.15%	1.15%	1.16%	1.14%	1.15%	1.15%	1.14%	1.15%	1.15%	1.15%	1.14%	1.12%	1.11%	1.10%	1.11%	1.11%	1.11%	1.13%	1.12%	1.13%
Concentrator																																			
Magnetite Recovery	%	98.44%		98.44%	98.4%	98.4%	98.4%	98.4%	98.4%	98.4%	98.4%	98.4%	98.4%	98.4%	98.4%	98.4%	98.4%	98.4%	98.4%	98.4%	98.4%	98.4%	98.4%	98.4%	98.4%	98.4%	98.4%	98.4%	98.4%	98.4%	98.4%	98.4%	98.4%	98.4%	98.4%
Concentrate V Grade	%			1.08%	1.10%	1.10%	1.10%	1.09%	1.09%	1.09%	1.10%	1.09%	1.09%	1.09%	1.11%	1.12%	1.11%	1.13%	1.11%	1.12%	1.12%	1.11%	1.12%	1.12%	1.12%	1.11%	1.09%	1.08%	1.07%	1.07%	1.07%	1.08%	1.09%	1.08%	1.10%
Concentrate Produced - Dry	kt		13,136	402	427	415	409	416	417	410	426	418	412	414	407	423	385	409	420	424	420	412	419	411	425	405	405	408	427	450	427	435	440	448	171
Kiln																																			
Kiln Recovery	%	83.50%		83.5%	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%
Kiln - Production - V	t - V		120,466	3639	3902	3794	3760	3803	3789	3721	3914	3805	3758	3786	3774	3942	3584	3855	3897	3959	3916	3812	3915	3831	3965	3738	3676	3684	3824	4034	3831	3919	4017	4054	1568
Leach																																			
Leach Recovery	%	93.80%		93.8%	93.8%	93.8%	93.8%	93.8%	93.8%	93.8%	93.8%	93.8%	93.8%	93.8%	93.8%	93.8%	93.8%	93.8%	93.8%	93.8%	93.8%	93.8%	93.8%	93.8%	93.8%	93.8%	93.8%	93.8%	93.8%	93.8%	93.8%	93.8%	93.8%	93.8%	93.8%
Leach Production (Preg Solution)	t - V		112,997	3,413	3,660	3,559	3,527	3,567	3,554	3,491	3,671	3,569	3,525	3,551	3,540	3,697	3,362	3,616	3,656	3,714	3,673	3,575	3,673	3,594	3,719	3,506	3,448	3,455	3,587	3,784	3,593	3,676	3,768	3,802	1,471
Precipitation																																			
Precipitation Recovery	%	96.50%		96.5%	96.5%	96.5%	96.5%	96.5%	96.5%	96.5%	96.5%	96.5%	96.5%	96.5%	96.5%	96.5%	96.5%	96.5%	96.5%	96.5%	96.5%	96.5%	96.5%	96.5%	96.5%	96.5%	96.5%	96.5%	96.5%	96.5%	96.5%	96.5%	96.5%	96.5%	96.5%
Precipitation/AMV Production	t - V		109,042	3294	3532	3434	3404	3442	3429	3368	3543	3444	3402	3427	3416	3568	3244	3489	3528	3584	3545	3450	3544	3468	3589	3383	3327	3334	3461	3651	3467	3547	3636	3669	1420
MVO Reactor																																			
MVO Recovery	%	98.50%		98.5%	98.5%	98.5%	98.5%	98.5%	98.5%	98.5%	98.5%	98.5%	98.5%	98.5%	98.5%	98.5%	98.5%	98.5%	98.5%	98.5%	98.5%	98.5%	98.5%	98.5%	98.5%	98.5%	98.5%	98.5%	98.5%	98.5%	98.5%	98.5%	98.5%	98.5%	98.5%
MVO Production	t - V		107,406	3244	3479	3383	3353	3391	3378	3318	3489	3392	3351	3376	3365	3514	3196	3437	3475	3530	3491	3398	3491	3416	3535	3333	3277	3284	3409	3596	3415	3494	3582	3614	1398
NV Furnace																																			
Nitrovan Furnace Recovery	%	99.00%		99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%	99.0%
Final V Product	**Mt V**		**104,948**	**3212**	**3444**	**3349**	**3319**	**3357**	**3344**	**3285**	**3455**	**3359**	**3317**	**3342**	**3331**	**3479**	**3164**	**3403**	**3440**	**3495**	**3457**	**3364**	**3456**	**3382**	**3500**	**3299**	**3245**	**3252**	**3375**	**3560**	**3381**	**3459**	**3546**	**3578**	**1384**
