



# Kalgoorlie Consolidated Gold Mines (KCGM)

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## Soil and Waste Characterisation

### Section 2 – Soil and Waste Materials

#### Inventory

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## Executive Summary

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Outback Ecology Services was commissioned by Kalgoorlie Consolidated Gold Mines (KCGM) to conduct a comprehensive, two-staged characterisation study of soil and waste materials for the KCGM operations.

This report, which comprises Section 2 of the overarching KCGM Soil and Waste Characterisation Report, presents the summarised inventory of the soil and waste characterisation study, broad classifications for each material unit, and recommendations for material use and placement within constructed landforms. Information on the characteristics, volumes and placement recommendations for each material presented in the inventory will be used to facilitate appropriate landform design, planning and scheduling of soil and waste materials, and associated rehabilitation prescriptions.

The six classifications provided (Table ES1) are based on standard soil science parameters which pertain to the likely erodibility of the materials and ability to support sustainable vegetation. However, where applicable, the classifications are also based on comparison to analogue values from the KCGM site, and / or to appropriate values for mining / rehabilitation scenarios in the region.

The characterisation of inventory components has highlighted that the availability of suitable rehabilitation material for use on the outer slopes of waste rock landforms and tailings storage facilities, which is likely to remain stable (i.e. resist erosion) and support plant growth, is limited (Table ES1). Much of the stockpiled topsoil and oxide materials on site have physical and chemical characteristics (e.g. high salinity, high sodicity, poor structural stability, very low hydraulic conductivity, hardsetting characteristics) which indicate that their use as a rehabilitation resource is likely to be restricted to flat areas of waste landforms. This has significant implications for the design, rehabilitation prescriptions and closure criteria associated with the constructed waste landforms at the KCGM operations.

The lack of suitable rehabilitation materials on site has significant implications for the design, rehabilitation prescriptions and closure criteria associated with the constructed waste landforms at the KCGM operations.

**Table ES1 Summary of KCGM soil and waste inventory classifications and associated volumes of each material**

<b>Classification</b>	<b>Description</b>	<b>Volume (m<sup>3</sup>)</b>
<b>Class 1</b>	Topsoil material suitable for application to outer slopes or flat surfaces	408,112
<b>Class 2</b>	Topsoil material suitable for application to flat surfaces only	1,356,157
<b>Class 3</b>	Oxide or soil material for use as a cover material on outer slopes or flat areas	128,500
<b>Class 4</b>	Oxide or soil material for use as a cover material on flat areas only	25,514,948
<b>Class 5</b>	Bulk waste rock fill material <sup>1</sup> .	84,815,947
<b>Class 6</b>	Potentially problematic material to be encapsulated within landforms	5,469,054

1. The bulk waste rock material (Class 5) will be suitable as an erosion resistant outer slope material. Further testing of different lithologies and particle size distributions of 'as-mined' waste rock material will be conducted to refine the classification for use of this material as an outer slope surface material.

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## 1.0 INTRODUCTION

Outback Ecology Services was commissioned by Kalgoorlie Consolidated Gold Mines (KCGM) to conduct a comprehensive, two-staged, characterisation study of soil and waste materials at the KCGM operations. Stage 1 of the investigation comprised a review of existing information and gap analysis, while Stage 2 incorporated a sampling and analysis program to characterise existing soils and waste materials in rehabilitated areas, and develop a soil and waste materials inventory of stockpiled and future soil and waste materials on site.

This report, which comprises Section 2 of the overarching KCGM Soil and Waste Characterisation Report (Table 1), presents the summarised inventory of the soil and waste characterisation study, broad classifications for each material unit, and associated recommendations for material use and placement within constructed landforms and rehabilitation prescriptions. Information on the characteristics, volumes and placement recommendations for each material presented in the inventory will also be used to facilitate appropriate landform planning and scheduling of soil and waste materials.

