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6.8 Soils and Land Cover

6.8.1 Assessment Criteria

To assess the significance of potential impacts upon soils, the general methodology, as described in Section 6.1, has been used.

Soil and Land Cover

In the absence of specific Armenian guidelines that relate to the loss of soils or the reuse of agricultural land, the following receptors have been selected as sensitive soil resources. These include potential impacts on:

- Soils that are used, or available for use, in agriculture for production of food crops other than grass; and
- Soils that support biodiverse grasslands, and provide a source of nutrition for cattle and sheep, used by seasonal herders during the summer months.

The relevant IFC Performance Standards and EBRD Performance Requirements that relate to soils are set out in Table 6.8.1.

Table 6.8.1: Relevant IFC and EBRD Requirements that Relate to Soils

	Performance Standard / Requirement		Requirements
IFC	PS1	Assessment and Management of Environmental and Social Risks and Impacts	Assess the risks and potential impacts to environmental resources, such as soil. Potential impacts such as the loss and or deterioration of soil resources are to be considered.
	PS3	Resource Efficiency and Pollution Prevention	Natural resources, including soils, are protected from pollution risks, including contamination from chemicals and fuels, change in state as a consequence of dust deposition, and change in surface water regime or drainage.
	PS6	Biodiversity Conservation and Sustainable Management of Living Natural Resources	Soils that support natural habitats are considered as sensitive, because they form an integral part of the natural resource and their contribution to ecosystems services.
EBRD	PR1	Environmental and Social Appraisal and Management	Consider in an integrated manner the potential environmental impacts, including that of soil, associated with the proposed project. Minimize, mitigate, or offset / compensate for adverse impacts and to identify, and where feasible adopt, opportunities to improve environmental performance.

Table 6.8.1: Relevant IFC and EBRD Requirements that Relate to Soils			
	Performance Standard / Requirement		**Requirements**
	PR3	Pollution Prevention and Abatement	Technical characteristics of the installation, its geographical location and local / ambient environmental conditions shall be considered to apply pollution prevention and control technologies and practices (techniques) that are best suited to all polluting activities in all economic activities, and from effluents and emissions at the facility level, to a regional and global level where appropriate.
	PR6	Biodiversity Conservation and Sustainable Management of Living Natural Resources	The sustainable use and management of natural resources, in all types of habitats, irrespective of whether they have been disturbed or degraded previously, or whether or not they are protected or subject to management plans. This is to achieve no net loss / net gain of biodiversity in the affected habitat. Soils support these habitats and the ecosystem services they provide, and consequently are to be considered in the same way.

These Performance Standards / Requirements have been considered in determining receptor sensitivity in Table 6.8.2. The sensitivity of each soil association, defined in Chapter 4.7.1, has then been assessed in relation to the main Project components that would result in the disturbance of soil resources during the construction phase of the Project.

Table 6.8.2: Sensitivity of Soils in Terms of Productivity in Relation to Project Infrastructure Components

Soil Association	Project Component										
	Erato	Tigranes-Artavazdes	Primary Crushing Plant	Secondary Crushing Plant	BRSF	HLF, ADR	Haul Roads and Access Roads	Overland Conveyor	Maintenance and Storage	Worker Accommodation Camp	Waterline
Brown forest steppe						HIGH					
Mountain black							MEDIUM			MEDIUM	
Mountain chestnut						HIGH					HIGH
Mountain meadow	MINOR						MINOR				
Mountain meadow steppe				MINOR			MINOR				
River Valley soils						MED-IUM					

Table 6.8.2 identifies that soils of high sensitivity (Brown Forest Steppe and Mountain Chestnut) and medium sensitivity (Mountain Black and River Valley soils) are present within the Project-affected area, and would be adversely affected as a consequence of constructing the HLF, ADR, haul and access roads, overland conveyor and worker accommodation camp. These soils represent those which support versatile agricultural land that would be either temporarily or permanently lost as a consequence of construction and operation. As a result, they are identified to have a medium to high sensitivity as these soils are currently used for agricultural production; a land use that cannot be sustained post-development, following closure of the mine, although the HLF closure would include the reclamation of the HLF and surrounding area to pasture and woodland, the agricultural uses would be limited in comparison to the baseline condition.

Other infrastructure components within the Project affected area (namely the open pits, crushing plants, BRSF, haul and access roads, overland conveyor and maintenance and storage facilities) support soils which are classified as being of minor sensitivity (Mountain Meadow and Mountain Meadow Steppe). These are classified as such due to their lack of agricultural productivity, depth of the resource, and structural integrity. Even though these soils are not agriculturally productive, their weak structure, thin depth and naturally high background concentrations of certain elements have resulted in the diverse grassland habitats considered in Chapter 4.10, and include the support of critical habitats, such as that of *Potentilla porphyrantha* (Chapter 4.10.3). Consequently, sensitivity of these soil types cannot be adequately determined using Table 4.7.3; however, they have been defined as sensitive to disturbance, handling and storage due to the presence of these critical habitats.

6.8.2 Potential Impacts

Physical Loss of Soil Resources

The baseline analysis (Chapter 4.7.7) has identified that the majority of the land that will be subject to disturbance is currently a grassland habitat (68%), and that this is currently utilised for seasonal summer grazing, as well as hay cropping and herb collection at lower elevations (see Chapters 4.7.7 and 4.10). There are five soil associations, identified in the baseline surveys (see Figure 4.7.3), within the Project affected area. These can be distinguished by altitude and underlying parent material. The soil associations identified are ubiquitous both locally, in the Amulsar region, and nationally. The soil associations are:

- Mountain chestnut;
- Brown forest steppe;

- Mountain black;
- Mountain meadow steppe;
- Mountain meadow; and
- River Valley soils

The volume of soil disturbed by soil association has been calculated for the elements of the Project footprint and is shown in Table 6.8.3.

Table 6.8.3: Potential Disturbance by Soil Association, by volume (to nearest 100m^3)														
Soil Type	**Soil Horizon**	**Tigranes - Artavazdes Open Pit**	**Erato Open Pit**	**HLF**	**BRSF**	**Haul and Access Roads**	**Crusher platform**	**Overland Conveyor + Discharge Structure**	**Maintenance Workshop**	**Worker Accommodation Camp**	**Other**	**Total TS (m^3)**	**Total SS (m^3) Total (m^3)**	
Brown forest steppe soils	TS			146,800		3,600		200		30,000		180,600		
	SS			363,300		7,200		400					370,900	
Mountain black soils	TS					170,000		189,500		45,000	48,600	453,100		
	SS					170,000		189,500					359,500	
Mountain-chestnut-soils	TS			190,300		3,200		30,700			102	224,300		
	SS			269,400		6,400		30,700			205		306,700	
Mountain meadow soils	TS	246,300	93,500			75,400						415,200		
	SS													
Mountain meadow steppe soils	TS				648,200	170,200	22,000		17,600			858,000		
	SS													
River Valley soils	TS			13,600								13,600		
	SS			27,300									27,333	

Where possible, natural soils and their profiles would be stockpiled for use in restoration post-closure of the mine. Within the open pits, HLF and BRSF the restoration of the land post-closure would result in a landform not suitable for the reclamation of natural soil profiles, as described in the baseline condition. Therefore, pre-mitigation, the loss of soils which are able to support agricultural production, would result in magnitude of change that is High. The sensitivity of the receptor is Minor to High, depending on soil association and location of Project Infrastructure component (see Table 6.8.4).

