Kestrel Report

RIDA Soil Conservation Plan: ML70481

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Abbreviations

ALARA	As low as reasonably achievable
ALS	Airborne laser scanning
CH	Cultural heritage
DNRM	Department of Natural Resources and Mines
DNRME	Department of Natural Resources Mines and Energy
DoD	DEM of Difference
DSDILGP	Department of State Development, Infrastructure, Local Government and Planning
DSDMIP	Department of State Development, Manufacturing, Infrastructure and Planning
DSITI	Department of Science, Information Technology and Innovation
EA	Environmental Authority
ESCP	Erosion and sediment control plan
GDP	Ground disturbance permit
KCR	Kestrel Coal Resources
ML	Mining lease
MSEC	Mine Subsidence Engineering Consultants
PED	Personal emergency device
RIDA	Regional Interests Development Approval
RPI Act	*Regional Planning Interests Act 2014*
RPI Regulation	Regional Planning Interests Regulation 2014
RUSLE	Revised Universal Soil Loss Equation
SCA	Strategic Cropping Area
SCP	Soil Conservation Plan
SLSA	Soil and land suitability assessment
WRAC	Workplace risk assessment and control

1 Purpose

As part of the approval process for mining lease ML70481, an amended regional interests development approval (RIDA) was issued on 29 August 2016 (reference number RPI16/002/RIO TINTO), under section 53 of the *Regional Planning Interests Act 2014* (RPI Act). The RIDA provides specific conditions that must be met when underground mining is carried out within ML70481. Specifically, Condition 5(a) requires the preparation of a Soil Conservation Plan (SCP) to address the management of impacts to strategic cropping land (SCL), including subsidence related impacts.

This SCP has been developed to satisfy RIDA Condition 5(a). This SCP draws on, and interacts with, existing and related site management plans and incorporates the mine plan revisions for the 500-series made in 2023 in relation to the addition of LW500 and various adjustments to the 500-series panels.

1.1 Background

The Kestrel Mine is an underground metallurgical coal mine located approximately 40 km north-east of Emerald and 300 km west of Rockhampton (Figure 1).

The mine is held as a joint venture of Kestrel Coal Resources (Kestrel) (80%) and Mitsui Coal Pty Ltd (20%), with Kestrel as the operations entity. The mine is located within the Central Highlands Regional Council area and is accessed via Lilyvale Road.

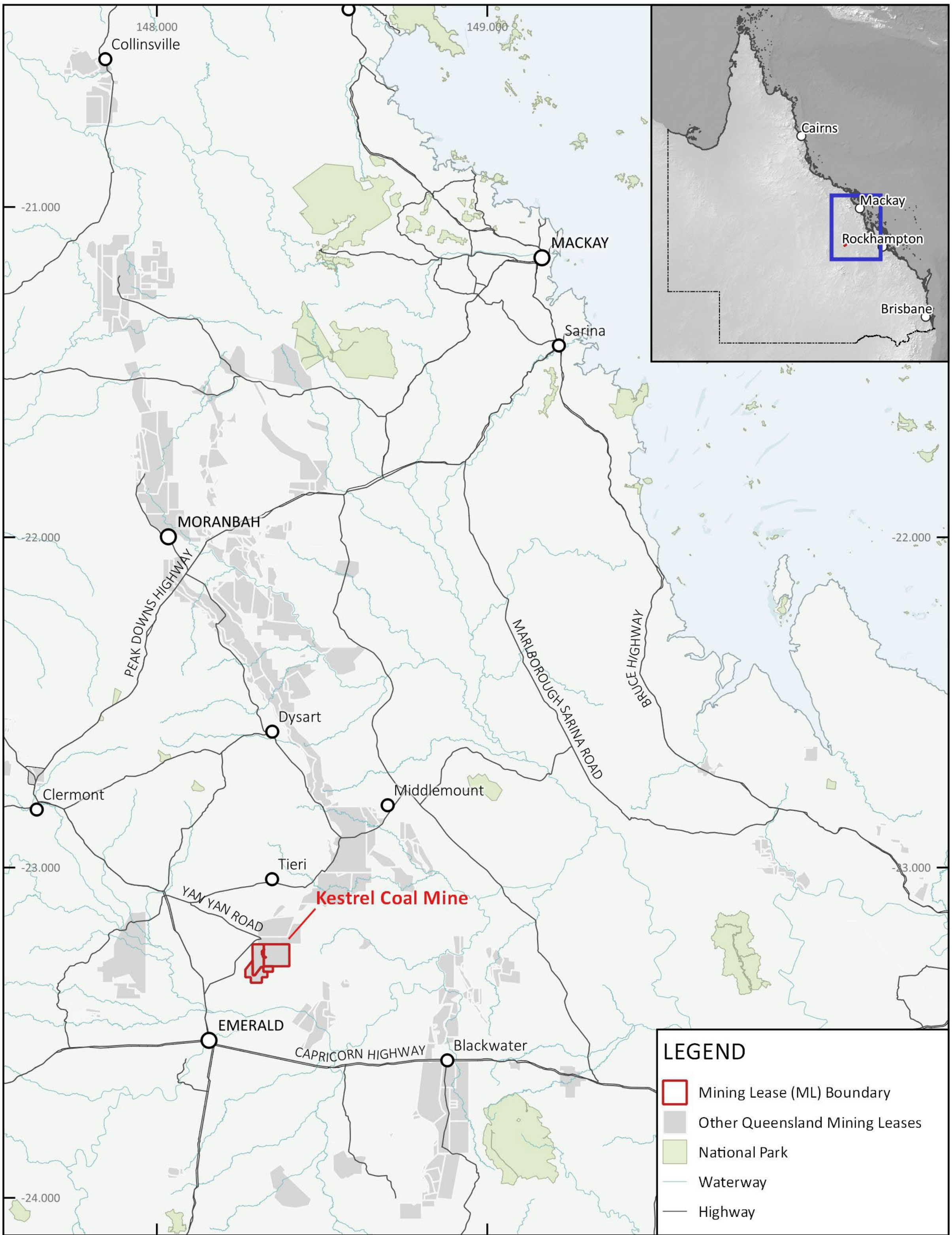
Operations at the Kestrel Mine originally commenced in 1992 and has a current mine life to 2032. Currently coal extraction and production at the Kestrel Mine occurs underground at depths of 300–450 m in the 400-series, with production rates of 8–11 Mt run of mine metallurgical coal per year. The current approved life of mine includes mining of a further series, referred to as the 500-series, which extends into ML70481 at depths of between 360 m and 470 m.

Mining operations up to and including the 400-series longwall panels have occurred on ML1978, ML70301, ML70302, and ML70330, none of which were subject to RPI Act approval requirements.

In 2016, ML70481 was granted to enable operation of the 500-series longwall panels. An SCL protection decision (SCLRD2012/000090) was issued for ML70481; one of the first issued under the new SCL regulatory environment. In March 2016, the SCL protection decision was transitioned to a RIDA under Section 53 of the RPI Act, referred to as RPI16/002/Rio Tinto - Kestrel Extension #4 Coal Project (RPI16/002).

The area of applicable SCL within ML70481 is shown in Figure 2. Kestrel holds all the freehold titles for all surface properties associated with the MLs with the exception of a parcel of State-owned land (Lot 8 on TT424), which lies within a watercourse reserve not mapped as SCL trigger land on ML70481. Kestrel manages agricultural lessees carrying out pastoral activities across all freehold lands not utilised for mining activities.

A preliminary SCP was endorsed by the Department of State Development, Infrastructure, Local Government and Planning (DSDILGP) on 12 November 2021, authorising the carrying out of resource activities that may result in 'temporary impacts' as per Table 1 of the RIDA. This revised SCP has been drafted to address the management of permanent impacts associated with underground mining within ML70481 and specifically to meet the requirements of Schedule 2 of the RIDA (refer Table 1).



