Graphinex – Esmeralda Graphite Project Environmental Impact Statement

Appendix S – Erosion Stability Assessment

GRAPHINEX

EROSION STABILITY ASSESSMENT

ESMERALDA GRAPHITE PROJECT



PREPARED FOR
QLD AUS GRAPHITE PTY LTD

13 MAY 2026

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1 Introduction

QLD Aus Graphite Pty Ltd (Graphinex) has commissioned AARC Environmental Solutions Pty Ltd (AARC) to develop an Erosion Stability Assessment (ESA) for the Esmeralda Graphite Project (the Project).

This assessment has been prepared to satisfy the information requirements of the *Statutory guideline: Progressive rehabilitation and closure plan* (DESI 2024) (PRCP Guideline), as it relates to the completion of erosion modelling to predict the long-term stability of final landforms. The assessment also considered the practice guidelines provided by the Office of the Queensland Mine Rehabilitation Commissioner (OQMRC) in *Leading practice guidance on erosion and landform evolution modelling to design post-mining landforms: Technical Paper* (Erosion Modelling Technical Paper) (Loch et al. 2025).

Erosional stability for the Project has been assessed using the Water Erosion Prediction Project (WEPP) model. The WEPP model was used to predict long-term stability outcomes for final landforms (both existing and proposed) on site.

The WEPP model is a process-based, distributed parameter, continuous simulation erosion prediction model. It considers various factors, including slope design, climate information, vegetation management structures and soil parameters (National Soil Erosion Research Laboratory 1995).

WEPP modelling was used to assess the erosional stability of various representative rehabilitated slopes, as identified in the final landform.

1.1 Project description

The Project is a greenfield graphite mine and processing plant located approximately 66 kilometres south of Croydon in the Croydon Shire local government area.

The Project includes the following:

- conventional open-cut mine;
- mine infrastructure area (including offices, workshops, laydown areas, washing bays, effluent and liquid waste storage, fuel storage and refuelling facilities, and airfield);
- on-site processing plant, magazine;
- water management infrastructure (including permanent watercourse diversion, flood levee, dams, drains, bunds, pipes and pumps);
- accommodation facility and associated sewage and water treatment plants;
- mine access tracks, haul roads, and internal roads;
- solar farm and energy storage system, transmission infrastructure and back-up diesel generators; and
- ROM pad, tailing storage facilities, product stockpiles and loading area, waste rock dumps.

The study area covers an area of approximately 4,518.8 hectares (ha) and is located wholly within the Croydon Shire Local Government Area (LGA). The site location is shown in Figure 1. The Project layout is shown in Figure 2.

The Proponent is seeking to prepare an Environmental Impact Statement (EIS) level assessment for the Project based on Terms of Reference for an EIS, Esmeralda Graphite Project, September 2025 (ToR).

