IMPACT ASSESSMENT

SECTION 4.2
TERRESTRIAL ENVIRONMENT QUALITY

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4.2 Terrestrial Environmental Quality

4.2.1. Introduction

The NT EPA's objective to terrestrial environmental quality is to maintain the quality of land and soils so that environmental values of site fauna, flora and vegetation communities are protected. To achieve this objective the KGL has considered land, soil, biological and hydrological aspects during its design and developed management plans to minimise impacts from the Project. The preceding section focused on biological aspects, and later sections will focus on hydrological aspects. This section focusses on erosion and sedimentation, acknowledging the interactions between soil, vegetation and water, to maintain terrestrial environmental quality.

4.2.2. Relevant Legislation

- ***Mining Management Act –*** Section 35 of the Act requires authorisation for mining activities that could cause "substantial disturbance", including activities that have the potential to cause erosion and sedimentation
- ***Soil Conservation and Land Utilisation Act*** - The main purpose of the Act is to prevent soil erosion and to conserve and reclaim soil
- ***Water Act*** - provides for the investigation, allocation, use, control, protection, management and administration of surface and groundwater resources, as well as the administrative process for licensing these activities and related purposes. Mining activities or another activity for a purpose ancillary to that mining activity, including the use of water as drinking water, are exempt from a number of provisions of the Act, including Parts 5 and 6 regarding surface water and groundwater respectively
- ***NT Weeds Management Act*** **-** The purpose of the Act is to prevent the spread of weeds in, into and out of the NT and to ensure that the management of weeds is an integral component of land management. The Act states that the owner and occupier of land must:
  - Take all reasonable measures to prevent the land being infested with a declared weed
  - Take all reasonable measures to prevent a declared weed or potential weed on the land spreading to other land; and
  - Within 14 days after first becoming aware of a declared weed that has not previously been known to be present on the land, notify an officer of the weed's location; and
- ***NT Environmental Protection Act 2012***.

Guidelines

Guidelines relevant to the management of erosion and sedimentation include:

- Guideline for the Preparation of an Environmental Management Plan (NT EPA)
- Environmental Assessment Guidelines on Acid and Metalliferous Drainage (NT EPA)
- Guidelines on Conceptual Site Models (NT EPA)
- Mine Close-out Objectives, Life of Mine Planning Objectives (NT DME 2006)
- National Water Quality Management Strategy: Implementation Guidelines (1998)

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000) guideline
- Strategic Framework for Mine Closure (ANZMEC 2000); and
- NT Land Clearing Guidelines (2010).

4.2.3. Relevant Activities

The Project area has a history of exploration and mining by various operators since 1929, therefore land at the site has already been disturbed. Remnant infrastructure at the site includes open pits, access roads, ruins from an old village and several mines and processing sites, waste rock dumps, tailings storage facilities, evaporation dams, and drains and sumps.

Proposed activities that have the potential to impact terrestrial environmental quality, that is land and soils, include:

- Construction of new infrastructure, particularly where disturbance of soil or alterations in surface water flow are likely (i.e. topsoil stockpiles, workshops, laydown areas, explosives magazine, offices, warehouse, laboratory, haul roads, sewage treatment systems, pipelines, power station (diesel or gas), powerlines, water storages and accommodation camp)
- Mining
- Vehicular movement – internal and external
- Tailing Storage
- Water diversion and storage
- Stockpiling of ore
- Stockpiling of waste; and
- Flood mitigation works.

4.2.4. Potential Impacts and Risks

Mining activities cause land disturbance, pre-disposing areas of exposed ground to erosion risk. Changes to the topography and land systems of the site are an inevitable and a permanent consequence of mining. The proposed changes resulting from the mining will be significant and primarily relate to the mine infrastructure, such as pits, waste rock landforms, tailings storage facilities, topsoil stockpiles, haul roads, heavy vehicle parking areas, Run of Mine (ROM) pads, fuel storage areas, processing plant, accommodation camp, laydown areas, production and monitoring bores, a magazine and explosives store. Additional details on infrastructure and location is provided in the Project Description (Section 2). To the extent practical, the required infrastructure has been located on previously disturbed areas.