PROJECT LOCALITY

KESTREL COAL MINE

Client	Kestrel Coal Pty Ltd
Date	11-05-2022
Author	R.Shambrook
Projection	GDA94
Scale	1:1500000

N

0 20 40 60 km

arc ENVIRONMENTAL SOLUTIONS

Q:\Kestrel Coal\80_Mapping_Data\01_Workspaces\Kestrel_ProjectLocality.qgz

Figure 1: Project location

2 Scope

Condition 1 of the RIDA authorises activities and disturbance to SCL within ML70481 generally in accordance with the activities identified in Table 1 of the RIDA; referred to as:

- ‘permanent impacts’ that may be associated with longwall mine subsidence within the originally proposed mining footprint defined by Plan SCLRD2012/000090 (limited to 949.0 ha) and disturbance associated with establishing and remediating surface infrastructure within the same mining footprint (limited to 71.0 ha); and
- ‘temporary impacts’ associated with mining activities that comply with the *Strategic Cropping Land Standard Conditions code for resource activities* (DNRM 2012).

As is common with mining operations, resource definition and understanding of geological conditions has improved since the original 2012 drafting of the approved mining footprint drawing (RIDA Attachment 1, SCLRD 2012/000090). This has resulted in a number of refinements to the location and alignment of the 500-series mining panels including the addition of the LW500 panel. As per the existing RIDA, 'underground mining impact' is taken to align with the panel extent for both the gate-road and longwall panel.

This SCP has the following scope:

- Longwall subsidence associated with longwall panels LW500 to LW509 as modified from that shown in the original RIDA approval to include LW500, exclude LW510 and various other longwall panel adjustments.
- Ongoing surface preliminary works required ahead of mining in ML70481, having limited and temporary surface disturbance. These works have already commenced under the currently endorsed SCP and include access tracks, gas drainage works, and other surface support infrastructure.

Figure 2 shows the revised layout of the 500-series longwall panels, the associated disturbance to SCL and the boundary of ML70481.

Condition 5(a) of the RIDA states a requirement to submit and have endorsed an SCP that:

- applies to all land within ML70481 (5(a)(i));
- is prepared by a suitably qualified person (5(a)(ii)); and
- meets the requirements of Schedule 2 of the RIDA (5(a)(iii)).

The holder must then:

- within 12 months of mining activities commencing on ML70481, review and if necessary revise the SCP, and thereafter review the SCP on an annual basis (5(b));
- ensure compliance with the most recent SCP endorsed by the Chief Executive (5(c));
- at any time submit a revised SCP to the Chief Executive for endorsement (5(d)); and
- continue to meet reporting requirements as detailed in Schedule 3 (5(e)).

The requirements of Schedule 2 of the RIDA and where those requirements are addressed are detailed in Table 1.

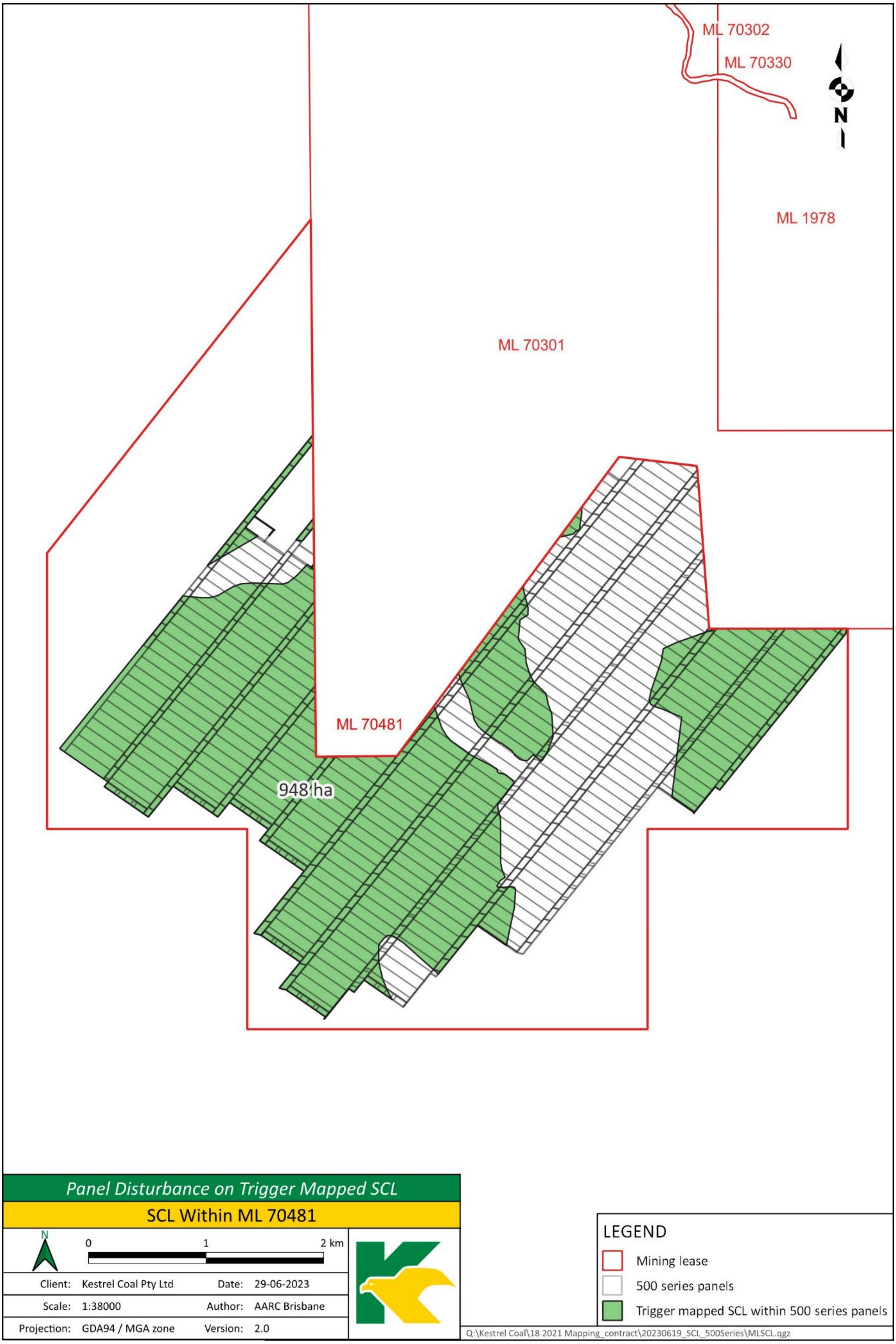


Figure 2: Revised 500-series mine plan.

Table 1: Detailed SCP Requirements (as per Schedule 2 of the RIDA)

Ref.	SCP requirements as per RIDA Schedule 2	SCP Section
a)	be developed in consultation – as it relates to potential impacts to cropping operations – with the owners or occupiers of land within the subject mining lease;	Section 2.2.1
b)	establish the baseline conditions of soils and of land within the subject mining lease, including but not limited to, ascertaining:	Section 3
	a. the predicted erodibility of the soils;	Section 3.3.3
	b. the pre-disturbance severity and extents of soil erosion and associated land degradation;	Section 3.3.6
	c. the location and the design capacity of all 'pre-disturbance' soil conservation works; and	Section 3.3.5 Section 5.2.1
	d. the likely pre-disturbance rates of soil erosion across all significant soil and land units within the subject mining lease.	Section 3.3.6
c)	identify and document all activities on the subject mining lease (resource activities or otherwise) that could increase or affect soil erosion and sedimentation;	Section 3.3
d)	the hydrological design of any new soil conservation works that are to be developed, modified or rebuilt must be consistent with the recommended design methods, equations and algorithms in the publication – Carey BW, Stone B, Norman PL, Shilton P (2015), 'Soil conservation guidelines for Queensland', DSITI, Brisbane, or alternatives identified as being applicable to Queensland conditions in the 4th edition of the publication 'Australian Rainfall and Runoff' (Engineers Australia) or a future edition of that publication.	Section 5.2.1
e)	describe in detail the location and design of suitable and effective soil conservation measures and soil conservation works.	Section 5.2.1
f)	detail how the integrity and functional efficiency of all soil conservation measures and soil conservation works will be effectively monitored, their performance assessed, and where they are found not to provide the necessary level of control, how any required changes to those measures or works will be implemented;	Section 5.2.1 Section 6
g)	describe how all soil conservation works will be maintained over the life of the proposed mine;	Section 5.2.1 Section 6
h)	describe the procedures to be implemented to:	
	i. respond to any complaints made regarding matters that are subject of the SCP;	Section 7.2
	i. resolve any disputes with property owners, landholders or other persons affected by the SCP	Section 7.2
	i. deal with the impacts not predicted in the SCP	Section 7.3
	v. respond to any non-compliances with the SCP; and	Section 7.2
	v. respond to any emergencies related to matters that are subject of the SCP	Section 7.2
i)	describe the role, responsibility and accountability of those persons who will be ultimately responsible for the administration of the SCP; and	Section 9
j)	demonstrate how the objectives of the SCP listed in Schedule 2 Item 1 (above) are addressed by the SCP.	This table

2.1 Objectives

Schedule 2 of the RIDA sets out the required objectives for the SCP, specifically:

- ensure erosive soil loss from land within and downslope of ML70481 is less than or consistent with existing levels;
- minimise, to the greatest practicable extent, the disturbance of soils or land within ML70481;
- no disturbance of soils or land outside of ML70481 (noting that the disturbance of pre-existing MLs are already authorised under the Environmental Authority (EA) and are not subject to the RIDA);
- no pollution of surface water as a result of disturbance (interpreted as mining-related disturbance) or changes in hydrology of land on ML70481; and
- to limit the extent and duration of any disruption or obstruction of farming operations to only that necessary to satisfy the above objectives.