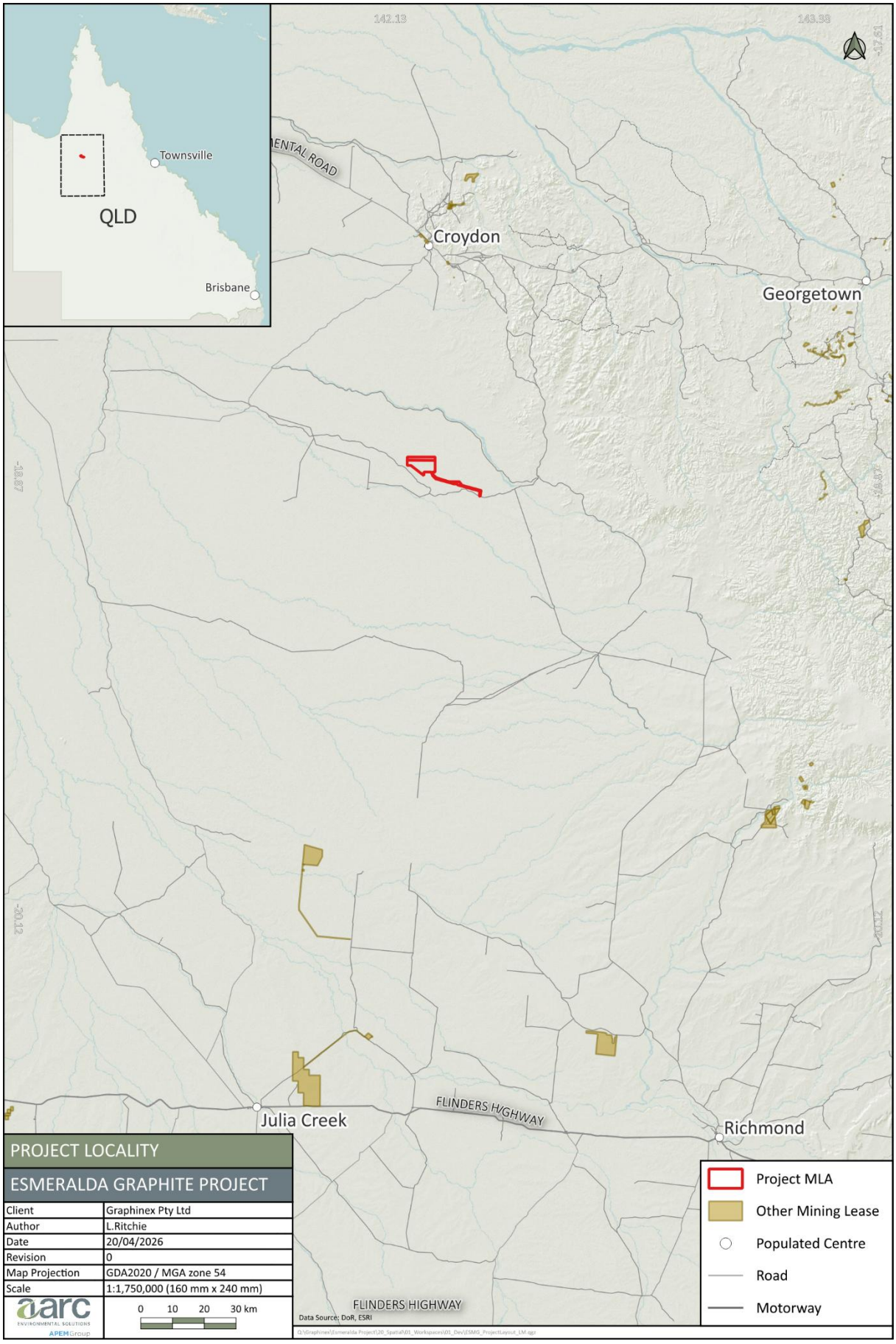


Figure 1: Project locality

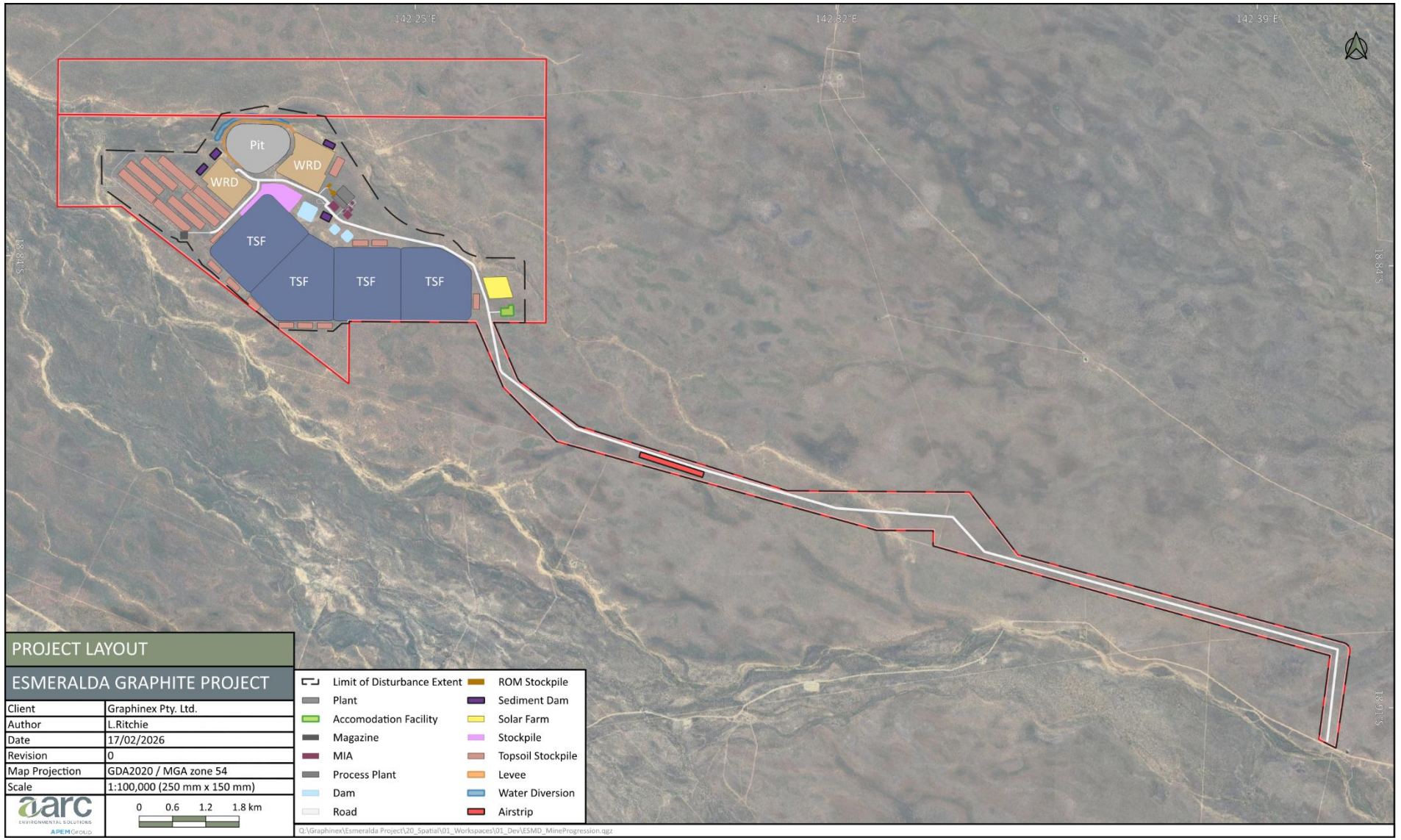


Figure 2: Project layout

1.2 Scope

The PRCP Guideline requires that final landforms must be safe, structurally stable and able to achieve the proposed post-mining land use (PMLU) for the area. To demonstrate this, the ESA provides an assessment of the following key items:

- review of the proposed final landform design;
- erosion modelling (WEPP analysis) for slopes in the final landform;
- recommendations of suitable landform design criteria and vegetation cover criteria for inclusion in the Progressive Rehabilitation and Closure Plan (PRCP); and
- recommendations for other management actions and measurable objectives to ensure the long-term stability of rehabilitated slopes.

This assessment incorporates modelling and analysis of theoretical surface erosion risk for structures. The assessment does not address the geotechnical stability of the constructed landforms or the associated risk of mass failure.