**Table 1 Structure of overarching KCGM Soil and Waste Characterisation report**

<b>Report Section</b>	<b>Detail of Each Section</b>
Section 1	Introduction Background Information Review (Stage 1 Report)
<b>Section 2</b>	<b>KCGM Soil and Waste Materials Inventory</b>
Section 3	Golden Pike Cutback Area
Section 4	As-mined Waste Rock
Section 5	Proposed Waste Landform Footprint Areas
Section 6	Existing Topsoil and Oxide Stockpiles
Section 7	Existing Rehabilitation and Rehabilitation Trial Areas
Section 8	Mt Percy
Section 9	Morrison Flats
Section 10	Kaltails
Section 11	References and Appendices Electronic data base of results

## 2.0 METHODS OF INVENTORY POPULATION AND CLASSIFICATION

### 2.1 Soil and Waste Material Classifications

The various soil and waste material resources on site have been classified into six classes based on their physical, chemical and geochemical characteristics, and resulting suitability for placement within constructed and rehabilitated landforms.

The six classes of soil and waste materials are as follows:

- Class 1: Topsoil material for use as a surface rehabilitation material, suitable for outer slopes or flat surfaces;
- Class 2: Topsoil material for use as a surface rehabilitation material, suitable for flat surfaces only;
- Class 3: Oxide or soil material for use as a cover material on outer slopes or flat areas;
- Class 4: Oxide or soil material for use as a cover material on flat areas only;
- Class 5: Bulk fill material (typically waste rock);
- Class 6: Potentially problematic material to be encapsulated within landforms.

Within the inventory, topsoils are defined as either; a) material in a current stockpile which has been delineated as a 'topsoil stockpile', or b) the surface soil within disturbance footprint areas to be stripped to a nominal depth of approximately 20cm.

Subsoils are those soils on future disturbance footprints lying directly beneath the topsoil horizon(s), and above any saprolitic material, which have been identified as a suitable resource for use on constructed landforms.

Oxide materials are defined as either, a) materials in a current stockpile which has been delineated as an 'oxide stockpile', or b) material delineated as oxide material from drill logs of Golden Pike Cutback regolith.

### 2.2 Soil and Waste Material Characteristics

The criteria for classification of the soil and waste materials into each class are presented in Table 2. The classifications provided are based on standard soil science parameters, however, where applicable, the classifications are based on a comparison to analogue soil values from the area, and / or appropriate values for mining / rehabilitation scenarios in the region.

In most cases the classification given for each component of the inventory is based on the combination of a number of characteristics. The ranges of the various chemical and physical parameters used to delineate

and classify the various components of the inventory are presented in Section 11 – Appendix C, of the overarching KCGM Soil and Waste Characterisation report.

**Table 2 Typical criteria for soil and waste material classification**

Material Classification	General Characteristics <sup>1</sup>	
	Chemical	Physical
<b>Class 1</b>	<ul style="list-style-type: none"> <li>• Non-saline or low salinity</li> <li>• Soil pH similar to surface analogue soils <sup>2</sup>.</li> <li>• Non sodic or low sodicity</li> <li>• Similar nutrient status to surface analogue soils <sup>2</sup>.</li> </ul>	<ul style="list-style-type: none"> <li>• Non dispersive</li> <li>• Moderate gravel content</li> <li>• Low to moderate hardsetting tendencies</li> <li>• High permeability</li> <li>• Low potential erodibility</li> </ul>
<b>Class 2</b>	<ul style="list-style-type: none"> <li>• Non-saline or low salinity</li> <li>• Soil pH similar to surface analogue soils <sup>2</sup>.</li> <li>• Low sodicity</li> <li>• Similar nutrient status to surface analogue soils <sup>2</sup>.</li> </ul>	<ul style="list-style-type: none"> <li>• Partially dispersive</li> <li>• Lower gravel content than Class 1</li> <li>• Moderate to high hardsetting tendencies</li> <li>• Moderate permeability (lower than Class 1)</li> <li>• Higher potential erodibility than Class 1</li> </ul>
<b>Class 3</b>	<ul style="list-style-type: none"> <li>• High salinity</li> <li>• Soil pH similar to deeper analogue soils <sup>2</sup>.</li> <li>• Sodic</li> <li>• Low nutrient status</li> </ul>	<ul style="list-style-type: none"> <li>• Structurally unstable (partially dispersive)</li> <li>• Moderate hardsetting tendencies</li> <li>• Low permeability</li> <li>• Moderate potential erodibility</li> </ul>
<b>Class 4</b>	<ul style="list-style-type: none"> <li>• High salinity</li> <li>• Soil pH similar to deeper analogue soils <sup>2</sup>.</li> <li>• Sodic or highly sodic</li> <li>• Low nutrient status</li> </ul>	<ul style="list-style-type: none"> <li>• Structurally unstable (partially or fully dispersive )</li> <li>• Hardsetting</li> <li>• Low to very low permeability</li> <li>• Very high potential erodibility</li> </ul>
<b>Class 5</b>	<ul style="list-style-type: none"> <li>• High salinity</li> <li>• Sodic (&lt;2mm fraction)</li> <li>• Low nutrient status</li> </ul>	<ul style="list-style-type: none"> <li>• Typically waste rock material</li> <li>• Very high % of coarse material (&gt;2mm)</li> <li>• Hardsetting</li> <li>• High permeability</li> <li>• Low potential erodibility</li> </ul>
<b>Class 6</b>	<ul style="list-style-type: none"> <li>• Typically PAF waste rock material <sup>3</sup>.</li> <li>• High salinity</li> </ul>	