These objectives can be summarised as striving for responsible land management stewardship – a goal aligned with Kestrel's land stewardship objectives.

2.2 SCP development

This SCP has been developed based on the RIDA obligations, technical advice derived from various background and baseline assessments, and practical approaches derived from observations, experience and knowledge of soil erosion and restoration in practice.

The SCP has been structured to reflect the key potential impact sources being underground mining subsidence, supporting surface infrastructure, and non-mined land management activities. The potential impacts, management and restoration approaches and monitoring and maintenance requirements associated with each potential impact source are discussed.

2.2.1 Consultation

Kestrel is aware, responsible and accountable of its position as a local and regional community member. Consultation regarding operations, environmental performance, restoration and closure is being and will continue to be undertaken as part of our community engagement activities, in accordance with all regulatory requirements, and aligned with our stakeholder engagement strategy.

The majority of Kestrel-owned land across our mining tenements that are not required for surface infrastructure are leased to a commercial pastoral company. With respect to soil conservation management practices and activities, the pastoral lessee is a key stakeholder. Kestrel coordinates meetings as required with the current lessee to discuss mine plans and discuss land management actions as a part of ongoing property management. In preparing this SCP, a risk assessment has been held that has included representatives of the Australian Agricultural Company (the current lessee) and independent soils scientists.

3 Baseline soil conditions (pre-mining disturbance)

This section outlines the existing environment prior to land disturbance in the areas of the Kestrel MLs. Including the soil types, landscapes and pre-disturbance land degradation.

3.1 Studies

Since the commencement of mining in 1992, Kestrel has undertaken numerous environmental studies across the areas of operation to assess the potential, and quantify the actual, impacts of underground longwall mining. Studies have included soil surveys and land capability and land suitability assessments, subsidence modelling and pre/post subsidence comparisons, hydrological and hydrogeological studies, and ecological baseline studies. Environmental monitoring of impacts attributable to mining have been ongoing.

In relation to ML70481 specifically, detailed environmental impact assessments have been undertaken for the ML application and EA approval processes for an area referred to as Kestrel Coal Mine Extension #4 (which covers the 500-series panels); with studies completed between 2002–2005. Key study documents that assessed the potential environmental impacts associated with the continuation of underground mining in the 500-series longwall panels are:

- the *Kestrel Mine Extension - Environmental Assessment Report, Final V4.0 August 2006* (Matrix+ 2006);
- the *Environmental Assessment Addendum Report – Kestrel Mine Extension Project, Final Version 2.4 August 2007* (Matrix+2007); and
- the *Environmental Assessment Report Kestrel Extension #4 November 2012* (EMM 2012).

Current soils knowledge is based on several soil surveys that have been undertaken across the various MLs as follows:

- 1993 (Emmerton): conducted a soils and land suitability assessment for dryland cropping in the Gordonstone West area (1:25,000 scale). Note that the prior name of Kestrel was the Gordonstone Mine;
- 1996 (Cannon): addressed soils and land suitability for the Gordonstone Mine, Gordonstone Extension and Gordonstone West Mines (1:25,000 scale);
- 2002 (MWH): conducted a pre-mining condition soil and land capability study of Gordon Downs; effectively covering ML 1978, ML70301, ML 70302, ML7030 and parts of ML70481 excluding the immediate area of existing surface infrastructure, and improving the mapping scale to 1:10,000; and
- 2011 (MWH): surveyed the remainder of ML70481 at 1:10,000 scale as part of the Environmental Assessment Report Kestrel Extension #4 November 2012 (EMM 2012). This study also addressed land capability, land suitability and SCL aspects.
- 2022 (Highlands Environmental): Agricultural land evaluation on Mining Lease 70481, Gordon Downs, central Queensland. This study includes an agricultural land evaluation, land suitability assessment and SCL zonal criteria assessment and determination.

With respect to subsidence impacts; in addition to the annual subsidence reports required by ML conditions, subsidence prediction and modelling studies have been undertaken for all panel series. In relation to the 500-series panels, Seedsman Geotechnics and Gordon Geotechniques have completed studies between 2002 and 2022 (refer Section 8).

3.1.1 Topography

Land on and surrounding ML 70481 is gently undulating with low to moderate relief. Slopes generally range from 1% to 3%, with small areas ranging up to 5%.

On slopes where cropping activities have occurred in the past, some contour banks remain. However, the only soil conservation works within ML70481 are those existing immediately to the east of LW500 and associated with Lot 11 SP178401. These works are mostly located off-lease and consist of a sequence of contour banks draining south to a drainage channel located just off ML70481. Subsidence associated with LW500 is not predicted to have any impact on the contour banks themselves and will not impact the drainage channel.

3.1.2 Surface water and water courses

Kestrel sits within the Nogoa River catchment, a tributary of the Mackenzie River, which joins the Fitzroy River before flowing to the ocean near Rockhampton. The site is located in the upper and mid-reaches of the Crinum Creek catchment, which flows across ML70481 before flowing to the Nogoa River. Several other drainage lines are present as ephemeral flow creeks, including:

- Homestead Creek: the reaches which overlay the MLs (principally ML1978 and ML70301) consist of a wide shallow channel with ephemeral standing water. In some sections a bifurcated channel exists while its lower reaches approaching the Crinum Creek confluence becoming increasingly braided and indistinct with flows likely to follow multiple flow paths.
- Belcong Creek: flows from north-west to south-east across the site traversing ML70481 and ML70301. The upper reaches are characterised by an undulating channel with alternating scours and depositional features. Bank vegetation comprises grasses and scattered trees with little vegetation in the channel bed. Cattle tramping has been noted along the banks and may affect bank stability. The lower reach of Belcong Creek, upstream of the confluence with Crinum Creek, follows a meandering path with active bank erosion and bank retreat evident on the outside of most bends.
- Crinum Creek: flows from north to south meandering on the western boundary of ML1978, crossing ML70301 before its confluence with Belcong and Homestead Creeks and Liskeard Gully in ML70481. The riparian zone is forested but the floodplains are largely cleared of trees for agricultural purposes. While the channel banks are generally grassed and appear to be stable away from bends, the creek displays significant undercutting at some of its larger meanders.
- Liskeard Gully: traverses ML70301 and ML70481. Channel banks are covered with grass and the surrounding areas are forested. Closer to its confluence with Crinum Creek, Liskeard Gully comprises of an incised relatively straight channel.

Water quality results show significant variability in relation to flow rates, rainfall intensity, and runoff, demonstrating the ephemeral nature of the watercourses. Upstream land managers can also impact water quality through rainfall runoff and water releases during heavy rainfall periods.

3.2 Land use, land capability and land suitability

3.2.1 Land use

The *Central Highlands Regional Council Planning Scheme 2016* (CHRC 2016) includes Kestrel and the surrounding region within the Rural zone code which has as its purpose to:

- provide for rural uses including cropping, intensive horticulture, intensive animal industries, animal husbandry, animal keeping and other primary production activities;
- provide opportunities for non-rural uses that are compatible with agriculture, the environmental features, and landscape character of the rural area where the uses do not compromise the long-term use of the land for rural purposes; and

- protect or manage significant natural resources and processes to maintain the capacity for primary production.