Table 6.8.4: Significance of Potential Impact of the Soil Types at Different Project Infrastructure Components within the Project Area as a Result of Soil Loss during Construction Phase

Project Infrastructure	Soil Type	Sensitivity	Magnitude	Significant
Tigranes-Artavazdes open pit	Mountain Meadow	Minor	High	✓
Erato open pit	Mountain Meadow	Minor		
BRSF	Mountain Meadow Steppe	Minor		
HLF	Brown Forest Steppe	High		
	Mountain Chestnut	High		
	River Valley soils	High		
Haul and Access roads	Brown Forest Steppe	High		
	Mountain Chestnut	High		
	Mountain Black	Medium		
	Mountain Meadow	Minor		
	Mountain Meadow Steppe	Minor		
Crushers	Mountain Meadow	Minor		
	Mountain Meadow Steppe	Minor		
Conveyor	Brown Forest Steppe	High		
	Mountain Chestnut	High		
	Mountain Black	Medium		
	Mountain Meadow Steppe	Minor		
Maintenance area	Mountain Meadow Steppe	Minor		
Worker Accommodation camp	Mountain Black	Medium		
Water pipeline	Mountain Chestnut	High		

A smaller proportion of the Project affected area would be amenable to post-closure restoration to grassland; these areas include the access and haul roads that are not required on a permanent basis, and could be returned to an area suitable for agricultural use in the long term. Consequently, the disturbance of natural soils during construction in the absence of mitigation would be a significant potential impact.

Erosion of Soil Profiles during Construction and Operation

Changes in the natural soil system as a consequence of anthropogenic activities required for the Project development (see Chapter 3 Project Description) can cause destabilisation of

natural soil profiles, and soil structural deterioration. Consequently, there is the potential for increased rates of soil erosion from the outset of the construction phase. This potential adverse impact can cause short term soil loss during soil handling and longer term consequences should areas of soil erosion occur in periods of high rainfall and during snow melt. Therefore, the potential impact may be ongoing during the operational and closure phases of the development, in the absence of mitigation.

Furthermore, the sediment load and consequently the pollutant load transported into receiving waters may increase. The unlikely risk of landslides contributing additional sediment load to surface waters is a potential impact if soils become destabilised due to removal of surface cover and as a consequence of saturation of the profile following periods of high rainfall, or during snow melt (see Section 6.10.2).

Natural soils in this region vary in depth and quality with some more resilient than others. Table 6.8.5 shows the variation in the significance of the impact of erosion on the different soil types. Consequently, the shallower soils present on steep slopes (Mountain Meadow and Mountain Meadow Steppe) within the Project affected area are more at risk from erosion, as both the sensitivity and, therefore, the magnitude to change from the baseline would be greater. Erosion loss could result in a significant increase in the potential area of soils subject to damage and in the longer term increase the area adversely affected compared to the baseline conditions.

Table 6.8.5: Significance of Potential Impact of the Soil Types within the Project Area as a Result of Erosion during Construction Phase

Soil Type	Sensitivity	Magnitude	Significant
Brown forest steppe soils	Minor	Low	×
Mountain black soils	Minor	Low	×
Mountain-chestnut-soils	Minor	Low	×
River Valley soils	Minor	Low	×
Mountain meadow soils	Medium	Moderate	✓
Mountain meadow steppe soils	Medium	Moderate	✓

Erosion of Soils Post-Closure

Vegetation establishment on bare soil surfaces provides a measure whereby soil surfaces can be stabilised during the operation and post-closure stages. For a period of time post-closure, restored soil surfaces remain bare as there would be little or no vegetation cover. However,

generally once vegetation has established, and subject to the appropriate aftercare, established vegetation would increase resilience against erosion and therefore mitigate the potential impacts of an increase in erosion. The effect of erosion has the potential to increase the visual impact of the Project and would result in soil loss. Soil run-off can reduce flow velocity of watercourses, as a consequence of the deposition of suspended particulates within those watercourses. In the absence of a restoration and aftercare plan post-closure, fragile soils would result in the ongoing loss of structure and water holding capacity and, in consequence, reduce vegetation growth resulting in an ongoing risk of erosion taking place. The Project affected area is subject to a comprehensive Preliminary Mine Reclamation, Closure and Rehabilitation Plan (pMRCRP, Appendix 8.18), and a successful restoration scheme would be a significant benefit for the long term post-closure phase compared to the operational phase.

The sensitivity of the receptor is Medium owing to the fragility of the soils in terms of structure, nutrients, water holding capacity and supporting land use. The magnitude of change, from a future baseline condition (i.e. that of the restored site), would be Moderate in the absence of effective management to reduce erosion and therefore significant in the absence of mitigation.

Erosion from Stockpiled Soils

Soils that have been in storage mounds for up to 12 years, from construction to rehabilitation of the Project, are considered to be sensitive to erosion as they would be fragile and have little or no structure. The potential for erosion increases with exposure, gradient and heavy episodic rainfall events, in the period up to complete ground cover of restored vegetation. The stockpiled soil resource, taking account of the period of storage and the climatic conditions at Amulsar Mountain (see Chapter 4.2.2), is of Medium sensitivity. The magnitude of change from the baseline as a result of the erosion of stockpiled soils is Moderate; erosion of these stockpiled soils can result in poor quality restoration post-closure, and damage / severance of any soil structural quality. Consequently, this would be significant, in the absence of mitigation.

Loss of Soil Structure

Soil Handling during Construction

Soils will be stripped where possible and stored in mounds as per Figure 3.1 for later use in restoration. Appropriate design and maintenance of storage mounds and stripping

mechanisms will be ensured (see Section 6.8.3), especially where stripping of soils particularly valuable to agriculture or biodiversity, as identified in Table 6.8.5, cannot be avoided. Activities such as trafficking over soils, soil handling and storage can lead to a loss of topsoil and the quality of this within the Project affected area if carried out inappropriately. This potential impact would affect the quality of the restoration post-development. This potential adverse impact would be for the duration of the Project's life in most cases, but can also be short-term where soil mounds are not suitably protected. Table 6.8.6 identifies the sensitivity, magnitude and resulting significance of these soils in relation to their handling during the Project.

Table 6.8.6 Significance of Potential Impact of the Soil Types within the Project Area as a Result of Soil Handling

Soil Type	Sensitivity	Magnitude	Significant
Brown forest steppe soils	Medium	Moderate	✓
Mountain black soils	Medium	Moderate	✓
Mountain-chestnut-soils	Medium	Moderate	✓
River Valley soils	Medium	Moderate	✓
Mountain meadow soils	High	Moderate	✓
Mountain meadow steppe soils	High	Moderate	✓

When this is related to the soil sensitivity scale (Table 4.7.3) the weak, poorly structured and thin fragile Mountain Meadow and Mountain Meadow Steppe soils, which support critical habitats such as that of the *Potentilla porphyrantha* (see Chapter 4.10.3) are also considered sensitive. Therefore, this soil would be handled and stored separately. These critical habitats were found in areas of rocky outcrops, thin, weak, poorly structured soils (see Chapter 4.10.3 and Appendix 4.10.3) with a naturally high background level of As, Co, Cu, Ni, Pb, Sb and V. If stripping and storage is not carried out in an appropriate manner (Section 6.8.3), the soils and their respective seed banks will not be retained for use in restoration of the Project area during closure activities. Consequently, this could result in the permanent loss of the fragile critical habitats which have been identified within the project affected area (Chapter 4.10), and the permanent loss or degradation of the fragile soil eco-systems which support these habitats. Consequently, they are less resilient to change resulting in high sensitivity. The magnitude of the impact would be 'Moderate', due to the degree of change from the baseline and changes to the resource post-development in terms of landform. The impact is therefore considered significant in the absence of mitigation.

Soil Handling during Post-Closure Management

The potential impacts are similar to those considered for construction, and include loss of soil volume and soil structure (as a consequence of compaction) during soil restoration from storage to receptor areas within the Project. Adverse design for soil handling during post-closure would result in reduced quality for the final restoration as it is more difficult for vegetation to successfully establish. Table 6.8.7 identifies the significance of improper soil handling post-closure. Soils identified as more fragile and less resilient (Mountain Meadow and Mountain Meadow Steppe soils) are generally more sensitive resulting in significant potential impacts without mitigation.