Activities potentially impacting soils and their susceptibility to erosion include:

- Clearing of vegetation
- Stripping of in-situ soil resources in mining disturbance areas
- Alteration of soil structure during preparation for infrastructure and hardstand areas e.g. Mine facilities area, stockpile areas, waste rock dump, roads, tailing storage facilities and haul roads

- Increased erosion and sediment movement due to exposure of soils to wind and water during construction of mine infrastructure
- Soil erosion resulting from the construction of diversion drains; soil migration to surface waters
- Traffic and physical disturbance creating dust; and
- Alteration of physical and chemical soil properties (e.g. Structure, fertility, permeability and microbial activity) during soil stripping and stockpiling operations.

4.2.4.1. Clearing Vegetation

The new infrastructure will have an impact area of approximately 389.45 hectares, which includes 32.46 hectares of new infrastructure being located over existing disturbance areas. The vegetation community most affected by the Project would be vegetation community 5 – *Corymbia* and *Acacia sibirica* woodland. This is a reflection of its distribution over the Project area. Clearing vegetation leaves exposed soil vulnerable to erosion by both water (rain and surface flows) and wind.

Water may collect sediments during overland flow and as it passes through the proposed creek diversions. Suspended sediments would be deposited as stream flow velocity reduces further downstream. Sedimentation in downstream areas (where the velocities are lower) can lead to filling of the waterway channel and encroachment of the riparian vegetation into the waterway channel Deposited sediments can cause adverse effects on aquatic ecosystems, although these are limited in the Jervois area due to the ephemeral nature of the watercourses.

4.2.4.2. Erosion

The most common forms of water erosion likely to be encountered at the Jervois mine are:

- **Splash erosion** is the spattering of soil particles cause by the impact of raindrops on soil
- **Sheet erosion** is the uniform removal of soil in thin layers from sloping land
- **Rill erosion** is the removal of soil by water concentrated in small but well-defined channels; and
- **Gully erosion** produces channels deeper and larger than rills (generally greater than 300mm deep.

The soils across the Jervois Project area comprise well drained, light to moderately textured soils (maximum clay content 20-30%) with low EC values and low fertility (low CEC) (Perry *et al* 1962). Field analysis of the soil characteristics indicates that the risks from soil salinity and acidity are very low (VPS 2018).

Erosion risk associated with soil disturbance within the Project area is considered moderate due to the nature of both the surface and subsoils to slake when wet.

4.2.4.3. Potential Pollutant Sources

Potential erosion and sediment sources as well as the potential contaminants and impacts at the Jervois mine are presented in Table 4.2-1.

Table 4.2-1 Potential erosion and sediment sources

Disturbance category	Potential contaminant	Potential impacts
Spoil / Waste rock dumps		
Available / Unavailable / Re-contoured	Unconsolidated material with varying quantities of saline and sediment pre-disposition. Bare areas vulnerable to storm activity, Acid mine drainage (AMD)	Sheet and rill erosion of potentially alkaline/ acidic/saline deposits leading to deposition of contaminants and sediment volumes. Sediments causing damage to receiving waters through reduction in water quality and degradation of in-stream habitats.
Topsoiled (to be revegetated)	Unconsolidated materials, sediment and turbidity	Sheet and rill erosion leading to sedimentation of waterways and loss of valuable rehabilitation material.
Topsoiled, ripped and seeded	Unconsolidated materials, sediment and turbidity	Minimal once established.
Topsoil		
Topsoil stripping area	Unconsolidated materials, bare areas vulnerable to storm activity.	Sheet, tunnel, rill and gully erosion leading to movement and deposition of sediments, deleteriously impacting on receiving waters.
Topsoil Stockpiles	Unconsolidated materials, sediment and turbidity	Sheet, rill erosion leading to sedimentation of waterways and loss of valuable rehabilitation material.
Peripheral lands		
Exploratory and access tracks	Disturbance of natural landform resulting in possible bare landforms increasing sediments in natural runoff	Exacerbation of rill and gully erosion leading to movement and deposition of sediments potentially causing damage to water quality and in stream habitat of receiving waters.
Haul Roads	Disturbed materials from surface of the road, erosion of table drain material vulnerable to storm activity	Sedimentation of nearby watercourses