Prior to mining, regional and local land use included grazing of native and improved pastures, and cropping. In the 1980s (prior to mining) and again in the early 2000s (post commencement of mining), the Gordon Downs property had been assessed by the then Soil Conservation Branch of the Queensland Department of Primary Industries, for the design and installation of soil conservation works appropriate for a cropping regime. A review of recent aerial photography confirms some of these structures remain in place today. In 1983 approximately 4% of ML70481 was subject to cropping activity, increasing in 1993 to approximately 13% and again in 2004 to approximately 21%. Since 2004, cropping activity has diminished such that there is not currently any cropping activity occurring in ML70481. The property is now predominantly used for grazing based on native and naturalised grasses, as well as the forage crop Leucaena (*Leucaena leucocephala*).

ML70481 is located on surface freehold lands owned by Kestrel, with both mining and pastoral activities being completed in the area. Land capability assessments have been undertaken for the site at various points in time and EA rehabilitation requirements are expressed as achieving the land capability classes nominated within the EA, although it should be noted that the use of land capability criteria within the EA significantly pre-dates approval of the ML70481 area.

A previous land capability assessment was completed by MWH (2011). This assessment was integrated with an earlier 2002 study (MWH 2002) to cover the whole of the Kestrel Extension #4 area, which later became ML70481. The most recent land capability study to assess the ML70481 area was undertaken by EMM (2012). In relation to the Kestrel Extension #4 area, the assessment findings are summarised in Table 2 and Figure 3.

Table 2: Assessed land capability classes (EMM 2012)

Land use capability class	Pre-mining area (ha)
Class III	1,624.4
Class IV	72.0
Class V	42.5
Class VI	196.9
Class VII	528.1

Progressive Rehabilitation and Closure Plan development occurring in 2023 will propose a conversion to the use of the more contemporary and relevant land suitability criteria.

3.2.2 Land suitability

Land suitability assessments have been undertaken for areas covering the ML70481 footprint in both 1996 (CSIRO), and then in 2002 for part of the current ML70481 area (MWH 2002) and 2011 for the remainder of the current ML70481 area (MWH 2011) (refer Table 3). The 2002 and 2011 assessments also predicted post-mining land suitability.

Table 3: Assessed land suitability classes (MWH 2011)

Suitability Class	Pre-mining (ha)	
	Winter Crop	**Summer Crop**
Class 3	1,139.3	1,139.3
Class 4	578.4	578.4
Class 5	746.1	746.1

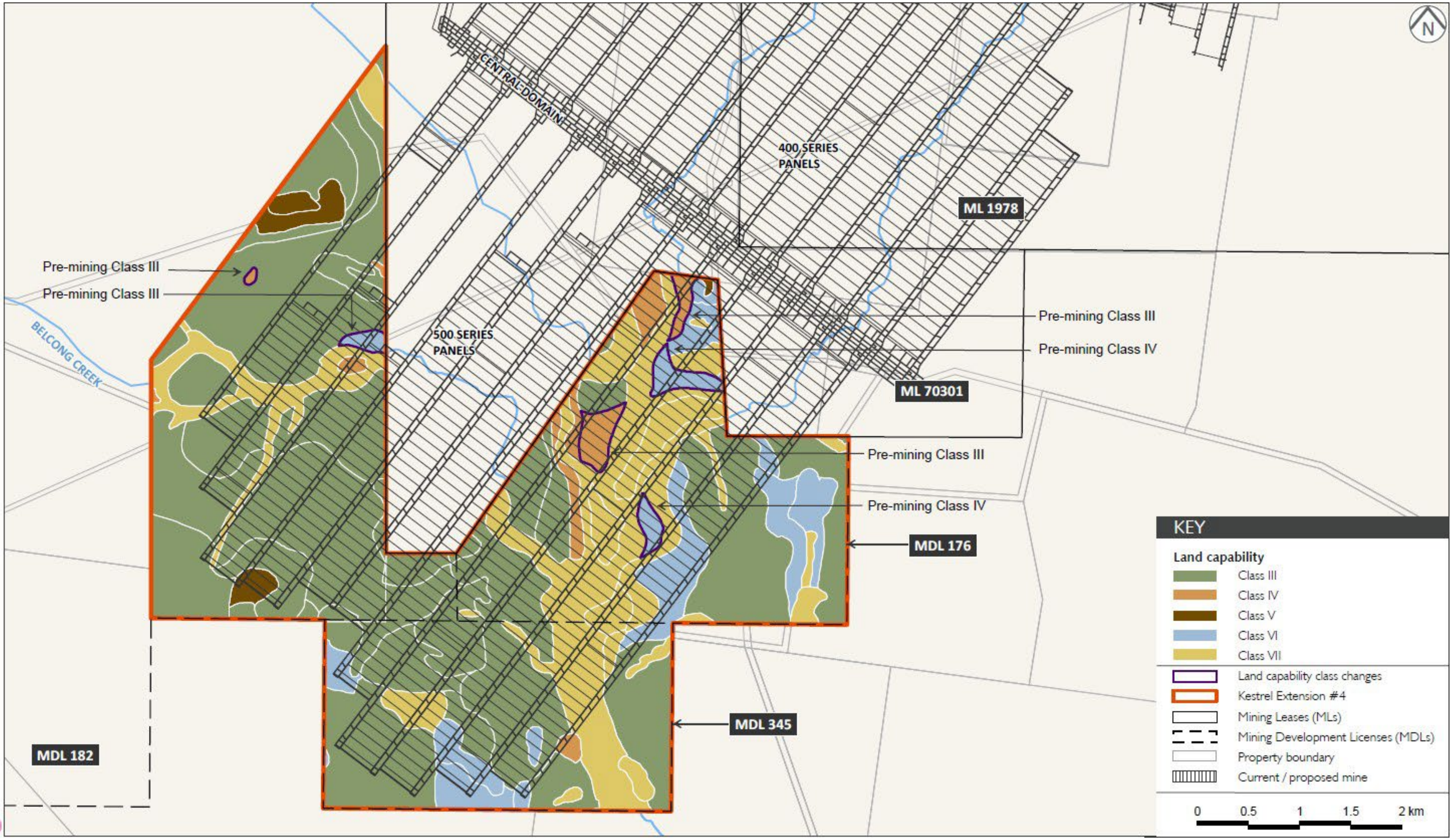


Figure 3: Land capability classes (EMM 2012)

Highlands Environmental undertook a land suitability assessment of ML70481 in 2022 (Highlands Environmental 2022) following the *Guidelines for Agriculture Land Evaluation in Queensland* (DSITI & DNRM 2015) and using the *Regional Land Suitability Frameworks for Queensland* (DNRM & DSITIA 2013) for the *Inland Fitzroy and Southern Burdekin Area*, being the relevant framework for the Kestrel Mine.

The *Guidelines for Agriculture Land Evaluation in Queensland* refers to five (5) classes of land suitability decreasing progressively from Class 1 to Class 5. Soils have been assessed against eight (8) land use limitations for dryland cropping for both summer production (sorghum) and winter production (wheat and chickpeas).

All soil landscapes possess some form of limitation for both seasons of cropping, with all but the Adelong Soil Landscape (1a) being suitability class 3 or lower (Table 4). The Adelong Soil Landscape (1a) is the least limited soil type with a suitability class of 2, being limited by erosion hazard (subsoil), soil water availability, surface condition, and wetness. Only the Orion (2a) and Picardy (3a) soil types are also suitable for cropping for both seasons but with increased limitations. Land suitability maps for both cropping seasons for ML70481 are provided (Figure 4 and Figure 5).

Table 4: Suitability classes for soil landscapes: ML70481

Soil Landscapes	Dryland Summer Crop (sorghum)		Dryland Winter Crop (wheat/chickpea)	
	Suitability Class	**Defining limitations**	**Suitability Class**	**Defining limitations**
1a Adelong	2	Erosion hazard; Soil water availability; Surface condition; Wetness	2	Erosion hazard; Soil water availability; Surface condition; Wetness
1b Isaac	4	Soil water availability	5	Soil water availability
1c College	4	Surface condition	4	Soil water availability; Surface condition
1d Lascelles	5	Wetness	5	Soil water availability; Wetness
2a Orion	3	Water erosion; Rockiness	3	Water erosion; Rockiness
2b Jimbaroo	5	Soil water availability	5	Soil water availability
3a Picardy	3	Water erosion; Erosion hazard; Narrow moisture range	3	Water erosion; Erosion hazard; Soil water availability; Narrow moisture range
3b Springton	4	Surface Condition	4	Soil water availability

After Highlands Environmental 2022.