Table 6.8.7 Significance of Potential Impact of the Soil Types within the Project Area as a Result of Soil Handling Post-Closure

Soil Type	Sensitivity	Magnitude	Significant
Brown forest steppe soils	Medium	Moderate	✓
Mountain black soils	Medium	Moderate	✓
Mountain-chestnut-soils	Medium	Moderate	✓
River Valley soils	Medium	Moderate	✓
Mountain meadow soils	High	Moderate	✓
Mountain meadow steppe soils	High	Moderate	✓

Soil Storage

Potential impacts associated with storage of soil includes compaction and loss through erosion and inappropriate storage. The loss of the soil structural integrity also potentially impacts organism activity, water retention capacity and nutrient retention capability. Storage of soils generally takes place during the construction phase, therefore potential impacts are considered to be an adverse short-term impact. Table 6.8.8 identifies that those with shallow soil profiles and fragile structures are more prone to compaction if handled and stored in adverse conditions. The resultant potential impact is significant in the absence of mitigation for Mountain Meadow and Mountain Meadow Steppe soils, and not considered significant elsewhere.

Table 6.8.8 Significance of Potential Impact of the Soil Types within the Project Area as a Result of Storage

Soil Type	Sensitivity	Magnitude	Significant
Brown forest steppe soils	Minor	Moderate	×
Mountain black soils	Minor	Moderate	×
Mountain-chestnut-soils	Minor	Moderate	×

Table 6.8.8 Significance of Potential Impact of the Soil Types within the Project Area as a Result of Storage			
Soil Type	**Sensitivity**	**Magnitude**	**Significant**
River Valley soils	Minor	Moderate	×
Mountain meadow soils	Medium	Moderate	✓
Mountain meadow steppe soils	Medium	Moderate	✓

Contamination of Topsoil

Baseline soils have been identified as having naturally elevated background levels of As, Co, Cu, Pb, Ni, Sb and V (see Chapter 4.7.5). The baseline analysis in Chapter 4.7.5 identifies the Project affected areas that contain soils with naturally elevated background levels. No soil has been identified as contaminated as a consequence of anthropogenic activity.

Mountain soils that exhibit elevated metal concentration (Chapter 4.7.6) are associated with the appropriate habitat conditions for a range of mountain flora, including that of *Potentilla porphyrantha* (see Chapter 4.10.3). Project affected area topsoil will be stripped and stored separately from other soil to enable the reuse, translocation and restoration of similar habitats (see Section 6.8.3).

Soils which become contaminated as a result of construction and operational activities (e.g. oil-staining from machinery / vehicles, saturation from spills, saturation from contaminated waters at the HLF/ARD plant) will be removed and undergo clean-up procedures as required for mitigation (see Section 6.8.3). Further consideration is given to potential sources of contamination in the following sections.

Acid Rock Drainage (ARD)

ARD has the potential to contaminate natural soils adjacent to mining activity including that of the BRSF. ARD can originate from sulphur-bearing surfaces, e.g. rock containing gold ore, having direct contact with exposed surfaces (such as the open pits, BRSF and HLF) and water (see Chapter 4.6.8). ARD can precipitate or leach onto undisturbed soil surfaces, resulting in contamination of the soil profile.

Contaminated soils can potentially impact on soil ecosystems, nutrient cycling, structural stability, and their water retention capacity. This in turn impacts upon the resilience of the soils to change and rehabilitation during the closure phase.

The sensitivity of the soil resource is Medium, as a consequence of the secondary effects of associated with the potential effects from contamination from ARD, and the magnitude of change would be Medium or Major depending on the area of affected soil. In the absence of mitigation, this contamination as a result of ARD is significant. The ARD Management Plan provides the details of the mitigation resulting from this potential effect (see Appendix 8.19).

Deposition of Dust

Activities during construction and operation of the Project can result in mineral dust becoming deposited on the surface of exposed soil in the area surrounding the Project footprint (see Chapter 6.6.4). Particulate deposition can cause both long and short term adverse impacts on soil quality. Short term impacts include the temporary loss of biologic function and nutrient cycling, consequently causing a temporary loss in soil value as normal land use function is potentially reduced. Short term impacts from particulate deposition occur from sporadic events, including the periodic use of machinery, project phasing, and can be exacerbated by events such as seasonal weather patterns.

Long term impacts are those that are detrimental and persist beyond the closure phase. The long term changes in soil chemistry from particulate deposition, can have long term effects on species competition and community structure within natural habitats.

Positive benefits can also result from particulate deposition including soil enhancement; rock dust has effectively been used as a soil amendment in agriculture. Rock dust can increase the structural stability of the soil, through increased water and nutrient retention capability, allowing the soil to support more diverse plant communities and land uses. Furthermore, particulate deposition has been found to improve soil hydrology, buffer acid soils, and increase plant available potassium concentrations in the soil[1].

The sensitivity of the soils *in situ* is low, as the chemical composition derives from weathered rock that will be mined as a consequence of the Project. The magnitude of the impact is low and not significant; however adjacent to dust generating sources such as haul roads, there is the potential for a higher levels of dust fall and the magnitude of the impact would be moderate. A 50m buffer zone has been defined around the footprint of the mine (see Section 6.6) and it is within this zone that dust deposition would be greatest. The potential for

[1] Barrie Oldfield, 1996. *Rock Dust Puts Out More Than You Think*. Sixth International Permaculture Conference & Convergence.

beneficial impacts associated with dust deposition on to the soil would confer to the long term and would be evident following mine closure. The potential for deposition of dust during the life of the Project has been considered in Section 6.6.

Project Infrastructure Impacted Spills and Leaks

Spills from machinery and processing are generally associated with lubricants, engine oils and fuel. These could lead to contamination of soils in stockpiles or those *in situ* and adjacent to operational areas. This potential impact would persist over the short term but can have a long term effect, depending on the extent of the contamination. This could include oil-spills, chemicals used in extraction of the gold.

The sensitivity is considered to be Medium as the soil would be resilient to minor episodes of contamination. The magnitude of the potential impacts is considered to be Moderate depending on the contamination. There is potential for secondary impacts during restoration of the site if soils cannot be cleaned and require removal following contamination. The potential impact is therefore significant, in the absence of mitigation.

Cyanide Contamination

Soil contamination from cyanide would originate from a spill or leak from the HLF, collection ponds, and to a lesser extent the ADR plant during extraction and processing of the gold ore complex. The risk of soil contamination from cyanide is unlikely; however, if failure of the cell liners, drainage ditches and geomembrane liners were to occur, or contaminated dust from the heap was released into the air and deposited on the soil surface, the impacts upon the affected area would be adverse in the short term, but in the longer term neutral, as cyanide decomposes by oxidation, via bacteria and UV, releasing nitrogen into the soil.

Consequently, the sensitivity of the resource is High, and the magnitude of change is Moderate, and therefore would be significant in the absence of mitigation measures.

6.8.3 Mitigation Measures

Loss of Soil Resource and Soil Structure

Disturbance of Natural Soils within the Project Footprint

Relevant management plans:

- Footprint Management Plan, FMP (Appendix 8.8); and
- Biodiversity Management Plan, BMP (Appendix 8.21)

Natural soils within the Project footprint include those which are important for agriculture, grassland habitats, and critical habitats, such as that of *Potentilla porphyrantha*. Agriculture and grassland land uses have a cross over due to the potential for grasslands to be used for pasture and hay depending on weather conditions. Due to the varying nature of the soils which support these different land uses, different mitigation measures are intended according to their intended post-closure land use (Table 6.8.9).