1. Classification ranges for various parameters are provided in Section 11 – Appendix C, of overarching KCGM Soil and Waste Characterisation report.

2. Chemical and physical characteristics of analogue soils are provided in Section 5 of overarching KCGM Soil and Waste Characterisation Report.

3. Details of potentially acid-forming (PAF) material are provided in Section 3 of overarching KCGM Soil and Waste Characterisation Report.

The materials included within the KCGM soil and waste materials inventory are presented in Table 3 and Figure 1. Also provided in Table 3 are references to the relevant sections of the overarching KCGM Soil and Waste Characterisation report, and other references, which detail the characteristics of each individual material.

**Table 3 Soil and waste material units included in the inventory**

Site Location	Soil and Waste Types	References for Further Information
Golden Pike Cutback	Topsoil, subsoils, oxide, transitional and waste rock material yet to be mined.	<ul style="list-style-type: none"> <li>• Outback Ecology (2010) Soil and Waste Characterisation, Section 3.</li> <li>• SWC (2008) Golden Pike Extension Soil Survey</li> </ul>
As-mined waste rock	Existing waste rock from batters	<ul style="list-style-type: none"> <li>• Outback Ecology (2010) Soil and Waste Characterisation, Section 4.</li> </ul>
Waste rock landform footprint areas	Topsoil and subsoil materials yet to be stripped	<ul style="list-style-type: none"> <li>• Outback Ecology (2010) Soil and Waste Characterisation, Section 5.</li> <li>• SWC (2008) Native Soil Profile Characterisation.</li> </ul>
Existing topsoil and oxide stockpiles	Existing stockpiles of topsoil (16 stockpiles) and oxide material (3 stockpiles) on site	<ul style="list-style-type: none"> <li>• Outback Ecology (2010) Soil and Waste Characterisation, Section 6.</li> <li>• SWC (2008) Topsoil Characterisation</li> </ul>

Materials not currently included in this inventory, which will be the subject of subsequent reports, include:

- Stockpiles around the Kaltails TSF (to be sampled in 2010);
- Soils at the Gidji TSF (to be sampled in 2010).