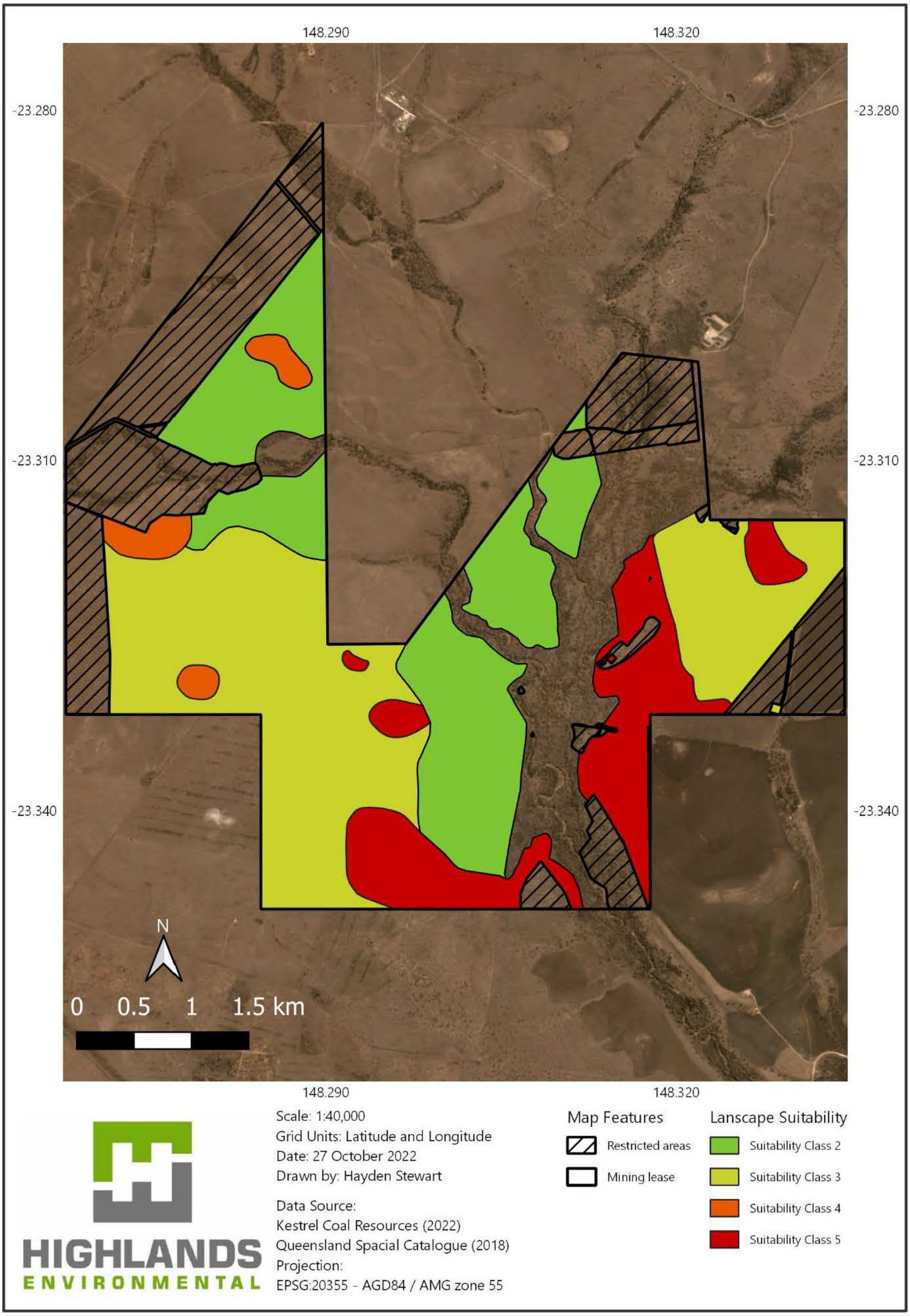


Figure 4: Land suitability for dryland summer cropping: ML70481 (Highlands Environmental 2022)

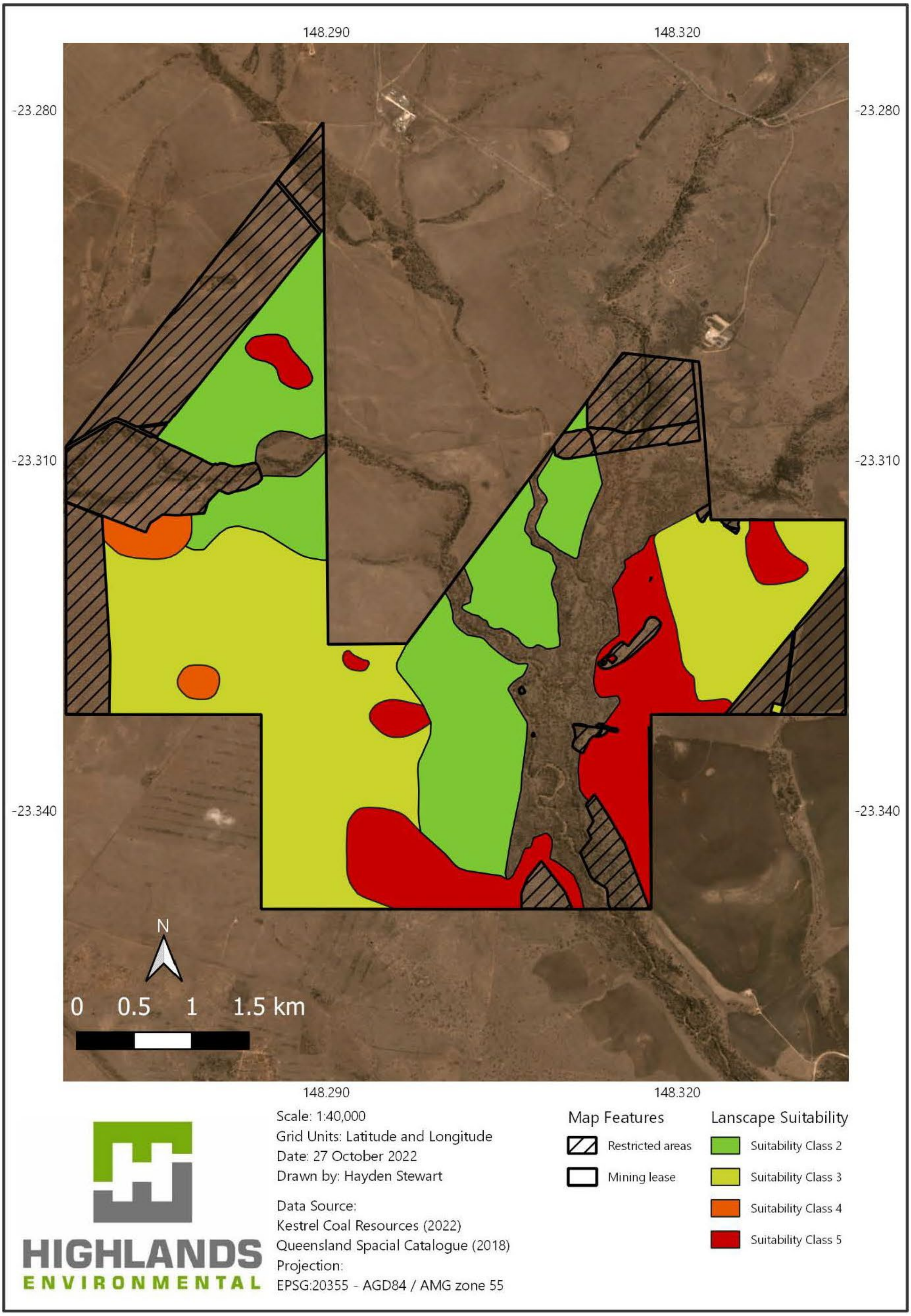


Figure 5: Land suitability for dryland winter cropping (Highlands Environmental 2022)

3.3 Soils

3.3.1 Requirements

Condition 2(a) of Schedule 2 of the RIDA requires the baseline conditions of soils to be established for ML70481, specifically:

- the predicted erodibility of soils;
- pre-disturbance severity and extents of soil erosion and associated land degradation;
- the location and design capacity of pre-disturbance soil conservation works; and
- likely pre-disturbance rates of soil erosion across all significant soil and land units.