Table 6.8.9 Disturbance of Natural Soils within the Project Footprint

Soil association	Land use
Brown Forest Steppe	Agricultural
	Grassland
Mountain Chestnut	Agricultural
	Grassland
Mountain Black	Agriculture
	Grassland
River Valley soils	Agriculture
	Grassland
Mountain Meadow Steppe	Grassland
	Critical habitats
Mountain Meadow	Grassland
	Critical habitats

Land in agricultural use comprises soils of Brown Forest Steppe, Mountain Chestnut, River Valley soils and Mountain Black (Table 6.8.9). These have been identified as potentially being significantly impacted by the Project if mitigation measures are not implemented (Section 6.8.2) as within the Project affected areas where disturbance of these soils will occur, the land use has the ability to be restored to agriculture following mine closure.

All of the soil associations host grasslands (Table 6.8.9) which are often used for hay and pasture depending on weather conditions (Section 4.7). Consequently, if mitigation measures are not implemented, the potential impact to these soils could be significant thereby impacting on the ability of the landscape to be returned to a similar baseline condition following mine closure.

Mountain Meadow Steppe and Mountain Meadow soils also support critical habitats (Table 6.8.9) such as those of *Potentilla porphyrantha.* Due to these critical habitats the impact of the development on these soils has the potential to be significant in terms of the biodiversity they support. Consequently, specific mitigation measures are provided to ensure these habitats are protected either for their translocation, nursery growth or for restoration of the

habitat post-closure (see BMP, Appendix 8.21).

Implementation of the following will reduce the loss of the soil resource generally within the Project affected area (see FMP, Appendix 8.8):

- Height of soil mounds will no greater than 3 m for topsoil removed from within areas of critical habitat. Where topsoil is conserved for general reclamation and rehabilitation and not for specific commercial agricultural or ecological habitats, stockpile mounds will be up to 5 m in height. Where subsoil is present and it is required for restoration and rehabilitation, it will be removed up to a depth of approximately 1m below the base of the topsoil. Subsoil will be stored separately in heaps no greater than 5 m in height from the base.
- Where practical, the soil mounds will be designed and located to provide visual screening;
- Soil will be removed and handled only when sufficiently dry; so as to minimise the impact of compaction during handling and storage
- The separate stripping, handling and storage of topsoil from subsoil movements; and
- Minimising the number of machine movements across topsoil.

Soils supporting critical habitats, such as *Potentilla porphyrantha*, will be removed and stored separately for use in restoration of this habitat post-closure, in order to protect the substrate that supports the Armenian Red Book-listed species. These soils will be identified separately from other soil stockpiles to reduce contamination between different soils. The soils supporting these habitats are naturally elevated in certain elements (Chapter 4.7.5), which has aided the creation of their respective habitats by reducing species competition due to these generally harsher conditions. Consequently, the stockpile would include rock and stones which would be removed with the soil. These stockpiles would require protection from erosion during the operational phase and could be used for translocation of *Potentilla porphyrantha* (see Section 6.11), growth of *Potentilla porphyrantha* in nurseries, or for reclamation of the *Potentilla porphyrantha* habitat following closure of the mine using the soil seed bank.

Disturbance of Natural Soils outside the Project Footprint

Mitigation has been identified in the following management plans:

- FMP (Appendix 8.8); and
- pMRCRP (Appendix 8.18).

Construction will result in the disturbance of soils outside the Project footprint. To a practical extent the footprint of temporary facilities, such as construction access roads and laydown areas, will be designed to coincide with longer term project requirements to reduce disturbance and long term impacts to soils. At the end of the construction phase, or when no longer required, the temporary facilities will be reclaimed using stored soils in accordance with the procedures outlined in the pMRCRP (Appendix 8.18). Mine traffic will be restricted to existing roads and access and haul roads to avoid the disturbance of natural soils outside of the Project footprint. This includes the progressive restoration of redundant access tracks, incorporated into the FMP (Appendix 8.8), based on the reinstatement of turf or soils, and the reseeding of areas based on the approach in Table 6.8.10. Likewise, foot traffic will be restricted to existing access roads or paths to the extent practical.

Soil Erosion

Relevant management plans:

- FMP (Appendix 8.8);
- SWMP (Appendix 8.22); and
- pMRCRP (Appendix 8.18).

Potential impacts associated with topsoil erosion will be mitigated by instituting good international industry practice (GIIP) for sediment and erosion control for all Project facilities, including soil storage stockpiles. The Project's pMRCRP (Appendix 8.18) includes the measures required for erosion control, including specific details regarding erosion prevention and sediment control measures that can be utilized at the site, as conditions require. Revegetation of disturbed areas will contribute to long-term mitigation of soil erosion during post closure phase.

Implementation of the following control measures during topsoil stripping and stockpile formation will mitigate the potential for erosion or sediment loading that may arise during soil handling and storage:

- Use of geotextile silt fencing, silt traps, and/or straw bales to reduce sediment transport within the construction site. GIIP will be implemented to avoid overland flow away from the construction area; this will reduce the transport of sediment away from its origin;
- Diversion of "clean" (non-contact) water away from works areas;
- Dust suppression by wetting or application of a dust control agent;

- Grading of the site to channel surface flows into ditches to reduce flow velocities and to decrease the potential for erosion;
- Collection and pumping of runoff to settling facilities, or the treatment of potentially affected water, including water used to decontaminate equipment, and impacted runoff;
- Regular inspection and maintenance of silt control measures;
- Provision of temporary storm water retention capacity;
- Proof-rolling of subgrade or stockpile materials;
- Covering of soil and re-establishment of vegetation on cleared areas not used for construction and establishment of a vegetative cover on topsoil stockpiles; and
- Implementation of the SWMP (Appendix 8.22), to assess impacts of site runoff on receiving surface water bodies and the effectiveness of construction erosion control measures.

Disturbed and stockpiled soils will be managed as follows:

- Where short term disturbance is required for infrastructure development, soils will be stockpiled on a temporary basis with soil returned following completion of construction and the surface revegetated; and
- Where long term disturbance is required (duration of the operational phase), soil will be stored in mounds, where appropriate separating top from subsoil. All soil mounds will be sown with a grass seed mixture appropriate to the storage location and maintained for the duration of the operational phase. The indicative location of the long term soil mounds are shown on Figure 3.1.

The pMRCRP (Appendix 8.18) contains the procedures for the restoration of soils, where practical on a progressive basis, to rehabilitate worked out parts of the site returned to grassland. The cultivation and establishment of natural and semi-natural vegetation will be challenging in the harsh mountain environments, and the extent of local practical experience is limited, as is the availability of suitable soil and plant material. Rehabilitation and restoration of soils and vegetation will therefore require early research and trials to determine the best approaches for ground replacement, creation and amelioration of soil forming materials, vegetation establishment and aftercare (see Section 6.11).

To the extent practical and based on the designs in the pMRCRP (Appendix 8.18), land disturbance will be mitigated during reclamation. Topsoil stockpiled during construction and

properly maintained in the interim will be distributed over re-graded land surfaces to facilitate revegetation. The rehabilitation plan will be implemented as a key element of mine closure, which will include progressive restoration of redundant roads, together with the reinstatement of the land surface and management of disturbed soils as a resource for the restoration of decommissioned areas. Detailed rehabilitation plans will be required for the HLF, crushers, haul roads, and other site infrastructure; these will form a part of the pMRCRP.

Management of Topsoil Stockpiles

Relevant management plans:

- FMP (Appendix 8.8); and
- pMRCRP (Appendix 8.18).

Topsoil stockpiles will be designed and maintained in a manner to retain as much of the stored materials' integrity as possible. Specifically, topsoil from areas of critical habitat will be stored in stockpiles no higher than 3 m in height, to reduce the potential for compaction and physical and biological changes to the soil during storage. The location of topsoil bunds will be located at intervals adjacent to the areas that will have soil removed, during construction (see Figure 3.1). The actual position of storage mounds will take account potential impacts during operation (over-trafficking, contamination with de-icing agents and dust from haul road surfaces), such that the integrity of the topsoil stores will be maintained for the duration of the operational phase. Soils that area required principally for the restoration of the BRSF, HLF and other infrastructure that will not be returned for use in commercial agriculture (i.e. primarily used for rehabilitation and revegetation) will be stored in mounds no greater than 5 m in height.