Sales & Revenue	**Units**	**Notes**	**Tot/Av**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**2051**
Sales	Mt V		116,163	3743	3744	3649	3619	3657	3644	3585	3755	3659	3617	3642	3631	3779	3464	3703	3740	3795	3757	3664	3756	3682	3800	3599	3545	3552	3675	3860	3681	3759	3846	3878	1684
NitroVan discount to FeV	%	5.00%		5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%
Revenue	**R'M**		**64,065**	**2107**	**2237**	**2275**	**2138**	**2178**	**2171**	**1941**	**2033**	**1981**	**1959**	**1972**	**1966**	**2047**	**1876**	**2005**	**2025**	**2055**	**2034**	**1984**	**2034**	**1994**	**2058**	**1949**	**1919**	**1923**	**1990**	**2090**	**1993**	**2036**	**2083**	**2100**	**912**
Costs	**Units**	**Notes**	**Tot/Av**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**2051**
Production Costs (incl. Royalty)	R'M		28,152	858	892	885	880	886	887	880	896	887	882	885	879	895	859	883	891	896	896	888	895	887	900	881	879	882	895	913	892	905	896	914	606
Ancilliary Costs	R'M		-28,632	-873	-909	-901	-895	-902	-902	-894	-913	-903	-897	-900	-894	-911	-871	-897	-908	-913	-911	-902	-910	-901	-916	-894	-892	-895	-912	-934	-910	-921	-916	-931	-603
G&A, Marketing & Other Costs	R'M		-10,402	-331	-338	-337	-331	-333	-333	-321	-330	-325	-323	-324	-324	-331	-315	-327	-329	-332	-330	-325	-330	-326	-332	-322	-319	-320	-326	-335	-326	-330	-335	-336	-222
Total Costs (incl. Royalty)	**R'M**		**-39,034**	**-1204**	**-1247**	**-1238**	**-1226**	**-1235**	**-1235**	**-1216**	**-1243**	**-1228**	**-1220**	**-1224**	**-1217**	**-1243**	**-1186**	**-1225**	**-1237**	**-1245**	**-1242**	**-1227**	**-1240**	**-1227**	**-1248**	**-1216**	**-1212**	**-1215**	**-1238**	**-1269**	**-1236**	**-1252**	**-1251**	**-1268**	**-825**
EBITDA	**Units**	**Notes**	**Tot/Av**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**2051**
EBITDA	**R'M**		**25,031**	**903**	**990**	**1037**	**913**	**943**	**936**	**725**	**790**	**753**	**738**	**748**	**749**	**804**	**690**	**780**	**788**	**810**	**793**	**757**	**794**	**766**	**809**	**733**	**708**	**708**	**753**	**821**	**757**	**784**	**832**	**832**	**87**
Capital Expenditure	**Units**	**Notes**	**Tot/Av**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**2051**
Stay-in-business capex	R'M		2,208	68.71	71.32	83.31	70.44	70.90	70.91	70.40	71.64	70.98	70.60	70.77	70.37	71.54	68.86	70.63	71.29	71.65	71.65	70.99	71.56	70.97	71.96	70.47	70.36	70.56	71.53	72.94	71.35	72.29	71.61	38.37	26.73
Expansion, Environmental & Legal Capex	R'M		10.00	5.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Capex	**R'M**		**2,218**	**73.71**	**76.32**	**83.31**	**70.44**	**70.90**	**70.91**	**70.40**	**71.64**	**70.98**	**70.60**	**70.77**	**70.37**	**71.54**	**68.86**	**70.63**	**71.29**	**71.65**	**71.65**	**70.99**	**71.56**	**70.97**	**71.96**	**70.47**	**70.36**	**70.56**	**71.53**	**72.94**	**71.35**	**72.29**	**71.61**	**38.37**	**26.73**