The following subsections describe the soils identified across the Kestrel MLs and address the above RIDA requirements.

3.3.1.1 Previous studies

Current soils knowledge is based on a number of soil surveys that have been undertaken across the various MLs as follows:

- 1993 (Emmerton): conducted a soils and land suitability assessment for dryland cropping in the Gordonstone West area (1:25,000 scale). Note that the prior name of Kestrel was the Gordonstone Mine;
- 1996 (Cannon): addressed soils and land suitability for the Gordonstone Mine, Gordonstone Extension and Gordonstone West Mines (1:25,000 scale);
- 2002 (MWH): conducted a pre-mining condition soil and land capability study of Gordon Downs; effectively covering ML 1978, ML70301, ML 70302, ML7030 and parts of ML70481 excluding the immediate area of existing surface infrastructure, and improving the mapping scale to 1:10,000; and
- 2011 (MWH): surveyed the remainder of ML70481 at 1:10,000 scale as part of the *Environmental Assessment Report Kestrel Extension #4 November 2012* (EMM 2012). This study also addressed land capability, land suitability and SCL aspects.
- Highlands Environmental (2022): Agricultural land evaluation on Mining Lease 70481, Gordon Downs, central Queensland, covering the LW500 area. This study included an agricultural land evaluation, land suitability assessment, and SCL zonal criteria assessment and determination.

3.3.2 Soil types

The distribution of soil types within Kestrel includes soils derived from:

- recent Quaternary alluvium (Qa) sediments;
- Tertiary basalt (Tb) sheets; and
- older Emerald Eocene (Te, w) reworked sediment.

The soils of ML70481 from the survey by Highlands Environmental (2022) are shown in Figure 6 and summarised in Table 5. The various soils studies listed above should be referenced for further details on soils.

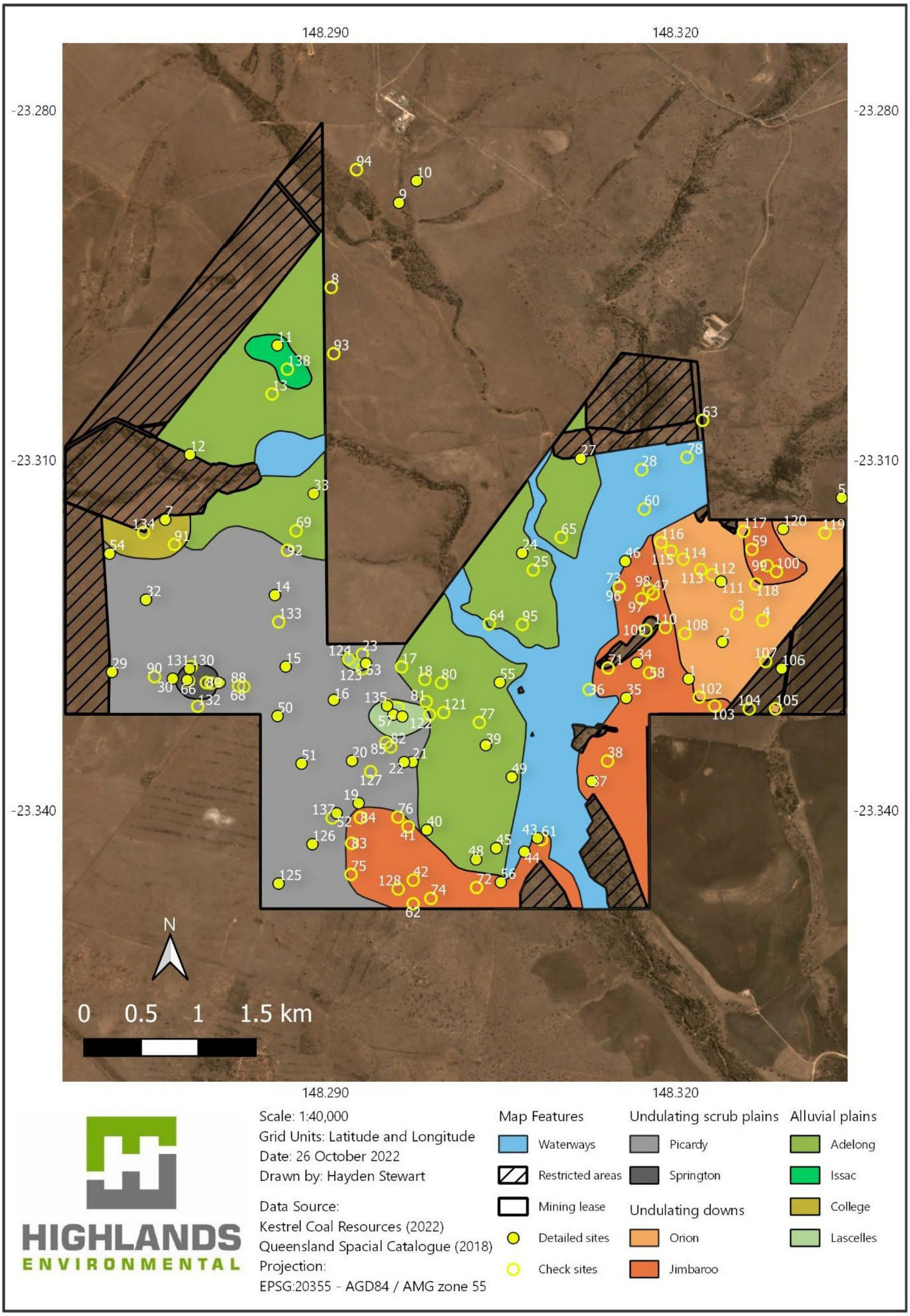


Figure 6: Soils of ML70481 (Highlands Environmental 2022)

Table 5: Soil types - ML70481 (from Highlands Environmental 2022)

Soil Landscape lithology / parent material	Soil Landscapes		Brief Description	Occurrence in study area
Derived from recent Quaternary alluvium (Qa) sediments	1a	Adelong	Self-mulching, deep, grey cracking clay soils on level alluvial plains	Widespread, 525.7 ha
	1b	Isaac	Deep, brown loamy clay soils on upper alluvial floodplains and levees	Minor, 16.3 ha
	1c	College	Deep gradational clay soils with highly saline and sodic subsoils on alluvial floodplains	Minor, 24.3 ha
	1d	Lascelles	Deep duplex soils with sandy A horizons and sodic, poorly drained clay subsoils on alluvial floodplains	Minor, 17.4 ha
Derived from Tertiary basalt (Tb) sheets	2a	Orion	Self-mulching, deep (> 60 cm depth) clay soils with surface stone	Widespread, 178.0 ha
	2b	Jimbaroo	Self-mulching, shallow (<60 cm depth) clay soils with surface stone	Widespread, 279.1 ha
Derived from older Emerald Eocene (Te,w) reworked sediment	3a	Picardy	Crusting to coarse self-mulching, deep grey clay soils formed on highly weathered sediments	Widespread, 530.2 ha
	3b	Springton	Deep red clay soils with calcareous subsoil on gently undulating plains and rises	Minor, 9.8 ha

The soil mapping completed by MWH (2011) and the associated soil types have been used in the pre- and post-disturbance soil erosion modelling (see Section 3.3.6). The soil erodibility (‘K’ Factor) values for the RUSLE2 erosion prediction model have been derived for these soil types through a study by Titmarsh (2018).