Soil stockpiles will be graded to shed runoff, to the extent practical, and seeded with an appropriate blend of cover plants to maintain soil fertility during storage, and to further decrease the potential for erosion. An appropriate grass seed mixture will be used to stabilise the surface of the mound. The outer slopes of both top and subsoil mounds can be used receptor areas for turves of sub-alpine grasslands, as directed by the Ecological Clerk of Works.

Relevant management plans:

- Emergency Preparedness and Spill Response Plan, EPSRP (Appendix 8.9);
- Cyanide Management Plan, CMP (Appendix 8.11);
- SWMP (Appendix 8.22);
- Acid Rock Drainage Management Plan, ARDMP (Appendix 8.19);
- Air Quality, Noise and Vibration Management Plan, AQNVMP (Appendix 8.14); and
- pMRCRP (Appendix 8.18).

Contamination of Topsoil

Spills and Leaks

The location of topsoil mounds will ensure that the potential for contamination is minimised. The implementation of an EPSRP (Appendix 8.9) mitigates the potential for adverse impacts to soil and water quality in the event of an accidental spill or release during normal construction or operating conditions.

Specialised training and personal protective equipment (PPE) will be provided as necessary to employees working in proximity to cyanide-bearing solutions and in the HLF area. The CMP (Appendix 8.11) contains specific procedures for cyanide handling in accordance with the International Cyanide Code. The Plan also contains procedures for spill avoidance and for spill containment and cleanup.

The ARDMP (Appendix 8.19) mitigates the potential for adverse impacts to soils and water quality in the unlikely event that ARD is released into the environment outside of the ARD plant. The ARDMP (Appendix 8.19) details specific measures to mitigate a release of ARD from the mine, and the clean-up required for soils and water.

Appropriate bunded containment will be required around areas where spills could occur, such as storage tanks, and areas where chemicals, fuels, or lubricants are being handled or used will be underlain by a suitable liner, or paved to prevent any accidental spills from reaching the underlying soils.

Appropriate sorptive materials for the materials stored or in use in a particular area will be provided and kept stocked in an easily accessible location, so that in the event of a spill or accidental discharge, the spill can be contained and cleaned to reduce spread and contamination of adjacent soils.

Down gradient monitoring wells will be regularly sampled to verify that no fugitive solution from the BRSF underdrains or overdrains, and therefore has a potential to contaminate adjacent undisturbed soils.

A leachate detection system will be installed around the periphery/down-gradient of the sanitary landfill. Regular monitoring of the leachate detection system would provide detection of any leachate seepage from the materials disposed of in the facility through the liner system. Any leachate detected by the system will be analysed for chemical composition to determine the magnitude of the potential impact to soil quality and water resources, and to provide a context for assessing subsequent mitigation measures.

Dust Deposition

Relevant management plans:

- AQNVMP (Appendix 8.14)

To reduce dust deposition onto the soil surface, dust suppression measures will be utilised to minimise the impacts as per the measures identified in the AQNVMP (Appendix 8.14). These mitigation measures will be implemented to control dust emissions for mining operations during the construction and operational phase.

Restoration of Soils for Natural Habitat Creation

Relevant management plans:

- pMRCRP (Appendix 8.18); and
- BMP (Appendix 8.21).

Soils supporting natural habitats disturbed by the Project footprint, such as that for *Potentilla porphyrantha*, are to be stripped and stored separately so they can be used for translocation following construction, and restored post-closure. The soil supporting these natural habitats is particularly fragile and would be prone to loss through erosion following disturbance. Implementation of the following measures will ensure that there is enough soil to support the natural habitat restoration, and will compensate for the loss of these soil resources damaged during the Project lifetime:

- Loose rock from the surface of the pit would be stockpiled with soil as it is excavated and removed in advance of developing the open pit;

- Rock-soil mixture will be stockpiled separately for use in *Potentilla porphyrantha* habitat restoration; and
- Re-spreading of rock-soil mixture up to a depth of 0.2m in areas where the final landform promotes soil retention and formation (Chapter 3.15, and Appendix 8.18).

Management of Restored Soils

Relevant management plans: • pMRCRP (Appendix 8.18).

Following restoration of soils, a typical revegetation programme would include:

- Cultivation and levelling of topsoil to produce a suitable surface to establish grassland;
- Arrange collections of large boulders on the surface, where practical using weathered rocks collected prior to disturbance;
- Assessment of soil fertility and chemistry to determine the requirement for fertiliser use;
- Sow appropriate grass seed mixture, selected on the basis of soil type and elevation, at a time prior to the onset of winter snowfall to give sufficient time for grass to germinate and establish; and
- Ongoing aftercare for a minimum period of 5 years.

The details of aftercare management are required by the pMRCRP (see Appendix 8.18).

6.8.4 Monitoring and Audit

As previously identified, the mitigation measures that relate to soil management throughout the life of the Project are addressed in the following management plans:

- Footprint Management Plan (Appendix 8.8);
- Emergency Preparedness Spill Response Plan (Appendix 8.9);
- Cyanide Management Plan (Appendix 8.11);
- Surface Water Management Plan (Appendix 8.22);
- Integrated Waste Management Plan (Appendix 8.13);
- Air Quality Noise Vibration Management Plan (Appendix 8.14);
- Acid Rock Drainage Management Plan (Appendix 8.19);
- Preliminary Mine Reclamation Closure and Rehabilitation Plan (Appendix 8.18); and
- Biodiversity Management Plan (Appendix 8.21).

The effectiveness of the mitigation and management strategy will be subject to ongoing monitoring defined in Standard Operating Procedures (see Table 6.8.10).

Table 6.8.10: Soil Resources, Mitigation and Monitoring		
Soil resources, mitigation and monitoring		
Monitoring approach	Baseline	Physical attributes (structure, pedology and depth) have been determined from published sources and validated through detailed soil surveys undertaken during 2013 and 2014. Five main soil associations have been identified: **Mountain black soils:** shallow to deep black earths, topsoil depth typically 25 to 300mm. **Meadow steppe soils:** weakly structured shallow topsoils, on average 150 mm, overlying a shallow subsoil. Typically, chestnut brown colour with a sharp transition to underling weathered rock. generally present at elevations above 2400 m to 2600 m(AOD) **Mountain Meadow soils:** immature, weakly structure, sub-Alpine soils, generally present at elevations 2600 m (AOD). These soils generally have a shallow profile with a topsoil depth typically less than 200 mm. At altitude, there are increasing amounts of bare ground, with little or no soil cover, vegetation established in cracks and hollows in rock. **River Valley soils: D**eep topsoil approximately 0.3m, generally present at elevations up to 2200 m, comprising a loose textured silts and clay, loamy in places. The soils are fertile and suitable for a range of agricultural activities. **Mountain chestnut soils:** Topsoil is of a heavy clay-sandy texture, decreasing in clay content with depth, has weak profile development, and depths of approximately 200 mm. They have a moderate topsoil organic matter content (2-6%) and are relatively shallow. They typically lie at elevations between 1500 to 1900 m (AOD). **Brown Forest steppe soils:** They have a characteristically weak clay-sandy structure with high organic matter levels. They typically occur at elevations between 1600 to 1900 m (AOD). Within each of the soil associations the soil units should be treated separately for the requirements of soil management.
Significant effects		
Loss of soil resources		• Mixing of top and subsoil with overburden during handling and storage; • Erosion of soil resource from stockpiles and adjacent to exposed surfaces; • Loss of the resource in areas adjacent to disturbed areas if overland surface flows extend beyond the Project affected area with suspended sediment, resulting in erosion and deposition.
Loss of soil structure		• Traffic over *insitu* soils, resulting in compaction of top and subsoils;