Industrial Areas	Hydrocarbons and hydrocarbon contaminated sediments	Water quality impacts.
Sediment runoff from hardstand areas.	Leaching and erosion of soils containing hydrocarbons and movement and release of hydrocarbons into surrounding environment	Sedimentation of nearby watercourses.
Exploration Activity	Disturbed materials, sediment and turbidity	Sedimentation of nearby watercourses.
Land clearing (woody vegetation)	Disturbed materials, sediment and turbidity	Sedimentation of nearby watercourses.
Drainage channels	Disturbance of landform resulting in possible bare landforms increasing sediments in runoff	Sheet, tunnel, rill and gully erosion leading to movement and deposition of sediments, deleteriously impacting on receiving waters.
Licenced stream diversions / Levees	Disturbance of landform resulting in possible bare landforms increasing sediments in runoff	Sheet, tunnel, rill and gully erosion leading to movement and deposition of sediments, deleteriously impacting on receiving waters.

4.2.4.4. Dust Deposition

Dust deposition may impact on natural ecosystems adjacent to the Project area if reasonable quantities of dust are sustained over extended periods of time. Dust deposition issues are most likely to occur along haul roads, where there is a narrow corridor within natural areas or publicly accessible areas immediately adjacent to activities involving heavy machinery and the transportation of ore. Activities within the mine (i.e. open mine pits and waste piles) would also create dust, but these issues would be created and managed within the mine disturbance area and are less likely to spill over into adjacent natural areas.

4.2.5. Mitigation and Monitoring

Mitigation measures will be required to avoid, control, reduce or eliminate impacts of Project activities on terrestrial qualities. Monitoring may be required for some aspects, to evaluate the level of residual impact and the effectiveness of mitigation.

An Erosion and Sediment Control Plan (ESCP) has been prepared for the Project (refer Section 5). It outlines prescriptive measures that will be implemented to avoid, minimise, mitigate and manage the movement and deposition of sediment.

The ESCP management measures include:

- Minimising disturbance footprints
- Installation of erosion and sediment control measures prior to construction
- Avoiding the clearing of new areas during periods of intense rain
- Rehabilitating progressively, where practicable

- Stripping topsoil from areas to be disturbed and reusing immediately or stockpiling where practicable
- Controlling slope gradient
- Constructing diversion channels to direct clean runoff around disturbed areas and into natural drainage lines
- Providing sediment traps on major drainage channels from disturbed areas
- Providing protection in drains (e.g. Grass) where water velocity may cause scouring
- Installation of sediment traps, silt fences and hay bales where necessary to control sediment movement
- Regular inspection and maintenance of sediment control structures, particularly following rainfall events, to ensure their ongoing functionality
- Construction adequate bunds around potential contamination sources, to contain contaminated water in the event of heavy rainfall
- Spill clean-up and emergency management procedures developed and implemented
- Personnel to be trained in the use of spill kits and emergency response procedures
- Providing optimal surface conditions to promote revegetation; and
- Revegetating final surfaces with fast establishing ground cover.

The following provides a summary of some of the key mitigation features of the ESCP.

4.2.5.1. Vegetation Clearing Controls

The amount of land disturbance and vegetation clearing will be minimised. Construction personnel will be briefed during inductions regarding the conservation value of land and soil and their responsibilities with regard to protecting these during construction. Additional controls will include: vegetation clearing protocol will be developed in association with the Biodiversity Management Plan (including: procedures for demarcating limits of clearing; staged clearing of vegetation to minimise areas of disturbed bare ground); clearing when soil moisture conditions are optimal to avoid excessive disturbance to soil and landform; use of already-disturbed areas (rather than undisturbed) wherever possible; development and implementation of a land stabilisation and revegetation strategy; progressive revegetation of cleared land as Project activities are completed.

4.2.5.2. Drainage Structures

The ESCP provides a discussion on control measures for four types of drainage channels:

- permanent watercourse drainage (diversions). Erosion control measures are generally specified as part of a specific approval for these works.
- permanent drainage that does not require regulatory approval but will remain in place at the end the concept mine plan and effectively act as a watercourse.
- temporary drainage in low gradient areas such as catch drains, diversion channels or flow diversion banks that either collect concentrated flow or overland flow.
- temporary drainage down slopes such as chute drains.