3.3.3 Soil erodibility

The soil erodibility ‘K’ factor (for the RUSLE2 model) is a measure of the susceptibility of soil to erosion and is defined as the rate of soil loss per erosion index unit as measured on a unit plot maintained under continuous bare fallow. Given the time-consuming nature of determining erodibility strictly in accordance with this definition, estimation methods using soil attributes including particle size distribution, organic matter content and density of eroded soil have been developed. The specific basis of calculation of the ‘K’ factor has been based on a footnote to the definition of soil erodibility within RIDA RPI16/002/RIO TINTO (applicable to adjoining areas within ML70481), and which states:

> *The soil erodibility 'K' Factor of the RUSLE is defined as the rate of soil loss per erosion index (EI30) unit, for a specified soil as measured on the unit plot. It intends to represent the long-term susceptibility of different soil to erosion due to inherent soil properties. The unit of the 'K' Factor is t/ha/h per ha/MJ/mm.*
>
> *The original basis of the calculation was the soil erodibility nomograph of Wischmeier and Smith (1978), which estimates K from surface soil structure, organic carbon content and particle size distribution, and profile permeability. Wischmeier and Smith's M parameter (the particle size parameter) should be replaced by the method of Lu et al (2003) which accounts for the use of fully dispersed particle size data. The resultant K value is then adjusted using the wet sediment density adjustment equation of Loch and Rosewell (1992).*

References:

Loch RJ and Rosewell CJ (1992). Laboratory methods for measurement of soil erodibility (K factors) for the Universal Soil Loss Equation. Australian Journal of Soil Research, 30, 233-248.

Lu H, Prosser IP, Moran CJ, Gallant JC, Priestley G and Stevenson JG (2003). Predicting sheetwash and rill erosion over the Australian continent. Australian Journal of Soil Research, 41, 1037-1062.

Wischmeier WH and Smith DD (1978). Predicting rainfall erosion losses - a guide to conservation planning. Agriculture Handbook No. 537. United States Department of Agriculture, Washington DC.

To meet this definition, a determination of RUSLE2 soil erodibility 'K' factors for all of the soils of ML70481 was undertaken in November 2018 (Titmarsh 2018). Titmarsh used the methodology developed by Loch and Rosewell (1992), and subsequently enhanced by Loch and Rosewell (1992) and others, as nominated by the basis of calculation cited above. It should be noted that, given the application of the RUSLE2 to hillslope sheet and rill erosion, soils with similar surface properties as identified by soils studies across ML70481 (MWH 2002 and 2011) have been aggregated and riparian soils excluded, with sampling and analysis being restricted to ML70481 soils classified as SCL.

Section 3.3.3 provides the erodibility 'K' factors for the relevant ML 70481 soils as per Titmarsh (2018). The soil types refer to those of EMM (2012), which are presented in Figure 6.

Titmarsh (2018) notes that soil erodibilities across ML70481 are similar, but that this is not unexpected considering the soils and their parent material. Erodibilities compare well with published values for similar soils (e.g. Silburn 2011). The soil type most likely to require greater management is CStc, given that the subsoils of Sodosols are highly erodible. Here the 'stable' topsoil is required to be maintained (having a 'K' factor similar to the other soils) so as not to leave the subsoil exposed.

Zund (2017) provides the most recent broadscale mapping of inherent soil erodibility however, the method used is not equivalent to the USLE K-factor derivation, but is a classification that describes a surface soil's stability or resistance to erosion. The scale of the dataset (1:250,000) is such that it is only reliable down to a sub-catchment level. The dataset suggests that all soils in the ML70481 area are categorised as being "moderately stable surface soils".

Table 6: Derived soil RUSLE2 'K' Factors

Soil Type	Soil Erodibility 'K' factor ((t.ha.h)/(ha.MJ.mm))
A – Alluvium; Grey or Black Vertosols	0.039
Afs – Alluvium; Fine sandy or silty surfaced Black, Brown or Grey Vertosols and Dermosols	0.037
B – Basalt; Black, Brown and Grey Vertosols >0.6 m deep	0.034
Bs – Black, Brown and Grey Vertosols <0.6 m deep	0.034
Bvs –Shallow Basalt; Black or Brown Dermosols; and Black or Brown Vertosols;	0.034
Bvsb – Very Shallow Basalt; Brown Dermosols or Brown Tenosols	0.039
C – Colluvium; Black or Grey Vertosols	0.044
Cg – Colluvium; Black or Grey Vertosols with gilgai	0.044
Cgc – Colluvium, Black and Grey Vertosols overlying mottled greenish-grey or green cracking clays	0.038
CS – Cainozoic Sediments; Grey and Black Vertosols	0.035
CStc – Texture Contrast Soils on Cainozoic Sediments; Red and Brown Sodosols and Chromosols	0.040
Krb – Read and Brown Soils on Calcareous Materials; Red and Brown Vertosols	0.036
Ks – Shallow Calcareous; Brown Dermosols and Tenosols	0.038

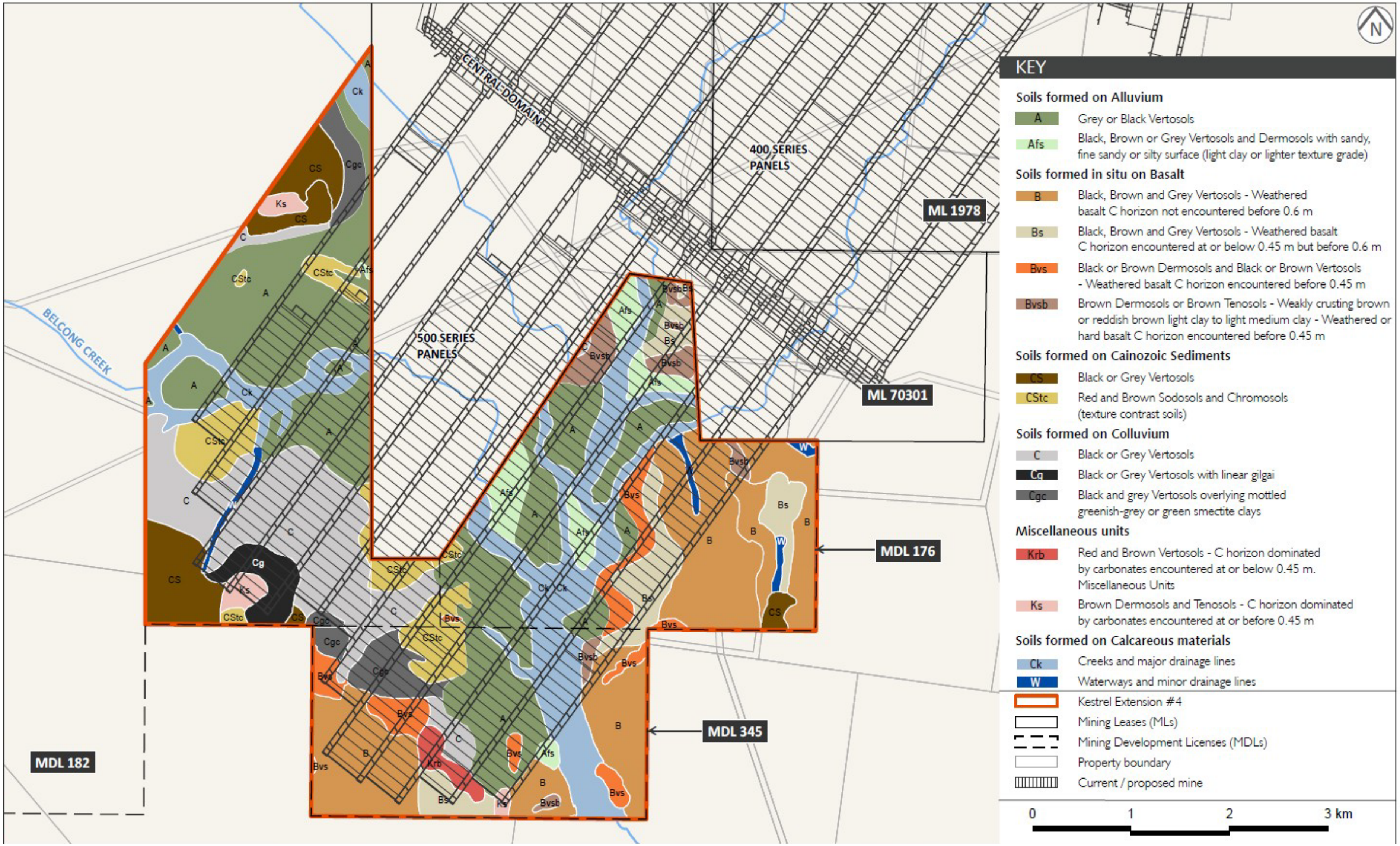


Figure 7: Soils of ML70481 (after EMM 2012)

3.3.4 Pre-disturbance erosion and land degradation

Soil erosion can be defined as the natural or accelerated removal or deposition of soil to the effect of being detrimental to agricultural, pastoral, or forestry activities, or public or private structures, works or infrastructure. Soil erosion can cause a reduction in agricultural productivity as well as off-site impacts including a contribution of sediments and nutrients to streams and estuaries; and in the case of the Fitzroy catchment, to the Great Barrier Reef. The rate of soil erosion for a given area is dependent on soil properties, surface condition (vegetative or other cover condition), slope, slope length, and local climate conditions.