Table 6.8.10: Soil Resources, Mitigation and Monitoring	
	• Improper soil storage resulting in slumping and compaction of the soil resource, and the possibility of waterlogging; • Soil compaction and smearing during handling and storage, during periods when the soil profile is waterlogged.
Contamination of topsoil	• Dust deposition, resulting in a change in the topsoil chemical composition; • Spills from machinery and processes leading to contamination of soils in stockpiles or those *in situ* and adjacent to operational areas.
Structure, drainage and erosion during restoration & aftercare	• Handling of soils, including compaction, smearing during removal from soil mounds, and replacement during restoration; • Loss of soil during handling and then subsequently by erosion from exposed soil surfaces; • Poor vegetation establishment, with consequential loss of soil structure and water holding capacity and nutrients for plant growth in the early stages of revegetation.
Specific Actions	
Level 2 Management Plans	The Project Execution Plan (PEP) prepared by Lydian will direct the responsibilities of the E-PCM Contractor. The PEP will include all procedures for handling and storage of top and subsoils during the construction phase.
	The pMRCRP (Appendix 8.18) defines the management of soils from the construction phase through to the mine closure plan, so that on reclamation, the soil resource has been maintained to achieve the objectives of the Plan. Performance measures will be included against which monitoring and restoration activities will be measured against to inform when further actions can be stopped.
	The SWMP (Appendix 8.22) defines the management of surface water including the design and maintenance of ditches that control surface water flow around soil storage mounds and prevention of erosion and scour of soil resources. Performance measures will be included against which monitoring and maintenance activities will be measured against to inform when further actions can be stopped.
	The EPSRP (Appendix 8.9) defines the measures that will be taken to manage, control and monitor substances that have the potential to contaminate soil resources. Performance measures will be included against which monitoring and maintenance activities will be measured against to inform when further actions can be stopped.
	The BMP (Appendix 8.21), defines the management of ecosystems from the construction phase through to the post-closure phase, so that restoration of habitats can be effectively achieved. Performance measures will be included against which monitoring and restoration activities will be measured against to inform when further actions can be stopped.
	The AQNVMP (Appendix 8.14) defines the management of construction and operation activities throughout project life to minimise the emissions of dust and noise from vehicles and infrastructure. Performance measures will be included against which monitoring and maintenance activities will be measured against to inform when further actions can be stopped.
	The ARDMP (Appendix 8.19) defines the Project ARD sources and through Predictive modelling provides mitigation and management of these sources during

Table 6.8.10: Soil Resources, Mitigation and Monitoring	
	construction and operation activities throughout the project life and post-closure.
	The CMP (Appendix 8.11) defines the measures that will be taken in order to prevent Cyanide contamination of the environment. It identifies the potential sources, mitigation measures to minimise the likelihood of its transportation into the environment including the design of Project Infrastructure, and management measures for workers, Infrastructure and emergency response in the unlikely event Cyanide is leaked into the environment.
Level 3 SOPs	The level 2 plans will be underpinned by the following SOPs that will provide specific guidance on sampling locations and procedures during the construction, operational and closure phases. The level 3 SOPs will include the following: • Meteorological station –Use of meteorological data from the meteorological station for determining soil handling periods, and feedback to site operations, will be covered in the ESMP. • Soil volume survey, to coincide with completion of soil stores, the mounds will be surveyed and identified on all mine plans, together with protection and route of the cut-off drainage ditching. The volume of soil together with the physical characteristics will be recorded for use in the development of the pMRCRP (Appendix 8.18). • Soil revegetation – on completion of topsoil and subsoil restoration, the surface will be sown with an approved low maintenance grass seed mixture. The establishment of vegetation will be surveyed within 1 month of sowing and then annually, to determine whether additional seeding is needed and the requirements for an annual management programme including cutting and control of pernicious weeds. • Soil erosion surveys to be undertaken twice annually, on or before the onset of winter snowfall, to determine areas where additional protection (i.e. use of geotextile) is required and after snow melt, to determine whether the areas affected by erosions and feedback into the SWMP (Appendix 8.22), with regard to surface water management. These will be augmented by continual visual observation during and following precipitation events which will consequently require some training of appropriate individuals. • Soil chemical analysis (operational phase), procedure for the annual collection of natural topsoils adjacent to: o Open pit o Crushing Plant o BRSF o Water treatment plant, and o HLF Procedures for selecting sampling location and collection, together with requirements for containers, reference standards and shipment to accredited laboratory for analysis. Chain of custody documentation. • Soil restoration (closure phase), procedures for ensuring that top and subsoils are replaced to the correct depth and altitude, taking account of the baseline conditions. Monitoring of soil physical and nutrient status for the purpose of establishing vegetation on restored areas. • Soil nutrient analysis (aftercare phase), procedures for the annual sampling of soils to determine quality for establishment and growth of vegetation. Analysis to include pH, nitrogen, phosphate and potassium and cation exchange capacity.

<table>
<tr><th colspan="4">Table 6.8.10: Soil Resources, Mitigation and Monitoring</th></tr>
<tr><td></td><td colspan="3">Procedures for selecting the sampling strategy, duplication, together with requirements for containers, reference standards, and shipment to accredited laboratory for analysis. Chain of custody documentation.</td></tr>
<tr><th colspan="2">Soil Monitoring strategy</th><th>Strategy</th><th>Monitoring</th></tr>
<tr><td rowspan="2">Removal</td><td>Top / subsoil</td><td>Prior to removing soils the depth of topsoil will be identified for each working area, so that this horizon can be lifted and stored (in separate stores) with heights no greater than 3m in areas of critical habitat from the base of the stockpile.
Where topsoil (to be used in general reclamation and rehabilitation and not for specific commercial agricultural or ecological habitats), stockpile mounds will be up to 5 m in height. Where subsoil is present and it is required for restoration and rehabilitation, it will be removed up to a depth of approximately 1m below the base of the topsoil. Subsoil will be stored separately in heaps no greater than 5 m in height from the base.</td><td>The location, height and volume of each storage mound will be surveyed and the details recorded on the mine plan.

The monitoring requirements will take place during the construction phase and will be included in the ESMP.</td></tr>
<tr><td>Soil units</td><td>The primary soil units comprise:
• Brown Forest Steppe
• Mountain Chestnut
• Mountain Black
• River Valley soils
• Meadow Steppe
• Mountain Meadow</td><td>Topsoils from each unit will be recorded by area and soil type, and will be stored, where practical within separate soil stores. Records of the use of the soil in restoration and rehabilitation to be maintained on the pMRCRP (Appendix 8.18).</td></tr>
<tr><td>Revegetation</td><td>Soil Mounds</td><td>Within 1 month of completing a soil store and at least 1 month prior to the onset of winter snow fall, top and subsoil storage mounds will be sown to a suitable grass seed mix:
Species | %
Mine site</td><td>All soil mounds to be inspected 1 month after sowing and a record of the success establishment taken.