1.3 Final landform designs

The ESA considered two final landforms, being the tailings storage facility (TSF) and the waste rock dump (WRD). The closure of the TSF will consist of the construction of a capping layer, using waste rock materials and soil, which will then be reseeded. Similarly, a growth media will be placed across the WRD at closure to facilitate vegetation growth.

The post-mining land use for both of these areas is grassland, which is a variant of a low-intensity cattle grazing land use, which excludes cattle grazing on the two final landforms being assessed. This land use was adopted as the final slopes generally exceed those typically suited for grazing activities, and therefore, require additional management controls to function as a stable and sustainable post-mining landform. The intent of the grassland PMLU is for these areas to be rehabilitated with vegetation species composition and distribution consistent with the surrounding grazing land use, while excluding cattle access to these areas.

1.4 Model selection

As outlined in the Erosion Modelling Technical Paper, model selection should be undertaken with consideration of the project stage, risk and complexity. The Erosion Modelling Technical Paper provides a hierarchy of modelling approaches that provides the following guidance:

- For low-risk landforms, RUSLE or WEPP using internally derived parameters is likely to be sufficient at all stages of the project.
- For medium-risk landforms, RUSLE or WEPP using internally derived parameters will be sufficient for planning stages.
- For high- or medium-risk landforms, once projects have excavated large volumes of material and some planning of landform construction has commenced, erosion modelling to a higher level of detail and accuracy using calibrated WEPP and/or SIBERIA would be advisable.

Preliminary geochemistry results prepared by RGS (2026) were assessed to determine the relevant risk categorisation of the final landform structures on site. The WRD should be considered a low-risk landform as the overburden and waste rock onsite has been classified as NAF-Barren and suitable as bulk fill or cover material with no acid mine drainage management required if placed into out-of-it dumps.

The TSF should be considered a medium-risk landform based on the geochemistry of the tailings. Tailings samples have been assessed as moderate to high-risk materials by RGS (2026) as some samples were classified

as PAF. The bulk of generated tailings are proposed to be managed at closure by disposal into the backfilled void with a waste rock cover and soil capping layer. The final TSF cell will be retained with an engineered waste rock and soil cover sufficient to reduce the risk of the TSF following closure to a medium-risk landform for the purposes of WEPP modelling.

Based on the Erosion Modelling Technical Paper guidance, WEPP modelling using internally derived parameters is sufficient for the purposes of this assessment. WEPP modelling was conducted for a 100-year period to ensure sufficient climatic variability in the results presented.

2 Methodology

2.1 Soil profile

WEPP soil profiles were developed based on soil and subsoil sampling and analysis results from the Soils and Land Suitability Assessment (SLSA) prepared by GT Environmental Pty Ltd.

Soil surveys were taken across the Project area from 10 to 15 December 2025. Preliminary sampling locations were derived from the desktop review of background information, existing available soils information and an examination of satellite imagery patterns. The specific locations of the survey sites were further refined in the field based on available site access and whether the location was likely representative of the soil profile class (SPC) being described (GT Environmental 2026). Free survey, transect and gradsect techniques (Gunn et al. 1988; McKenzie et al. 2008) were used to verify SPCs and assign boundaries to each. A sampling intensity of 1:50,000 soil survey was selected for the disturbance footprint.

Soil samples were collected from all dominant SPCs present in the study area. For each site selected as an analysed site, the soil samples were collected from a detailed site that was considered to be representative of that SPC. Laboratory analysis was undertaken to assist in determining the overall characterisation of the soils and to establish any physical and chemical limitations of the soils. Samples were analysed at Eurofins APAL Pty Ltd and Environmental Analysis Laboratory (EAL) which are accredited by the National Association of Testing Authority (NATA) and certified by the Australasian Soil and Plant Analysis Council (ASPAC) (GT Environmental 2026).

The SPC results were converted into WEPP soil profiles for analysis, with the profiles presented in Table 1.

Table 1: WEPP soil profiles

Site	Depth (mm)	Sand (%)	Clay (%)	Organic Matter (%)	eCEC (meq/100 g)	Rock
1Cl(Ck)	100	90.2	6.6	1.6	1.18	0.5
	300	88.6	8.1	0.39	1.12	2.2
2Cl(Ck)	100	93.2	3.3	1.6	0.92	0.8
	300	93	5.2	-	0.54	0.7
3Cl(Ck)	100	84.7	8.4	0.81	0.76	3.2
	300	85.6	11.7	0.54	1.13	1.6
4Cl(Ck)	100	91.4	7.2	0.63	0.43	0.9
	300	83.8	10.1	0.71	0.58	1.6
5Cl(Nm)	100	84.6	11.6	0.68	0.8	2.2
	200	81.7	9.7	0.3	0.54	5.8
	350	59.8	4.4	-	0.45	33.6
6Cl(EI)	100	87.1	9.7	1.1	1.4	0
	300	83.6	13.9	-	1.13	0
7Cl(Nm)	100	87.8	7.5	1.7	1.96	1.2
	150	73.9	9.1	0.92	1.28	11.5

The distribution of the above SPCs in relation to the proposed disturbance footprint is detailed in Table _x_. Notably, 2Cl(Ck) and 3Cl(Ck) represent approximately 96% of the total volume proposed to be stripped and stored for rehabilitation post-closure, with 5Cl(Nm), 6Cl(El) and 7Cl(Nm) totalling only 0.7% of topsoil to be used for rehabilitation.