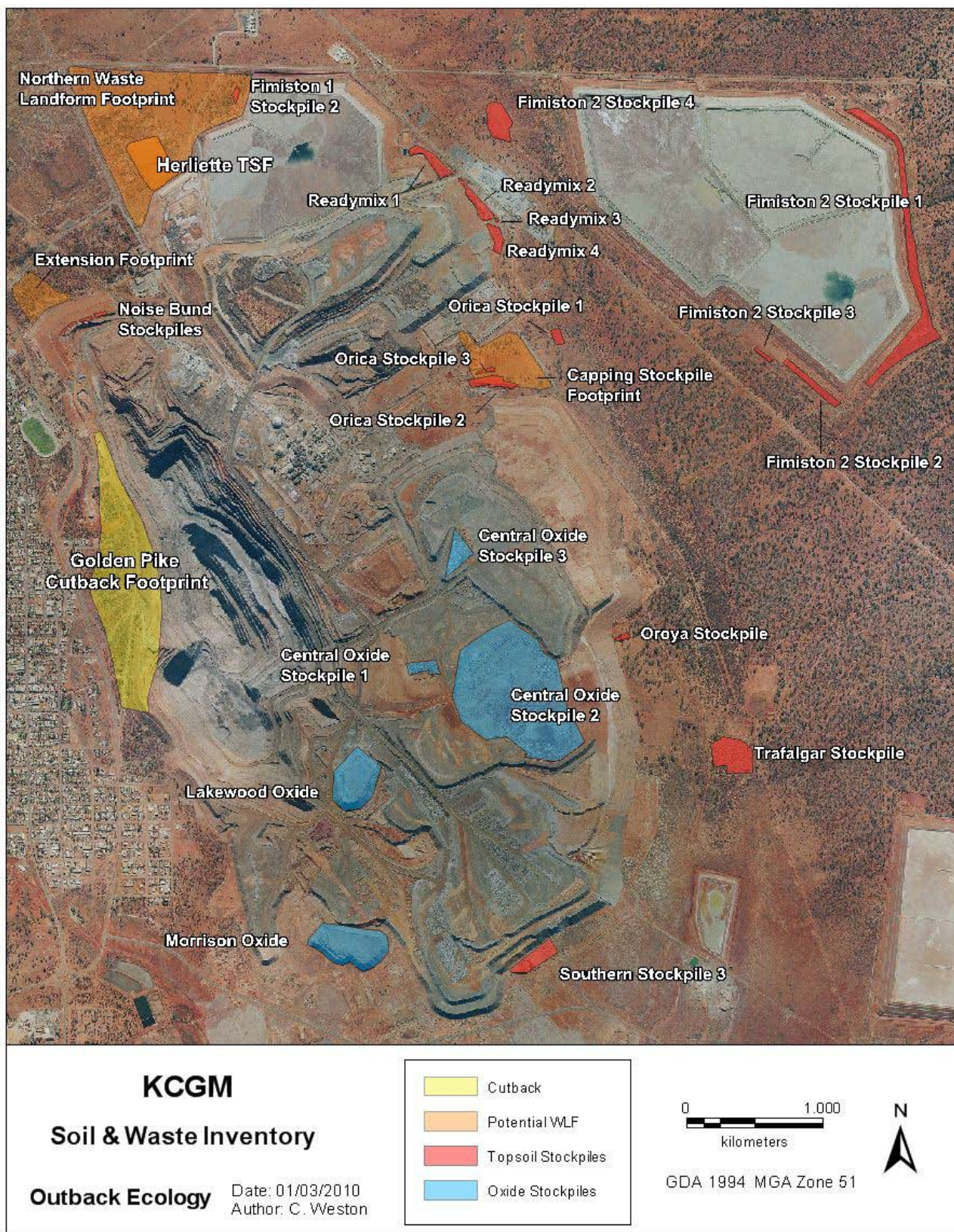


Figure 1 Location of soil and waste material units included in the inventory

### 2.3 Soil and Waste Material Volumes

Volumes of topsoil and subsoil materials yet to be stripped from the Golden Pike Cutback, Northern waste rock landform and Capping Stockpile footprints have been estimated based on the footprint area and likely depth of the topsoil and subsoil materials present (Table 4). It is possible that these volumes may change as more or less suitable material is encountered during soil stripping operations.

The volumes of stockpiled topsoil and oxide materials on site (Table 4) have been derived from site survey data detailed in: KCGM (2009) Topsoil and Oxide Stockpile Volumes as at 1<sup>st</sup> July 2009. KCGM Open Pits Survey Department.

The volumes of oxide, transitional and waste rock materials expected from the Golden Pike Cutback have been derived from information supplied by the KCGM geology department.

## 3.0 KCGM SOIL AND WASTE MATERIALS INVENTORY

### 3.1 Summarised Characteristics, Volumes and Classifications

The summarised soil and waste material inventory for all stockpiled and future soil and waste resources on site is presented in Table 4. The classifications and subsequent recommendations for material placement within the waste landforms are based on specific characteristics of each material and the measured performance of similar materials in exiting rehabilitated areas on site.