Any permanent diversion would be designed such that it appears and functions as a natural feature in the landscape largely indistinguishable from the natural watercourses in the area. For all permanent

diversions, vegetation would be used as the primary method of stabilising channel banks, terraces and floodplain drainage paths as engineering methods may not limit the liability for long-term maintenance cost post-mining.

Temporary drainage controls that are anticipated to last longer than 24 months would be designed to cater for a 100-year Average Recurrence Interval (ARI) design storm to provide effective separation of clean and dirty runoff. Temporary culvert crossings should have a hydraulic capacity of the 1-year ARI design storm.

4.2.5.3. Drain Velocity Control Structures

Excessive flow velocities can cause channel erosion. Flow velocities can be reduced by changing the drainage characteristic e.g. catchment size or drain design. If the channel width, depth or gradient cannot be altered, then there are two options for controlling erosion:

- Reduce the flow velocity through the placement of velocity control structure; and
- Increase the effective scour resistance in the channel through the placement of an effective channel liner such as rock or an appropriate liner, as well as scour protection for channel and drain outlets.

The ESCP (Section 5.1.F) provides examples of solutions for the above.

4.2.5.4. Drainage Control for Unsealed Roads

The following general principals would be followed in the design of drainage controls for unsealed roads:

- Stormwater runoff from unsealed roads should be allowed to shed at regular intervals. The runoff would be discharged into a sediment trap or released as sheet flow via a level spreader
- Where stormwater runoff from unsealed roads collects within table drains adjacent to the roadway, this water would be discharged from the table drain at regular intervals
- When access is required across a slope, the road would be sited as close as possible to the contour of the land. This allows upslope water runoff to pass evenly across the track, thus avoiding concentrated flow
- When an access road diagonally traverses a slope, the road will likely collect and concentrate upslope stormwater runoff. The collected runoff will be shed at regular intervals using a level spreader or drainage channels; and
- Wherever practical, table drains would form wide U-shaped drains to minimise potential invert erosion.

4.2.5.5. Watercourse Crossings

Watercourse crossings may consist of fords, culverts or bridges. The following principals will be applied to water crossings:

- Due to the ephemeral nature of the creeks, fish passage is unlikely to be a significant issue, none the less consideration will be given during design of crossings, recognising that passage is likely only to occur during periods of flood
- Culvert designs will consider the effects of debris blockages and potential erosive forces caused by overtopping flows
- Where possible, crossings of streams would be constructed at right angles to the flow and in locations where the channel is straight and has well defined banks; and
- Crossings would be covered with a non-erodible material such as rock or gravel and the upstream and downstream batters armoured to control erosion caused by overtopping flows.

4.2.5.6. Erosion Control Measures

The most common forms of water erosion likely to be encountered at the Jervois mine are:

- Splash erosion is the spattering of soil particles cause by the impact of raindrops on soil
- Sheet erosion is the uniform removal of soil in thin layers from sloping land
- Rill erosion is the removal of soil by water concentrated in small but well-defined channels; and
- Gully erosion produces channels deeper and larger than rills (generally greater than 300mm deep.

Various techniques will be applied to reduce the risk of erosion. The control technique will depend upon the erosion risk and the location. A summary of erosion control techniques that may be applied is provided in Table 4.2-2.

Table 4.2-2 Summary of erosion control techniques

Technique	Typical use
Cellular confinement systems	Containment of topsoil or rock mulch on medium to steep slopes. Control erosion on non-vegetated medium to steep slopes such as bridge abutments.
Compost blanket	Used during the revegetation of steep slopes either incorporating grasses or other plants. Particularly useful when the slope is too steep for the placement of topsoil, or when sufficient topsoil is absent from the slope.
Gravelling	Protection of non-vegetated soils from raindrop impact erosion. Stabilisation of site office area, car parks and access roads.
Heavy mulching	Stabilisation of soil surfaces that are expected to remain non-vegetated for medium to long periods. Suppression of weed growth on non-grassed areas.
Light mulching	Control of raindrop impact erosion on flat and mild slopes. May be placed on steeper slopes with appropriate anchoring. Control water loss and assist seed germination on newly seeded soil.
Revegetation	Temporary and permanent stabilisation of soil. Stabilisation of long term stockpiles.
Rock mulching	Stabilisation of long term, non-vegetated banks and minor drainage channels.