Table 2: Distribution of SPCs within disturbance footprint

SPC	Impacted Area (ha)	Depth of Stripping (mbgl)	Volume (m^3)	Volume (%)
1Cl(Ck)	93.87	0.2	187,740	1.71
2Cl(Ck)	1,080.32	0.5	5,401,600	49.3
3Cl(Ck)	1,127.3	0.45	5,072,850	46.3
4Cl(Ck)	62.36	0.35	218,260	2.0
5Cl(Nm)	2.4	0.25	6,000	0.1
6Cl(El)	19.24	0.3	57,720	0.5
7Cl(Nm)	4.05	0.15	6,075	0.1

The initial saturation was left at a default value of 75%, and interrill erodibility, rill erodibility, critical shear and effective hydraulic conductivity were estimated from the model for each soil profile. The following functions are used to estimate interrill erodibility (K_i), rill erodibility (K_r), critical shear (τ_c) and effective hydraulic conductivity (K_b) (National Soil Erosion Research Laboratory 1995; Alberts et al. 1995).

For soils that contain 30% or more sand:

$$K_i = 2728000 + 192100 \times VFS$$

$$K_r = 0.00197 + 0.00030 \times VFS + 0.03863 \times e^{-1.84 \times ORGMAT}$$

$$\tau_c = 2.67 + 0.065 \times CLAY - 0.058 \times VFS$$

For soils that contain less than 30% sand:

$$K_i = 6054000 - 55130 \times CLAY$$

$$K_r = 0.0069 + 0.134 \times e^{-0.20 \times CLAY}$$

$$\tau_c = 3.5$$

Where, VFS is percent very fine sand, $ORGMAT$ is the organic material contained in the surface soil, and $CLAY$ is percent clay.

In estimating effective hydraulic conductivity (K_b) for soils that contain 40% or more clay, the following function is used:

$$K_b = -0.265 + 0.0086 \times SAND^{1.8} + 11.46 \times CEC^{-0.75}$$

For soils that contain less than 40% clay:

$$K_b = 0.0066 \times e^{\frac{244}{CLAY}}$$

Where $SAND$ is percent sand, CEC is cation exchange capacity (mg/100g), and $CLAY$ is percent clay.

Considering the accuracy of the internally calculated baseline parameters, published literature based on the latest version of WEPP suggests that satisfactory predictions of runoff and soil loss can be made without additional laboratory testing (Wang et al. 2023). As such, it is reasonable to conclude that the baseline erodibility parameters are sufficient for predicting runoff and soil loss.

2.2 Climate profile

For each day of the simulation, WEPP requires ten daily weather variables, namely precipitation depth and duration, peak storm intensity and time to peak, minimum and maximum temperatures, dew point temperature, solar radiation, wind speed and direction. For inclusion into the WEPP model for runoff and erosion prediction, these observation parameters were generated using CLIGEN.

CLIGEN is a stochastic weather generator that produces daily estimates of precipitation, temperature, dewpoint, wind, and solar radiation for a single geographic point, using monthly parameters (means, standard deviations, skewness, *etc*.) derived from historic measurements (Nicks et al. 1995). CLIGEN requires a .PAR file, which was constructed using the methods outlined in Yu (2005). All parameters required a total of 12 entries, with each entry often corresponding to average values in each month. Additionally, as the U.S. Department of Agriculture created WEPP, all parameters used in creating the climate file are converted to U.S. customary units.

In developing the parameter file, daily weather data was sourced from SILO using the grid-point data method from 1 January 1970 to 24 March 2026. The data was taken from point 145.25, -18.85 and contained the following parameters:

- daily rainfall (mm);
- maximum temperature (°C);
- minimum temperature (°C);
- radiation (MJ/m^2); and
- relative humidity at maximum temperature (%).

The above information was used for the following CLIGEN parameters:

- mean rainfall amount on wet days (inches - 12 values, one for each month);
- standard deviation of rainfall amount on wet days (12 values, one for each month);
- skewness of daily rainfall amount on wet days (12 values, one for each month);
- probability of a wet day following a wet day (12 values, one for each month);
- probability of a wet day following a dry day (12 values, one for each month);
- the mean daily minimum temperature (°F - 12 values, one for each month);
- standard deviation of the minimum temperature (12 values, one for each month);
- the mean daily maximum temperature (°F - 12 values one for each month);
- standard deviation of the maximum temperature (12 values, one for each month);
- the mean solar radiation (langleys - 12 values, one for each month); and
- standard deviation of daily solar radiation (12 values, one for each month).

As there were no onsite rainfall intensity measurements for the Project, 6-minute pluviograph data was sourced from the Bureau of Meteorology. Pluviograph data from the North Head (0030112) and Collbold Gorge (0030147) stations were utilised based on the proximity to the site and to ensure sufficient timescales were used. The records spanned from 19 August 1996 to 2 July 2020. This information was used for the following CLIGEN parameters:

- mean maximum 30-min rainfall depth (in - 12 values, one for each month); and
- empirical distribution of the relative time to peak (12 values).

The initial parameters relating to daily rainfall, temperature and solar radiation were sourced directly from the SILO data.

The probability of a wet day following a wet day ($\Pr(W|W)$) and the probability of a wet day following a dry day ($\Pr(W|D)$) were calculated as follows (Yu 2005; Wang et al. 2018):

$$\Pr(W|W) = \frac{Nww}{Ndw + Nww}$$

$$\Pr(W|D) = \frac{Nwd}{Ndw + Ndd}$$

Where:

- a critical precipitation amount (cr) of 0.2 mm was set, such that a wet day is one where $r \geq cr$ where r is the amount of precipitation observed on that day;
- Ndd was the total number of dry days in a month following a dry day;
- Ndw was the total number of dry days in a month following a wet day;
- Nwd was the total number of wet days in a month following a dry day; and
- Nww be the total number of wet days in a month following a wet day.