More detailed information on the characteristics of each material and their classifications is included in the following Sections of the overarching KCGM Soil and Waste Characterisation report:

- Section 3 – Golden Pike Cutback Area;
- Section 4 – As-mined Waste Rock;
- Section 5 – Proposed Waste Rock Landform Footprints;
- Section 6 – Existing Topsoil and Oxide Stockpiles;

**Table 4 Inventory of soil, oxide and waste rock resources at KCGM**

Inventory Component	Location <sup>1</sup>	Feature	Topsoil	Subsoil	Oxide	Transitional	Waste rock		
							Basalt	Dolerite	Black Flag Shale
Golden Pike Cutback	Cutback Footprint	<i>Characteristics</i>	Gravelly sandy loam, non to moderately saline, non-sodic, high hydraulic conductivity.	Variable depth, gravelly sandy loam and gypsic hardpan, non-saline and non-sodic.	Variable. Wide range in salinity (typically moderate salinity), pH and structural stability, low nutrient status. Very low hydraulic conductivity and high water holding capacity expected.	Variable. Wide range in salinity, typically neutral to alkaline pH and structurally stable	Low salinity, non-acid forming <sup>5</sup> , high hydraulic conductivity, low water holding capacity	Low salinity, non-acid forming <sup>5</sup> , high hydraulic conductivity, low water holding capacity	Moderate salinity, potentially acid forming <sup>5</sup> .
		<i>Volume (m<sup>3</sup>)</i>	50,000 <sup>2</sup>	62,500 <sup>3</sup>	12,616,191	4,615,846	14,676,920	70,139,027	5,469,054
		<i>Classification</i>	Class 1	Class 3	Class 4	Class 4	Class 5	Class 5	Class 6
Waste landform footprints	Northern Waste Rock Landform Footprint (calcareous low hills)	<i>Characteristics</i>	Variable, typically low salinity, variable sodicity, structurally stable, high gravel content, not hardsetting.	Variable depth, high gravel content, typically sodic but not dispersive, moderate salinity, not hardsetting.					
		<i>Volume (m<sup>3</sup>)</i>	44,000 <sup>2</sup>	66,000 <sup>3</sup>					
		<i>Classification</i>	Class 1	Class 3					
	Northern Waste Rock Landform Footprint (flat plain)	<i>Characteristics</i>	Variable, typically low salinity and non sodic but some materials dispersive, low gravel content, not hardsetting.	Variable depth, typically highly sodic, moderate to high salinity					
		<i>Volume (m<sup>3</sup>)</i>	40,000 <sup>2</sup>	60,000 <sup>3,4</sup>					
		<i>Classification</i>	Class 2	Class 4					
	Herliette TSF cover	<i>Characteristics</i>	Variable, typically non to moderately saline, high gravel content, sodic but not dispersive, not hardsetting.						
		<i>Volume (m<sup>3</sup>)</i>	33,800						
		<i>Classification</i>	Class 1						

Inventory Component	Location <sup>1</sup>	Feature	Topsoil	Subsoil	Oxide	Transitional	Waste rock		
							Basalt	Dolerite	Black Flag Shale
Waste landform footprints	Capping Stockpile Footprint	<i>Characteristics</i>	Variable, non-saline, sodic, typically not hardsetting	Variable, non-saline calcareous gravels to sodic heavy clays					
		<i>Volume (m<sup>3</sup>)</i>	28,000	40000 <sup>3, 4</sup>					
		<i>Classification</i>	Class 2	Class 4					
Topsoil stockpiles	Fimiston 1 Stockpile 2 (west of Fim 1)	<i>Characteristics</i>	Loam texture. Low to moderate salinity, non-sodic to sodic						
		<i>Volume (m<sup>3</sup>)</i>	13,876						
		<i>Classification</i>	Class 2						
	Noise Bund Stockpiles (Croesus Stockpiles 1 to 5)	<i>Characteristics</i>	Sandy clay loam. Moderately saline, non-sodic, high gravel content, hardsetting.						
		<i>Volume (m<sup>3</sup>)</i>	9,291						
		<i>Classification</i>	Class 2						
	Fimiston 2 Stockpile 1	<i>Characteristics</i>	Variable texture, salinity (low to moderate EC) nutrient status and sodicity (typically sodic). Relatively high water holding capacity.						
		<i>Volume (m<sup>3</sup>)</i>	655,311						
		<i>Classification</i>	Class 2						
	Fimiston 2 Stockpile 2	<i>Characteristics</i>	Variable texture, salinity (low to moderate EC) nutrient status and sodicity (typically sodic). Relatively high water holding capacity.						
		<i>Volume (m<sup>3</sup>)</i>	58,038						
		<i>Classification</i>	Class 2						