Actions for grass management to be prepared within the ESMP</td></tr>
</table>

Table 6.8.10: Soil Resources, Mitigation and Monitoring			
		Phleum alpinum 10 *Poa alpine* 20 *Festuca ovina* 40 *Festuca valesiaca* 40 **HLF site** *Festuca valesiaca* 40 *Phleum pratense* 30 *Phleum alpinum* 30 Sowing rate 20Kg/ha Note: The use of soils from the critical habitats in translocation and for nurseries has been considered in Section 6.11.	
	Reclamation	All restored areas to be sown to a suitable grass seed mix, within 1 month of completing a defined area. Mixtures and application rates for reclamation grass seed mix are identified in the pMRCRP (Appendix 8.18). Sowing should take place at least 1 month prior to the onset of winter snow fall. Where reclamation continues during autumn and winter months, for example within the BRSF progressive closure, the soils and revegetation will take place in the first available growing season following the completion of the reclamation works.	All restored areas sown to grass will be inspected 1 month after sowing and a visual record of the success of establishment taken. The requirements for the restoration and aftercare are to be developed in the pMRCRP (Appendix 8.18), and based on monthly inspections of restored areas during the first 12 months of the aftercare period, and biannually thereafter for a minimum period of 5 years.
Erosion control	Mounds	Following the completion of soil stores, and in the period up to the full vegetation cover of the storage mound, the surface will be at risk from erosion from surface water drainage and wind.	The monitoring requirements will be defined in the ESMP and will include regular inspection of the mound surface and cut-off ditches to determine risk and evidence of erosion.
	Adjacent to working areas	Exposed soil profiles, adjacent to working areas are at risk of incipient and ongoing erosion, in the period up to full vegetation cover.	The monitoring requirements will be defined in the ESMP and will include the regular inspection of exposed surfaces, the excavation slope and associated cut-off drains.
	Reclamation	The exposed soil surfaces on	The monitoring requirements

Table 6.8.10: Soil Resources, Mitigation and Monitoring			
		restored areas are susceptible to erosion, and the risk is increased on steep gradients and where large surface areas are completed in a single season. The potential risk of erosion will be reduced through temporary soil drainage, combined with a revegetation strategy, based on establishing a suitable grass seed mix within 1 month of completing a defined area, and at least 1 month prior to the onset of winter snow fall.	will be defined in the pMRCRP (Appendix 8.18) and will include regular inspection of exposed soil surfaces in the period up to full vegetation cover, together with remedial treatment for potential sheet and/or gully erosion. Aftercare requirements for managing the vegetation, for a minimum period of 5 years, will be included in the closure plan.
Soil Chemistry	Contaminants & Dust fall	Undisturbed areas adjacent to the mine working and processing will be sampled for a range of contaminants including: pH, heavy metals, hydrocarbons and other potential contaminants. Monitoring will be ongoing during the operational phase.	Topsoil samples will be collected annually to a depth of 10cm and surface vegetation removed. Bulk samples will be submitted to an accredited laboratory for analysis.
Aftercare	Nutrients	Restored areas will be subject to a minimum of 5 years of aftercare management, in accordance with the pMRCRP (Appendix 8.18) until the vegetation is self-sustaining. Soil nutrient analysis will be undertaken annually to determine the requirements for vegetation management and fertiliser use.	Topsoil samples will be collected to a depth of 10cm using a sampling strategy determined by the size and location of the restored area. The samples will have the surface vegetation removed and bulked to be representative of the land use identified in the pMRCRP (Appendix 8.18). Bulk samples will be submitted to an accredited laboratory for analysis of: pH, and total N, P & K. The data will be used to define aftercare management over the next 12 month period (detailed aftercare as part of pMRCRP (Appendix 8.18).
	Soil Drainage	Restored areas will be subject to soil drainage survey, dependent on the restoration topography and the intended afteruse. Drainage design will be an output from the	Performance of drainage design will be monitored during snow melt and during the spring months after periods of heavy rainfall. Ditches and surface grips will be recorded on the

Table 6.8.10: Soil Resources, Mitigation and Monitoring			
		pMRCRP (Appendix 8.18) and detailed in annual aftercare management reports.	mine restoration plan. The condition and performance of ditches will be recorded and remedial actions will be identified in the aftercare programme, to be maintained for a minimum period of 5 years following restoration, until the vegetation cover is self-sustaining and the drainage integrity of the site is proven.

6.8.5 Residual Impacts to Soils

Subject to appropriate mitigation, and because the aim of the restoration design is to return those areas suitable for reclamation to be revegetated during closure, residual impacts to soils are considered to be minor and not significant. Net soil loss will result as a consequence of the open pits, HLF and BRSF areas as they will not result in a final landform suitable to support soil profiles, or the pre-mining environment. Therefore, the long term change in land use in these areas would be Major and significant because it is irreversible. Reclamation and revegetation measures are oriented towards restoration of pre-mining steppe grassland vegetation to the extent possible.

Loss of Soil Resource and Structure

Mitigation measures that have been identified are accepted industry best practice and will be implemented through the CEMP, when the bulk of soil handling will take place. Notwithstanding the mitigation measures, the significance of the residual effect will be Major for loss of the natural soils within the Project footprint; as they will not be fully recovered following disturbance. The management and monitoring requirements during soil handling and storage have been considered further in Chapter 8 and taking these mitigation measures into account the significance of the residual effect on soil structure is Minor.

Contamination of Topsoil

Mitigation measures that have been identified are accepted industry best practice and will be implemented through the PEP, including the recommendations given in Section 6.9. Procedures defined in the PEP, with respect to pollution prevention have been included in the EPSRP (Appendix 8.9), CMP (Appendix 8.11) and ARDMP (Appendix 8.19) and will continue through the operational phase in the ESMP. The residual effect is minor and not significant.

Management of Restored Soils

Management planning for reclamation and rehabilitation is also accepted as industry best practice and has been identified in the pMRCRP (Appendix 8.18). As all areas restored with soil will be subject to a minimum period of 5 years of active aftercare following closure, the significance of the residual effect is minor and therefore not significant. Comparison of the restored mine post-closure, with that of the operational phase, adherence to the requirements of the pMRCRP (Appendix 8.18), therefore the residual effect, following the appropriate aftercare management, is minor and not significant.

Table 6.8.11 presents a summary of the anticipated soil impacts, relevant operational phase, and planned mitigation measures.

Table 6.8.11: Impact Summary – Soils								
Source	**Activities**	**Primary Receptor (1)**	**Phase (2)**		**Significance (3)**		**Mitigation Measures**	**Management / Monitoring Plan**
			C	**O**	**ST**	**LT**		
Loss of soil resource								
Loss of natural soils	Construction Activities	L	X		MA to M-	MA to M-	• Clearly delineate footprint of soil disturbance prior to moving top and subsoils • Soil storage defined and marked out in advance • Haul routes between strip and stockpile areas clearly defined	Footprint Management Plan (FMP, Appendix 8.8)
Soil Erosion	Construction Activities; Ongoing soil management	L, SW, GW	X		MA to M-	M	• Use erosion, sediment and drainage control measures to reduce erosion, sediment loading, and surface runoff. • Salvage and stockpile as much topsoil as possible during clearing activities, and establish vegetative cover on the stockpiles to reduce erosion. • Implementation of appropriate drainage measures (ditches, channels, underdrainage and attenuation ponds) in order to reduce surface water runoff over sloping land, which could lead to detachment of soil particles. • Revegetate as much cleared land area as possible after construction.	Emergency Preparedness and Spill Response Plan (EPSRP, Appendix 8.9)

Table 6.8.11: Impact Summary – Soils								
Source	**Activities**	**Primary Receptor (1)**	**Phase (2)**		**Significance (3)**		**Mitigation Measures**	**Management / Monitoring Plan**
			C	**O**	**ST**	**LT**		
Loss of soil structure during operations								
Handling and storage	Ongoing soil management	L	X		M	M	• Separate handling and storage of different soils; to include different soil types and that of topsoil and subsoil horizons • Handle during dry conditions • Avoid traffic on soil surfaces • Height of soil mounds no greater than 3 m for topsoil within areas of critical habitat. Where topsoil (to be used in general reclamation and rehabilitation and not for specific commercial agricultural or ecological habitats), stockpile mounds will be up to 5 m in height. Where subsoil is present and it is required for restoration and rehabilitation, it will be removed up to a depth of approximately 1m below the base of the topsoil. Subsoil will be stored separately in heaps no greater than 5 m in height from the base. • Sow surface of soil mound to grass seed mixture	Footprint Management Plan and Mine Reclamation, Closure and Rehabilitaion Plan (FMP, Appendix 8.8 and pMRCRP, Appendix 8.18)