To estimate the mean maximum 30-min rainfall depth, the number of 30-minute (Δt) wet intervals (M) within a day, such that any rainfall events within a day form a single storm event, was calculated. The storm duration in minutes (D) was then calculated using the formula derived by Yu (2005) and Wang et al. (2018):

$$D = M\Delta t$$

The mean maximum 30-min rainfall depth ($\mathrm{MX.5P}$) was then calculated using the formula (Yu 2005; Wang et al. 2018):

$$\mathrm{MX.5P} = \frac{1}{k}\sum \max I_{30}$$

Where, be I_{30} is the maximum 30-minute interval within the storm duration and $\max I_{30}$ is the 30-minute interval of each month be for each year for k (months).

In determining the empirical distribution of relative time to peak, the peak intensity (i) of a storm event must first be calculated. The time to peak intensity of a storm (t_p) can be given by (Yu 2005; Wang et al. 2018):

$$t_p = \frac{i - 0.5}{M}$$

The empirical distribution of time to peak ($TimePk$) is calculated using the following formula (Yu 2005; Wang et al. 2018):

$$TimePk(i) = \frac{Ntp(i)}{Ntp(12)} \text{ for } i = 1, 2, \dots, 12$$

Where, taking the values calculated for t_p, let $Ntp(i)$ be the number of wet days with $tp \leq \frac{i}{12}$ for $i = 1, 2, \dots, 12$, as per a 12-break probability distribution.

Finally, dew point (T_{dp}) was estimated using the formula proposed by Lawrence (2005):

$$T_{dp} \approx T_{\circ F} - \frac{9}{25}(100 - RH)$$

Where, $T_{\circ F}$ is maximum temperature in degrees Fahrenheit, and RH is relative humidity at the maximum temperature.

The parameters calculated above were then entered into a PAR file and processed in WEPP using the Climate Builder tool. CLIGEN v5.3 was then used to build the final climate file.

2.3 Slope profile

Hillslopes were generated from the final landform spatial data using ArcGIS Pro. The final landform was converted from a Digital Elevation Model (DEM) at a 50-centimetre resolution into a slope percentage for use in WEPP modelling.

Four slopes were selected in total, two from each of the final landforms assessed. Slopes were selected considering slope length, slope complexity, and variations in slope percent across the slope. Slopes were constructed in WEPP using 21 samples per slope. Slope information collected consisted of the distance along the slope and the slope percent at each point.

The four slopes were identified as TSF-S1, TSF-S2, WRD-S1 and WRD-S2, and are shown in Figure 3.

The top of TSF-S1 is approximately 149 mAHD, with the bottom of the slope approximately 132 mAHD, giving a slope height of 17 m. The slope runs continuously for approximately 47 m and is a straight slope, with a slope percentage of 36%. TSF-S2 is similar, with a top of 149 mAHD and a bottom of 131 mAHD, for a total slope height of 18 m. The slope is also a straight slope, running for approximately 47 m, with a slope percentage of 38%.

The top of WRD-S1 is approximately 185 mAHD, with the bottom of the slope approximately 125 mAHD, giving a slope height of 60 m. The slope runs continuously for approximately 205 m and is generally linear, with a slope percentage of 29%. WRD-S2 is similar, with a top of 185mAHD and a bottom of 125 mAHD, for a total slope height of 60 m and is generally linear. However, the slope runs for 200 m, with a slope percentage of 30%.

2.4 Vegetation management profile

In creating the land use management parameters for WEPP modelling, groundcover classes were established at 5% intervals ranging from 0% to 100%. Groundcover was fixed at these percentages throughout the WEPP simulations, such that consistent cover was maintained across the 100-year simulation period without growth or decay.