Inventory Component	Location <sup>1</sup>	Feature	Topsoil	Subsoil	Oxide	Transitional	Waste rock		
							Basalt	Dolerite	Black Flag Shale
Topsoil stockpiles	Fimiston 2 Stockpile 3	Characteristics	Variable texture, salinity (low to moderate EC) nutrient status and sodicity (typically sodic). Relatively high water holding capacity.						
		Volume (m <sup>3</sup> )	26,790						
		Classification	Class 2						
	Fimiston 2 Stockpile 4	Characteristics	Variable texture, salinity (low to moderate EC) and sodicity (non to highly sodic)						
		Volume (m <sup>3</sup> )	112,454						
		Classification	Class 2						
	Fimiston 1 Stockpile (Readymix Stockpile 1)	Characteristics	Variable texture (sandy loam to sandy clay loam), moderate gravel content, variable salinity (low to moderate), non-sodic, moderate structural stability.						
		Volume (m <sup>3</sup> )	145,136						
		Classification	Class 1						
	Fimiston 1 Stockpile (Readymix Stockpile 2)	Characteristics	Variable texture (sandy loam to sandy clay loam), moderate gravel content, variable salinity (low to moderate), non-sodic, moderate structural stability.						
		Volume (m <sup>3</sup> )	108,635						
		Classification	Class 1						

Inventory Component	Location <sup>1</sup>	Feature	Topsoil	Subsoil	Oxide	Transitional	Waste rock		
							Basalt	Dolerite	Black Flag Shale
Topsoil stockpiles	Fimiston 1 Stockpile (Readymix Stockpile 3)	Characteristics	Variable texture (sandy loam to sandy clay loam), moderate gravel content, variable salinity (low to moderate), non-sodic, moderate structural stability.						
		Volume (m <sup>3</sup> )	406						
		Classification	Class 1						
	Fimiston 1 Stockpile (Readymix Stockpile 4)	Characteristics	Variable texture (sandy loam to sandy clay loam), moderate gravel content, variable salinity (low to moderate), non-sodic, moderate structural stability.						
		Volume (m <sup>3</sup> )	15,616						
		Classification	Class 1						
	Orica Stockpile 1	Characteristics	Not assessed						
		Volume (m <sup>3</sup> )	9,328						
		Classification							
	Orica Stockpile 2	Characteristics	Not assessed						
		Volume (m <sup>3</sup> )	84,119						
		Classification							
	Orica Stockpile 3	Characteristics	Not assessed						
		Volume (m <sup>3</sup> )	4,498						
		Classification							
Trafalgar Stockpile B (Southern Stockpile 1)	Characteristics	Sandy loam to clay loam texture, variable gravel content, variable salinity (non to moderately saline), non sodic, moderate stability, hardsetting							
	Volume (m <sup>3</sup> )	278,351							
	Classification	Class 2							