4.2.5.7. Sediment Control Structures

The primary function of sediment control measures is to trap the coarser sediment fraction. Sediment basins and some filtration systems used during dewatering operations are possibly the only sediment control techniques that have any significant ability to trap finer sediment particles such as silts or clays. Due to the difficulty of trapping these finer sediments, priority should be given to the use of effective erosion control measures wherever practical.

Primary control of sediment will be via sediment dams. Table 4.2-3 outlines the key assumptions and design criteria for sediment dams at the Jervois mine.

Table 4.2-3 Sediment dam criteria

Design criteria	Comment
Design rainfall event	10 Year ARI 24-hour storm duration
Design rainfall depth	The Jervois mine 10 Year ARI 24-hour rainfall depth: 98.4mm.
Volumetric catchment runoff coefficient	0.5
Runoff storage volume:	Design rainfall depth x Catchment Area (ha) x runoff coefficient.
Sediment storage volume:	Equal to dam storage volumes.
Total dam volume:	Runoff storage volume + sediment storage volume.
Primary Outlet:	Perforated riser pipe (wrapped in geofabric) sized to drain contents within 2 days or less. Pipe fitted with valve on outlet. Appropriate pipe diameter used.
Secondary (flood) Outlet:	Spillway with appropriate erosion protection at crest and downstream. Appropriate spillway width

Supplementary sediment controls can be used where the sediment producing catchment is small or the potential for producing sediment laden runoff is low. Appropriate supplementary sediment control techniques are listed in Table 4.2-4.

Table 4.2-4 Summary of supplementary sediment control techniques

Technique	Typical use
Rock filter dam	Locations where there is sufficient room to construct a relatively large rock embankment. The incorporation of a filter cloth is the preferred construction technique if the removal of fine-grained sediment is critical (high maintenance).
Check dam sediment trap	Supplementary sediment trap in minor concentrated flow areas. Trapping sediments in table drains and minor drainage lines Check dams may be constructed of rock, sand bags or compost filled socks
Buffer zones/ grass filter strips	Mostly suited to sandy soils Can provide some degree of turbidity control while the buffer zone remains unsaturated.
Sediment fence	Supplementary device for sheet flow from minor catchment areas Suitable for all soil types Require maintenance after every runoff event.

4.2.5.8. Mitigation of Impacts Associated with Dust

Dust management will include application of industry dust control measures such as:

- Use of water sprays on haul roads, unsealed surfaces, covering of exposed loads where practicable and maintaining moisture levels in bulk loose construction materials

- Reduced vehicle speeds
- Minimise open areas exposed to wind erosion
- Minimise time between stripping and construction/mining operations
- Progressive reinstatement of waste rock and top soil as construction works are completed; and
- Ongoing dust deposition monitoring program, if required.

4.2.5.9. Selection of Erosion and Sediment Control Measures

To assist in determining which ESC measure is applicable, a matrix of land uses, and ESC measures has been developed (Table 4.2-5). This matrix is based on:

- The phase of the mine site (operational, non-operational or construction)
- Land use type (specific to mining applications), adjacent land usage / classification and proximity to watercourses; and
- Level of priority in providing esc measures.