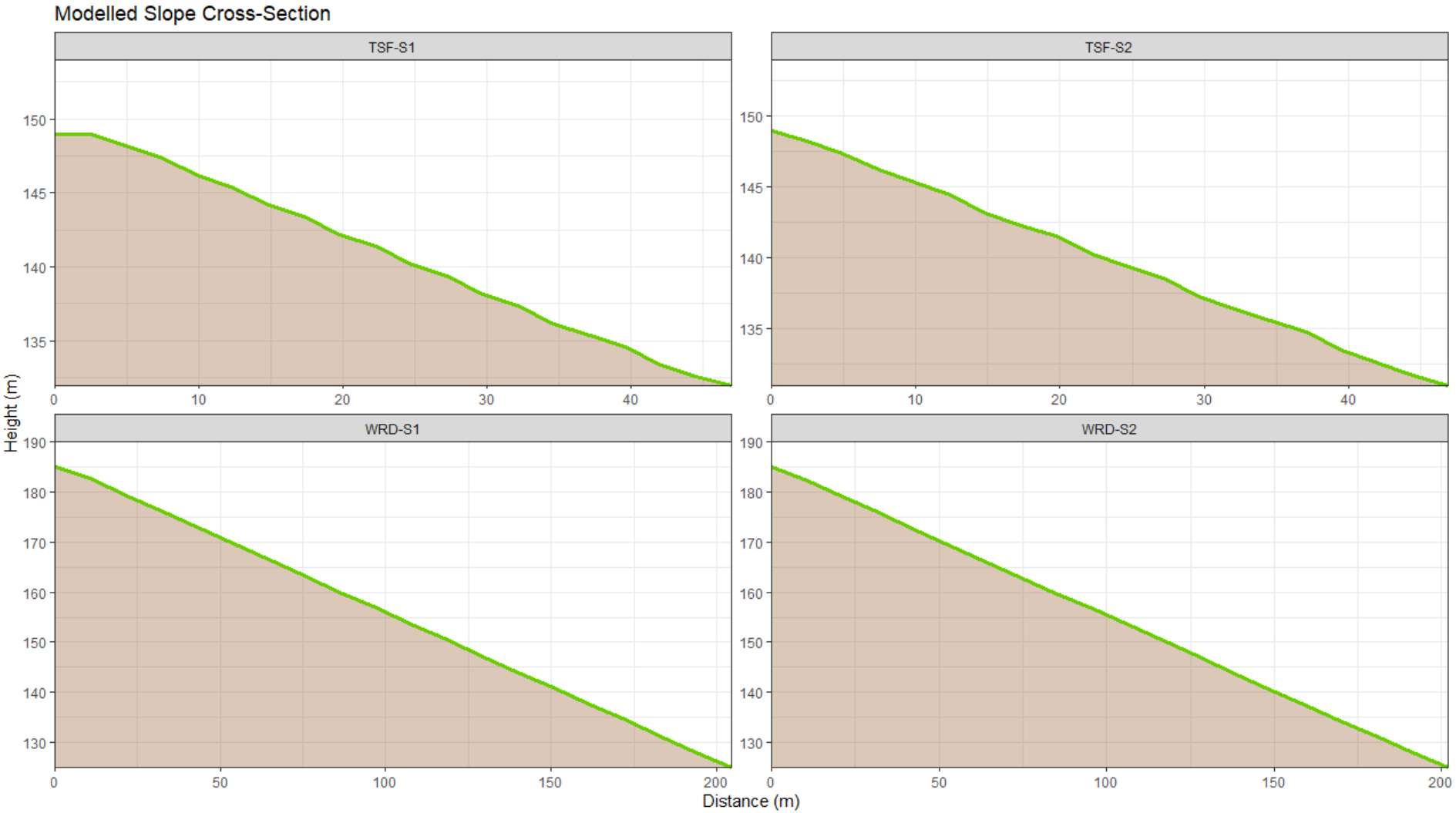


Figure 3: Modelled slope cross-sections

3 Results and discussion

588 100-year WEPP iterations were run, covering the range of soil samples and land use management profiles identified above. To determine the maximum potential erosivity of the slope, the average annual soil loss, expressed in tonnes per hectare per year (t/ha/yr), for each iteration was calculated and assessed against a target and maximum erosion rate.

A target erosion rate of 5 t/ha/yr has previously been adopted for assessing land suitability and erosivity risk based on peer-reviewed literature (Landloch 2013; Howard and Loch 2019). However, the Erosion Modelling Technical Paper now suggests that a long-term average erosion rate for a landform slope of 4 t/ha/y is proposed as a conservative modelling target to benchmark modelling scenarios for landform design. A maximum tolerable erosion rate of 10 t/ha/yr has also commonly been considered as acceptable for mining rehabilitation purposes (Lu 2001).

For the purposes of this assessment, a target erosion rate of 4 t/ha/yr has been adopted, with a maximum tolerable erosion rate of 10 t/ha/yr.

3.1 Erosion impacts

3.1.1 Waste rock dump

The average base (0% groundcover) erosion modelled across all WRD slopes is 100 t/ha/yr, with a maximum base erosion rate of 125t/ha/yr along WRD-S2 with soil type 5Cl(Nm). The groundcover required for all slopes and soil types to meet the maximum threshold is highly variable, ranging from 25% to 50%. The target threshold was similarly variable, ranging from 45% to 80%.

Predicted erosion rates (Table 3 and Figure 4) indicate that at a groundcover level of 80%, predicted erosion rates of the WRD slopes are below the target erosion rate of 4 t/ha/yr for all soil types. When considering the dominant soil types proposed to be included in rehabilitation, a 70% groundcover level is required to achieve the target erosion rate for the WRD slopes.

Where groundcover on the slopes achieves 50%, then erosion rates are below the maximum soil loss rates for all soil types. When considering the dominant soil types proposed to be included in rehabilitation, a 45% groundcover level is required to achieve the maximum erosion rate for the WRD slopes. As such, groundcover of 45% should be sufficient at the WRD during the early establishment of groundcover on the slopes, with a long-term target of 70% to achieve landform stability.

The results indicate that the best performing SPC was 2Cl(Ck) with an average base soil loss of 54.0 t/ha/yr and achieved the target soil loss at WRD-S1 and WRD-S2 with 45% groundcover. The poorest performing SPC was 5Cl(Nm) with an average base soil loss of 72 t/ha/yr and achieved the target soil loss at WRD-S1 and WRD-S2 with 75% and 80% groundcover, respectively. Of note, 5Cl(Nm) (which would require an 80% groundcover) consists of 0.1% of the total topsoil volume available for rehabilitation and is unlikely to be utilised on the slopes of the WRD, and could readily specified as not for use for these structures.

Table 3: Modelled groundcover requirements and soil loss rates for WRD slopes

Slope	Soil Type	Base Case (0% Cover)	Target Rate (4 t/ha/y)		Maximum Rate (10 t/ha/y)	
		Soil Loss (t/ha/yr)	Groundcover (%)	Soil Loss (t/ha/yr)	Groundcover (%)	Soil Loss (t/ha/yr)
WRD-S1	1Cl(Ck)	89.4	65	3.5	40	9.4
	2Cl(Ck)	53.6	45	3.5	25	9.0
	3Cl(Ck)	114.3	70	3.8	45	9.9
	4Cl(Ck)	102.8	65	3.9	45	8.6
	5Cl(Nm)	124.3	75	3.3	50	8.5
	6Cl(EI)	110.3	80	3.5	50	9.3
	7Cl(Nm)	105.7	75	3.4	45	10.0
WRD-S2	1Cl(Ck)	89.5	65	3.6	40	9.5
	2Cl(Ck)	54.4	45	3.7	25	9.2
	3Cl(Ck)	114.7	70	3.9	45	10.0
	4Cl(Ck)	103.0	70	3.3	45	8.7
	5Cl(Nm)	125.7	75	3.5	50	8.7
	6Cl(EI)	110.1	80	3.5	50	9.3
	7Cl(Nm)	108.1	77	3.6	50	8.6

3.1.2 Tailings storage facility

The average base erosion modelled across all TSF slopes is 73 t/ha/yr, with a maximum base erosion rate of 103 t/ha/yr along TSF-S2 with soil type 5Cl(Nm). The groundcover required for all slopes and soil types to meet the maximum threshold is variable, ranging from 20% to 55%. The target threshold was similarly variable, ranging from 45% to 85%.