Inventory Component	Location <sup>1</sup>	Feature	Topsoil	Subsoil	Oxide	Transitional	Waste rock			
							Basalt	Dolerite	Black Flag Shale	
Topsoil stockpiles	Oroya Stockpile (Southern Stockpile 2)	Characteristics	Variable texture (loamy sand to sandy clay loam) variable salinity (non to moderately saline), non-sodic, moderate gravel content, hardsetting.							
		Volume (m <sup>3</sup> )	10,519							
		Classification	Class 1							
	Southern Stockpile 3	Characteristics	Predominantly oxide material. Sandy loam to clay loam texture, high gravel content, very saline, non-sodic, moderate stability, hardsetting.							
		Volume (m <sup>3</sup> )	36,101							
		Classification	Class 2							
Oxide stockpiles	Central Stockpiles 1 to 3	Characteristics			Variable, typically very saline, neutral to alkaline pH, variable sodicity and structural stability, hardsetting, very low hydraulic conductivity, high water holding capacity.					
		Volume (m <sup>3</sup> )			920,601					
		Classification			Class 4					
	Lakewood Stockpile	Characteristics			To be confirmed					
		Volume (m <sup>3</sup> )			3,275,636					
		Classification			Class 4 (to be confirmed)					
	Morrison Stockpile	Characteristics			To be confirmed					
		Volume (m <sup>3</sup> )			4,046,674					
		Classification			Class 4 (to be confirmed)					

Inventory Component	Location <sup>1</sup>	Feature	Topsoil	Subsoil	Oxide	Transitional	Waste rock		
							Basalt	Dolerite	Black Flag Shale
As-mined waste rock	Various	Characteristics					High coarse fragment content, variable salinity (moderate to very high), sodicity, and soil strength (of <2mm fraction). High hydraulic conductivity and low water holding capacity.		Existing as-mined material known to contain shale – PAF material.
		Volume (m <sup>3</sup> )					na	na	na
		Classification					Class 5	Class 5	Class 6
	<b>Total volumes (m<sup>3</sup>)</b>		<b>1,724,269</b>	<b>168,500</b>	<b>Stockpiled: 8,242,911</b> <b>GPC: 12,616,191</b>	<b>4,615,846</b>	<b>14,769,920</b>	<b>70,139,027</b>	<b>5,469,054</b>

1. alternative names detailed in parentheses where applicable

2. volume based upon approximate area of suitable topsoil and 0.2m stripping depth

3. based upon approximate area and depth of suitable subsoil material

4. 'less favourable' subsoil material only to be collected if required for growth medium on flat surfaces

5. the acid forming potential of the waste materials from the Golden Pike Cutback is currently being assessed by Graeme Campbell and Associates, with the results to be submitted separately to this report.

### 3.2 Material Class Volumes

The total volumes and known locations of materials within each class will allow the incorporation of these materials into waste landform design and scheduling. A summary of the total volumes for each material class is provided in Table 5.

**Table 5 Total volumes of each material Class**

Classification	Description	Volume (m <sup>3</sup> )
<b>Class 1</b>	Topsoil material suitable for application to outer slopes or flat surfaces	408,112
<b>Class 2</b>	Topsoil material suitable for application to flat surfaces only	1,356,157
<b>Class 3</b>	Oxide or soil material for use as a cover material on outer slopes or flat areas	128,500
<b>Class 4</b>	Oxide or soil material for use as a cover material on flat areas only	25,514,948
<b>Class 5</b>	Bulk waste rock fill material	84,815,947
<b>Class 6</b>	Potentially problematic material to be encapsulated within landforms	5,469,054

1. The bulk waste rock material (Class 5) will be suitable as an erosion resistant outer slope material. Further testing of different lithologies and particle size distributions of 'as-mined' waste rock material will be conducted to refine the classification for use of this material as an outer slope surface material.

The characterisation of inventory components has highlighted that the availability of suitable rehabilitation material for use on the outer slopes of waste rock landforms, which is likely to remain stable (i.e. resist erosion) and support plant growth, is limited. Much of the stockpiled topsoil and oxide materials on site have physical and chemical characteristics (e.g. high salinity, high sodicity, poor structural stability, very low hydraulic conductivity, hardsetting characteristics) which indicate that their use as a rehabilitation resource is likely to be restricted to use on flat areas of waste landforms.

Amendments to the soil and waste materials (e.g. gypsum, organic matter) which may improve their characteristics are not considered appropriate due to the uncertainty of actual benefit and scale on which they would have to be applied.

The lack of suitable rehabilitation materials on site has significant implications for the design, rehabilitation prescriptions and closure criteria associated with the constructed waste landforms at the KCGM operations.

#### 4.0 REFERENCES

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