Table 6.8.11: Impact Summary – Soils								
Source	**Activities**	**Primary Receptor (1)**	**Phase (2)**		**Significance (3)**		**Mitigation Measures**	**Management / Monitoring Plan**
			C	**O**	**ST**	**LT**		
Contamination of soils								
ARD precipitation	Construction and operational activities	L, SW, GW	X	X	M-	M	• ARD prevention measures identified in mitigation for Acid Rock Drainage	Acid Rock Drainage Management Plan, Emergency Preparedness and Spill Response Plan, and Surface Water Management Plan (ARDMP, Appendix 8.19, EPSRP, Appendix 8.9 and SWMP, Appendix 8.22)
Dust deposition	Haul road traffic	L		X	M-	N	• Dust suppression measures identified in mitigation for air quality	Air Quality, Noise and Vibration Management Plan (AQNVMP, Appendix 8.14)
Soil Chemistry and Quality	Equipment and Vehicle Maintenance Areas; Storage, Loading/	L, SW, GW	X	X	M-	N	• Follow the EPSRP (Appendix 8.9) and CMP (Appendix	Emergency Preparedness and Spill Response Plan, Cyanide Management Plan, and Footprint Management Plan

Table 6.8.11: Impact Summary – Soils								
Source	**Activities**	**Primary Receptor (1)**	**Phase (2)**		**Significance (3)**		**Mitigation Measures**	**Management / Monitoring Plan**
			C	**O**	**ST**	**LT**		
	Unloading, Materials Handling Areas						8.11) for the site. • Provide initial and refresher SPCC and Cyanide Management Plan training for all pertinent employees and contractor personnel. • Keep suitable containment and cleanup supplies readily available. • Install under liner or pavement in chemical, fuel, and lubricant storage areas. • Design and install adequately sized bunded areas around bulk liquid and fuel storage areas. • Use personnel protective equipment (PPE) where required and occupational medical monitoring.	(EPSRP, Appendix 8.9, CMP, Appendix 8.11 and FMP, Appendix 8.8) Environment Policy (Appendix 8.1)
Loss of soil and soil structure during rehabilitation and restoration								

Table 6.8.11: Impact Summary – Soils								
Source	**Activities**	**Primary Receptor (1)**	**Phase (2)**		**Significance (3)**		**Mitigation Measures**	**Management / Monitoring Plan**
			C	**O**	**ST**	**LT**		
Soils handling and reclam-ation	Mining Activities	L, SW, GW		X	MA to M-	M-	• Use erosion sediment control measures to reduce erosion and sediment loading. • Salvage and stockpile as much topsoil as possible during clearing activities and establish vegetative cover on the stockpiles to reduce erosion. • Revegetate as much cleared land area as possible after construction. • Install a compacted clay liner and underdrain and overdrain systems to collect and channel contact water and seepage from Amulsar Mountain to the BRSF. • Install an impermeable barrier within the sanitary landfill to contain leachate. • Perform reclamation activities according to the established closure plan to the extent practical.	Footprint Management Plan, Emergency Preparedness and Spill Response Plan, and Mine Reclamation, Closure and Rehabilitaion Plan (FMP, Appendix 8.8, EPSRP, Appendix 8.9 and pMRCRP, Appendix 8.18)
Reveget-ation	Post-closure mining activity	L, SW		X	M-	N	• Soil handling programme for restoration • Minimum 5 year aftercare management programme	Mine Reclamation, Closure and Rehabilitaion Plan (pMRCRP, Appendix 8.18)

Table 6.8.11: Impact Summary – Soils								
Source	**Activities**	**Primary Receptor (1)**	**Phase (2)**		**Significance (3)**		**Mitigation Measures**	**Management / Monitoring Plan**
			C	**O**	**ST**	**LT**		
Notes: (1) Primary Receptors: L = land, SW = surface water, GW = groundwater (2) Project Phase: C = Construction, O = Operations (3) Expected Significance Rankings: ST = short-term with mitigation, LT = long-term with mitigation, MA = major, M - = medium, Mi = minor, N = negligible								

6.8.6 Conclusions

Potential Impacts

An impact assessment has been undertaken to assess the effects of construction, operation and closure of the mine with regard to soils and land cover within the Project footprint (see Table 6.8.11).

Short term impacts are those arising as a result of the construction and operation of the Project. These include the loss of the soil resource, deterioration of soil structure, and contamination of topsoils. The first two potential impacts are generally related to the construction phase of the Project; whilst the third can be associated with both construction and operational phases (and to a lesser extent during rehabilitation).

Long term impacts are those which are persistent following the post-closure phase of the Project. The fourth potential impact associated with soils is the long term use of soil for rehabilitation. This is an important aspect that dictates the success of post-closure revegetation establishment and habitat creation as the quality of the restored soil, in relation to its profile and its structural integrity, can be adversely implicated if mitigation measures are not put in place. This in turn can lead to long-term soil loss.

Mitigation Measures

Soil management during the construction and operational phases is the primary mitigation measure for the protection and conservation of the soil resource. Appropriate soil management takes into account the sensitivity of each soil association identified within the Project affected area. Mitigation measures minimise the effects that construction on the soil resource creates. These include industry standard soil management techniques, such as clearly delineating areas of soil strip, handling and storage of soils in appropriate weather conditions, limiting the area and height of soil storage mounds and revegetation of soil mounds. The residual effects that relate to loss of the natural soil ecosystem are Major and cannot readily be replaced following disturbance. The residual effects in term of soil use for rehabilitation of land following mine closure is considered to be minor, subject to the requirements of the pMRCRP (see Appendix 8.18).

All soils have had their chemical composition analysed and are found to have naturally elevated metal concentrations. These will be conserved for use in translocation and

restoration of specific habitats, in particular those soils required for *Potentilla porphyrantha* restoration (see Section 6.11, BMP Appendix 8.21, and pMRCRP Appendix 8.18).

During the operational phase the management of chemicals and fuels used for mining and processing have been specified in management planning which are considered standard industry practice for mining operations. For example, the CMP for the use of cyanide, the EPSRP in case of leaks and spills, the IWMP in the case of mercury, and the ARDMP in the case of ARD. The construction and use of these industry standard management plans minimise the effects on the soil resource to minor and therefore they are not considered to be significant.

Furthermore, impacts to the soil resource are minimised through the specification of appropriate handling, storage and the reinstatement of these soils. These should focus on the handling of soils from stockpiles to receptor areas under rehabilitation, followed by a programme of revegetation, drainage control and long term maintenance and management. This would accord with the objective of the mine closure plan, and therefore impacts to soils arising as a result of the improper handling, storage and reinstatement of these soils are minimised and the impacts therefore reduced to minor and insignificant.

Summary

There are five soil associations present within the Project affected area. The nature of the soils that would be disturbed by the mine construction and operation depend on the height, slope, aspect and climate conditions. Sensitive soils have been considered as those that support agricultural and horticultural uses. Those that are considered sensitive in relation to biodiverse ecosystems, and rare and endangered species, are considered in Section 6.11.

Potential impacts on soil resources include the:

- Loss of the soil resource during removal and as a result of storage;
- Reduction of the soil structure that is important for plant growth and to sustain agricultural productivity;
- Contamination of soils through mixing during removal, storage and restoration, or spillage of chemicals (including oils) that would harm the potential for plant growth both in storage and later for use in restoration; and

- Strategy for long term use of the soil resource post closure to support the restoration plans for the development.

The development would result in the permanent loss of soils from the open pits together with a change of land use when soils are replaced to restore the closed BRSF and HLF. However, a detailed soil management plan would aim to achieve no net loss of the soil resource required for rehabilitation post-closure, as a consequence of the development. In addition, different soil types as well as topsoil and subsoil will be removed and stored separately to allow for the design of detailed closure plans for within the Project affected areas (pMRCRP Appendix 8.18).

Management of soils would commence prior to construction so that the area disturbed during construction and operation can be minimised. In addition, rehabilitation and restoration can be completed on a progressive basis during the life of the Project.