Predicted erosion rates (Table 4 and Figure 4) indicate that at a groundcover level of 85%, predicted erosion rates of the TSF slopes are below the target level of 4 t/ha/yr. Similarly, if groundcover on the slopes is 55%, then slope erosion rates are below the maximum soil loss rate of 10 t/ha/yr. As such, groundcover of 55% should be sufficient at the TSF during the early establishment of groundcover on the slopes, with a long-term target of 85% to achieve landform stability.

The results indicate that the best performing SPC was 2Cl(Ck) with an average base soil loss of 40.5 t/ha/yr and achieved the target soil loss at TSF-S1 and TSF-S2 with 45% and 50% groundcover, respectively. The poorest performing SPC was 5Cl(Nm) with an average base soil loss of 96.7 t/ha/yr and achieved the target soil loss at TSF-S1 and TSF-S2 with 80% and 85% groundcover, respectively. In addition to soil type 5Cl(Nm) at slope TSF-S2, 3Cl(Ck) at TSF-S2 and 6Cl(EI) at TSF-S1 and TSF-S2 also required 85% groundcover to achieve the target erosion rate.

Table 4: Modelled groundcover requirements and soil loss rates for TSF slopes

Slope	Soil Type	Base Case (0% Cover)	Target Rate (4 t/ha/y)		Maximum Rate (10 t/ha/y)	
		Soil Loss (t/ha/yr)	Groundcover (%)	Soil Loss (t/ha/yr)	Groundcover (%)	Soil Loss (t/ha/yr)
TSF-S1	1Cl(Ck)	64.6	70	3.9	40	9.5
	2Cl(Ck)	38.3	45	3.6	20	9.8
	3Cl(Ck)	82.2	80	3.6	45	9.8
	4Cl(Ck)	78.1	75	3.7	45	9.2
	5Cl(Nm)	90.6	80	3.7	50	8.7
	6Cl(EI)	72.9	85	3.8	50	8.7
	7Cl(Nm)	62.0	75	3.7	40	9.7
TSF-S2	1Cl(Ck)	69.8	75	3.7	45	8.9
	2Cl(Ck)	42.7	50	3.4	25	8.8
	3Cl(Ck)	89.4	85	3.6	50	9.2
	4Cl(Ck)	84.8	80	3.0	50	8.6
	5Cl(Nm)	102.9	85	3.8	55	8.6
	6Cl(EI)	77.3	85	4.0	50	9.3
	7Cl(Nm)	67.5	80	3.8	45	9.4

3.2 Slope design considerations

The strongest drivers of erosivity on the site are slope design and groundcover. Overall, there is a significant decline in erosion rates when comparing total annual soil loss observed as groundcover increases, as shown in Figure 4. Such a result is to be expected given the importance of groundcover in reducing erosion rates and stabilising slopes (Landloch 2013). Considering both the historic and current slope designs proposed by the Project, adequate ground cover is necessary to maintain slope stability and minimise the effects of erosion along rehabilitated slopes.

Slope length and gradient also affect erosion rates, especially when adequate groundcover has not been established. Despite the TSF slopes being 16-18% steeper than the WRD slopes, the average base case erosion rate of the WRD slopes was 100 t/ha/yr, greater than the average base erosion rate of the TSF slopes of 73 t/ha/yr. The higher erosion rate of the WRD slopes is likely driven by the WRD slopes having greater slope lengths (200 m and 204 m long) than the modelled TSF slopes (47 m for both slopes). Where the practical construction of final landforms at either the TSF or WRD results in increased slope lengths or gradient increases, additional groundcover may be required to achieve target erosion rates across the final landforms.

Ensuring rapid early establishment of a functional grass cover is essential to minimising erosion losses. The current rehabilitation slope design accounts for berms on the landform, to reduce erosion on steep, long slopes (Landloch 2013). As such, it is reasonable to conclude that the proposed slope design is satisfactory for establishing a stable final landform.