le 4.2-5 Erosion and sediment control matrix

Phase (O = Operational; N = Non-operational; C=Construction)	Land use type	ESC Priority (L=low, M = Medium, H = High, HH = top priority	Drainage Control									Erosion Control							Sediment Control				
			Catch Drains	Check Dams (incl. fibre rolls)	Grass	Cellular Confinement systems	Hard Armouring	Rock Mattress	Rock Lining	Level Spreader	Rock Protection	Cellular Confinement systems	Compost Blanket	Gravelling	Mulching	Revegetation	Rock Mulch	Soil Binders	Rock Filter Dam	Check Dam Sed. Trap	Sediment Basin	Buffer Zone	Sediment Fence
O	Spoil / Waste rock dump (WRD) - Draining Externally	HH	✓									✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
O	Spoil / WRD - Draining Internally	M	✓	✓											✓				✓	✓	✓		✓
O	Spoil / WRD Topsoiled (to be revegetated)	H	✓	✓											✓	✓		✓	✓	✓	✓	✓	✓
O	Spoil / WRD Topsoiled, ripped and seeded	L	✓	✓	✓														✓	✓	✓	✓	✓
O	Topsoil stripping area	M	✓	✓											✓				✓	✓	✓	✓	✓
O	Topsoil Stockpiles	M	✓	✓	✓								✓	✓	✓	✓			✓	✓	✓	✓	✓
O	Exploratory and access tracks	M	✓	✓	✓	✓				✓		✓		✓	✓	✓	✓	✓	✓	✓		✓	✓
O	Haul Roads	H	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓					✓	✓	✓	✓	✓
O	Industrial Areas	L	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓		✓	✓	✓	✓	✓	✓
N	Exploration Activity	M	✓	✓	✓	✓				✓			✓	✓	✓	✓		✓	✓		✓	✓	✓
C	Land clearing (woody vegetation)	M	✓	✓						✓					✓				✓		✓	✓	✓
O	Drainage channels	HH	✓	✓	✓	✓	✓	✓	✓	✓	✓								✓				
N	Licenced stream diversions / Levees	H			✓	✓	✓	✓	✓		✓					✓	✓						
C	Construction / excavation work	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓

4.2.5.10. Site Closure, Decommissioning and Rehabilitation Strategies

The proposed Project represents a continuation of the use, i.e. mining, which has occurred on site for almost 90 years. The Project footprint will be largely contained within existing disturbed areas, so in relative terms there will be little change in the land use of the site.

Post-mining, the site will have improved opportunity for alternate uses as the Project proposes to progressively rehabilitate areas disturbed through mining practices and associated activities, therefore much of the legacy of historic mining will be improved. The Jervois Base Metal Project closure and rehabilitation objectives include:

- Establishment of safe and stable post-mining land surfaces to support long-term vegetation growth
- Returning land to pre-disturbance land use levels (as reasonably practical); and
- Preparing site suitability to future leaseholders.

A Mine Rehabilitation and Closure Plan (MRCP) has been prepared for the Project (refer Section 5). This plan includes the following:

- Areas not required for ongoing operations will be progressively rehabilitated
- Locate and design landforms to be rehabilitated to optimise blending with the surrounding topography
- Stockpile vegetative material and topsoil for later use
- Topsoil stockpiled in a designated area away from drainage lines, to prevent erosion or runoff.
- Revegetation with appropriate species, sourced locally where possible; and
- Annual monitoring of rehabilitation areas.

4.2.5.11. Monitoring and Emergency Reporting

The ESCP contains a template for record keeping of monitoring, operation and maintenance of erosion and sediment control measures on the site (refer Section 5).

An asset register database will be prepared for all ESC structures at the mine site. These assets will be located in a GIS map and a unique identification number (asset number) will be given to them.

Water quality (turbidity) in sediment dams at the Jervois mine will be monitored following a significant runoff event occurring. Monitoring will occur via a hand-held turbidity probe, and in the first four years of operations, a water quality sample will be taken and sent for lab analysis to determine TSS levels at the time of sampling. Lab analysis of samples for TSS and turbidity will be used to develop a relationship between turbidity and TSS at the Jervois mine.

Surface runoff and seepage from waste rock dumps that collects in the sediment dams would be monitored for water quality parametres including, but not limited to pH, EC, major anions (sulfate, chloride and alkalinity), major cations (sodium, calcium, magnesium and potassium), TDS and a broad suite of soluble metals/metalloids.

Sediment dam monitoring would be used to validate the anticipated quality of water runoff reporting to sediment dams. Initially, the sediment dam monitoring would occur on an event basis to demonstrate the water quality of stored waters is consistent with the relevant operating parametres to allow releases from sediment dams to occur if required.

accordance with IECA (2008) all erosion and sediment control measures will be inspected as follows:

- At least daily when rain is occurring
- Within 24 hours prior to expected rainfall: and
- Within 18 hours of a rainfall event of sufficient intensity and duration to cause on-site runoff.

Any failure of effectiveness of structure will be reported to the Senior Environmental Advisor.

The Jervois mine site emergency response plan will include a relevant TARP (targeted action response plan) for the waste rock dump sediment dams and uncontrolled sediment release in surface waters.