Cash Flow	**Units**	**Notes**	**Tot/Av**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**2051**
EBITDA	R'M		23,460	843.7	925.3	967.8	852.0	880.5	874.0	680.6	741.9	706.8	692.8	701.9	701.9	754.2	644.9	730.8	739.6	759.9	743.0	709.7	743.8	717.7	758.8	686.8	663.5	664.3	707.7	773.4	712.3	737.1	783.8	780.8	78.6
Capital Expenditure	R'M		-2,218	-73.7	-76.3	-83.3	-70.4	-70.9	-70.9	-70.4	-71.6	-71.0	-70.6	-70.8	-70.4	-71.5	-68.9	-70.6	-71.3	-71.6	-71.6	-71.0	-71.6	-71.0	-72.0	-70.5	-70.4	-70.6	-71.5	-72.9	-71.3	-72.3	-71.6	-38.4	-26.7
Tax	R'M		-5,972	-219.3	-238.4	-246.1	-218.9	-227.0	-225.5	-172.0	-189.0	-179.2	-175.4	-177.9	-178.0	-192.5	-162.1	-186.1	-188.5	-194.1	-189.3	-180.0	-189.5	-182.2	-193.7	-173.6	-167.1	-167.4	-179.5	-197.7	-180.6	-187.4	-200.5	-203.5	-9.9
Change in Non-Cash Working Capital	R'M		7,269	165.0	79.3	94.2	112.4	101.5	112.5	137.0	96.5	138.4	136.4	130.1	137.8	111.7	218.8	92.9	151.7	143.5	178.7	199.1	143.5	203.2	144.7	264.5	230.5	206.8	155.6	129.9	283.0	189.5	138.6	235.3	2406.6
Distributable Profit	**R'M**		**22,540**	**715.7**	**689.9**	**732.6**	**675.0**	**684.1**	**690.1**	**575.2**	**577.7**	**595.0**	**583.3**	**583.4**	**591.4**	**601.8**	**632.7**	**567.0**	**631.5**	**637.7**	**660.8**	**657.8**	**626.3**	**667.8**	**638.0**	**707.2**	**656.5**	**633.1**	**612.2**	**632.7**	**743.3**	**667.0**	**650.2**	**774.3**	**2448.6**
Withholding Tax	R'M	20%	4,508	143.1	138.0	146.5	135.0	136.8	138.0	115.0	115.5	119.0	116.7	116.7	118.3	120.4	126.5	113.4	126.3	127.5	132.2	131.6	125.3	133.6	127.6	141.4	131.3	126.6	122.4	126.5	148.7	133.4	130.0	154.9	489.7
Real Terms Cash Flow	**R'M**		**18,032**	**572.6**	**551.9**	**586.1**	**540.0**	**547.2**	**552.1**	**460.1**	**462.2**	**476.0**	**466.6**	**466.7**	**473.1**	**481.5**	**506.1**	**453.6**	**505.2**	**510.1**	**528.6**	**526.3**	**501.1**	**534.2**	**510.4**	**565.8**	**525.2**	**506.5**	**489.8**	**506.1**	**594.6**	**533.6**	**520.2**	**619.4**	**1958.9**
Real Terms Cash Flow	**US$'M**		**1,265**	**40.18**	**38.73**	**41.13**	**37.90**	**38.40**	**38.74**	**32.29**	**32.43**	**33.40**	**32.75**	**32.75**	**33.20**	**33.79**	**35.52**	**31.83**	**35.45**	**35.80**	**37.10**	**36.93**	**35.16**	**37.49**	**35.81**	**39.70**	**36.86**	**35.54**	**34.37**	**35.52**	**41.73**	**37.44**	**36.50**	**43.47**	**137.46**
Real Discounted Cash Flow / NPV	**US$'M**	**10%**	**371.0**	**38.31**	**33.57**	**32.41**	**27.15**	**25.01**	**22.94**	**17.38**	**15.87**	**14.86**	**13.24**	**12.04**	**11.10**	**10.26**	**9.81**	**7.99**	**8.09**	**7.43**	**7.00**	**6.33**	**5.48**	**5.31**	**4.61**	**4.65**	**3.92**	**3.44**	**3.02**	**2.84**	**3.03**	**2.48**	**2.19**	**2.38**	**6.83**