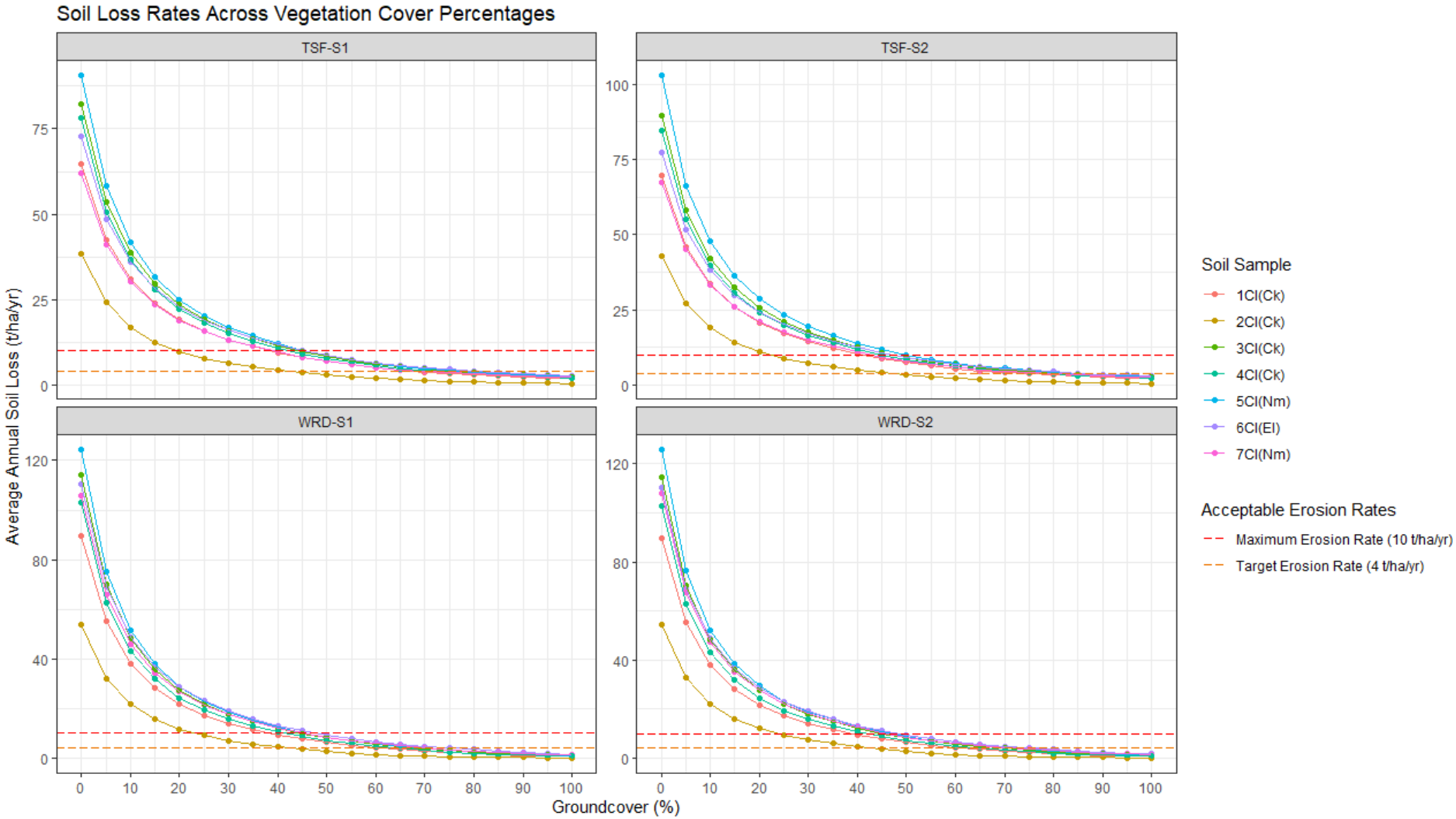


Figure 4: Modelled soil loss rates across slopes

3.3 Groundcover requirements

Effective groundcover requirements for the purposes of erosion protection can be achieved through a combination of vegetation and rock cover. Rock fragment cover contributed to delayed run-off flow and increased infiltration rates, diminishing the soil loss rates (Zavala 2020).

Waste rock will reach the surface during the natural settlement of the landform. As a result, rock fragments will become a component of the groundcover of these landforms in addition to vegetation cover. It is expected that in providing groundcover recommendations in this report, such cover will consist of grassland vegetation and rock fragments from waste rock. Therefore, where the combination of vegetation cover and rock fragments reach the cover percentages outlined in Section 3.1, such cover composition will provide a safe, stable and sustainable final landform with low erosional risk.

3.4 Mitigation measures

The final landforms have been designed to achieve the target erosion rate of 4 t/ha/yr based on appropriate groundcover requirements consistent with the proposed PMLU. However, in circumstances where groundcover targets may not be achieved, or where seasonal climatic circumstances may limit vegetation establishment, mitigation measures can be implemented to reduce erosion risk. Such measures include the following:

- limiting land clearing to the minimum amount of land required for the safe operation of the Project;
- ensuring that overland/runoff flows onto disturbed areas is avoided;
- amelioration of dispersive soils through the addition of gypsum, if disturbed or exposed, and especially if used in rehabilitation;
- progressive rehabilitation of landforms and direct placement of topsoil to help preserve the seed bank and reduce erosion;
- seeding of topsoil as soon as possible after placement onto rehabilitated areas to ensure root masses assist in mitigating erosion;
- placing of topsoil stockpiles away from drainage areas, roads, machinery, transport corridors, and stock grazing areas;
- hay mulching using non-feed quality hay/stubble at a rate of 8 t/ha, applied immediately after sowing/deep ripping; and
- the use of sediment control structures, such as retention ponds, to minimise the release of water and suspended sediments into the receiving environment.

4 Conclusion

Overall, the information provided indicates that under the proposed slope conditions and groundcover of 85%, the proposed final land use will meet the requirements outlined in the rehabilitation criteria. These findings rely on groundcover being maintained at greater than or about 85% under the representative future slope conditions to ensure that erosion rates remain below the target threshold.

Where groundcover is less than 85%, there is a risk of erosional instability on the slope, which may result in landform failure. The major design factors which contribute to the erosion of the landforms are the groundcover present, the slope length and the slope gradient.

It is recommended that when developing erosion monitoring criteria for the PRCP, quantitative and precise values should not be set across slopes and/or landforms. Erosion rates in the range of 1 to 10 t/ha/y cannot be measured quantitatively under field conditions with any degree of accuracy unless using large field plots, which are impractical in modern rehabilitation. Given the target rate of 4 t/ha/yr, erosion conditions should be focused on the establishment of groundcover and qualitative assessment of erosion features to ensure practicality while monitoring erosional stability using established means.

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