The 2002 soil and land capability study (MWH 2002) identified the predominant land use as winter crop production using organic farming techniques. At that time, the bulk of the area was owned by United Plantations (Australia) Pty Ltd, with some parts of ML 70481 being cropped in a similar manner. An assessment of aerial imagery indicates that, in 1983, approximately 100 ha (4%) of ML70481 was subject to cropping; this area increasing to just over 500 ha (21%) in 2004. The management practices involved weed control through frequent cultivation, rather than herbicides. The 2002 study (MWH 2002) noted appreciable land degradation over much of the area, principally through soil erosion and the development of cultivation-associated hardpans.

The 2002 study (MWH 2002) found erosion risk over large parts of the area was related to long slope lengths and the strongly self-mulching characteristics of the clay soils over most of the area. This self-mulching behaviour produces fine aggregates at the soil surface, which can be readily detached and transported by water. Significant erosion on sloping lands was visible on aerial photographs from 1992, as well as erosion of riparian areas resulting from the 1996 wet season. Erosion risk was considered to have been aggravated due to the then regime of frequent cultivation resulting in:

- hardpans across the cultivated area restricting water infiltration and hastening water runoff;
- fine, transportable aggregates in the plough layer as a result of high cultivation effort;
- periodic absence of surface cover and a consequent reduction in protection from raindrop impacts and impeded runoff; and
- degradation of contour banks and waterways as a result of high cultivation rates.

Where land was under pasture, minimal erosion was noted, even within subsided areas of ML1978. In 2008, following a significant reduction in cropping land use, visible evidence of active erosion was reported as being almost absent (MWH 2008). Rilled areas observed in 2002 had stabilised, and were noted as carrying perennial pasture species, principally butterfly pea (*Clitoria ternatea*), Sorghum and grasses. Some depressions along previously identified rill lines were stable and supporting good vegetative cover (MWH 2008).

In 2011, (MWH) noted land use comprising cattle grazing based on the browse shrub Leucaena (*Leucaena leucephala*) with associated grasses, butterfly pea (*Clitoria ternatea*), Sorghum with associated grasses, perennial Sorghum (*Sorghum spp.*) and native and naturalised grasses. The 2011 study found no evidence of active soil erosion over the Extension #4 study area but noted minor erosion at stock water points and some downslope vehicle tracks.

In 2019, an assessment of erosion based on detailed aerial imagery found no visible signs of erosion. Some drainage depressions were identified and ground truthed, with retained moisture impacting vegetation growth, and vehicular and cattle tracks.

3.3.5 Pre-disturbance soil conservation works

Since 1992, the majority of the Kestrel ML areas have been subject to detailed assessments by various government authorities. Where cropping activities were being undertaken, property plans were developed. Four draft non-statutory plans exist over ML70481, while a single property plan (SC204399) overlays a very small part of the eastern boundary of ML70481. The only soil conservation structures existing on ML70481 are those associated with SC204399, (predominantly contour banks and waterways) and are assumed to have been constructed in accordance with that approved property plan. Design parameters were provided as part of the approved property plans. Early subsidence restoration practices at Kestrel re-instated these structures, but given the reversion to pastoral activities, current restoration practice is to remove these prior to subsidence occurring and revegetate and stabilise the land surface.

The following points provide a summarised history of soil conservation works:

- During 1985 to 1986, all of the Gordon Downs property, then owned by United Plantations (Aust) Pty Ltd, was assessed and mapped by the then Queensland Department of Primary Industries Soil Conservation Services Branch, identifying land suitability classes and proposing soil conservation structures including waterways, contour banks, diversion banks and with design points identified. These are recorded as non-statutory plans.
- In 2004, a property plan (SC204399) was produced in accordance with the *Soil Conservation Act 1986* (SC Act), providing designs for soil conservation works on Lot 31 on RP615385 located immediately adjacent to the eastern boundary of ML70481 and slightly overlapping ML70481. This plan was provided by the then Department of Natural Resources Mines and Energy (DNRME) along with contour bank and waterway specifications.

As previously noted, while only a small percentage of ML70481 was cropped prior to mining, there has been a shift in land use away from most cropping activities to pastoral activities. Consequently, restoration practices have been aligned to a grazing land use such that re-instatement of soil conservation works is not required. Regardless, any change in land use to cropping would trigger an assessment of the requirement for any soil conservation works.

3.3.6 Pre- and post-disturbance rates of soil erosion

3.3.6.1 Soil erosion rates assessment

The RIDA requires an estimate of the likely pre-disturbance rates of soil erosion across the applicable soil units of ML70481. Pre- and post-disturbance erosion rates have been estimated using the Revised Universal Soil Loss Equation v2 (RUSLE2); a method used to estimate average annual soil loss caused by hillslope and rill erosion. The equation is limited to making predictions for long-term annual soil loss. The equation is:

$$A = R \; x \; K \; x \; LS \; x \; C \; x \; P$$

Where:

- **A** is the predicted annual average rate of soil loss by surface and rill erosion in t/ha/year;
- R is the rainfall erosivity factor based on the total erosive power of storms during an average year and is dependent on local weather conditions;
- **K** is the soil erodibility factor, specifically derived for the ML70481 area as described in Section 3.3.3;
- **LS** is the slope length and gradient factor, specifically the distance between the point of commencement of water runoff on the land and the point of sediment deposition or the point where runoff enters a well-defined channel, and the effect of slope steepness on erosion;
- **C** is referred to as the cover and management factor which compares cropping practices, residue management, and soil cover to a standard clean fallow plot. C-factors for different agricultural uses and management practices are developed based on their observed deviation from the standard clean fallow plot; and
- **P** is the conservation or support practice factor and reflects the impact of support practices on the average annual erosion rate. It reflects the ratio of soil loss with contouring and/or strip cropping to that with straight row farming up-and-down slope.

3.3.6.2 Climate Parameters

A climate model for ML70481 was constructed using SILO data (Queensland Government n.d.), the Bureau of Meteorology Design Rainfall Data System, and erosion density values sourced from Australian climate profiles contained in RUSLE2. The erosivity distribution for the climate model was estimated from monthly erosion density values (ratio of SI units), average temperature (°C) and precipitation (m). Surface water runoff was also calculated in the model using 10-year, 24-hour rainfall event precipitation data (m) sourced from the Bureau of Meteorology Design Rainfall Data System. The values used in producing the climate model are shown in Table 1 in Appendix A.

3.3.6.3 Soil Parameters

Soil parameters are estimated by the following inputs:

- Soil erodibility (‘K’ factor);
- Clay fraction (<0.002 mm) (%);
- Silt fraction (0.002-0.05 mm) (%); and
- Sand fraction (0.05-2 mm) (%).

Derivation of the soil erodibility or K-factor is discussed at Section 3.3.3 while the derivation of the other input factors is from the soil assessment reporting by MWH (2011).

3.3.6.4 LS factor derivation

Slope profiles for the gradient and slope length segments of ‘slope complexity’ in RUSLE2 were constructed from pre- and post-disturbance DEMs. Slope profiles were selected down the dominant slope for a map unit of each relevant soil type covering the revised longwall 500-series mine plan. L and S factors were determined through the RUSLE2 model. Each soil map unit was chosen as a major representative of the soil type over the longwall panels and the slope profiles were taken as the steepest slope sections for either the pre-disturbance or post-disturbance topography, providing a worst-case erosion loss.

3.3.6.5 C and P factor derivation

Vegetation management was kept consistent across pre- and post-disturbance landforms, with the default RUSLE2 management “range grass” of the “long term vegetation” category selected for all slopes. It should be noted that while RUSLE2 also supports, and was originally designed for, cropland vegetation management, such vegetation parameters are not appropriate given the final land use. Cropland vegetation management in RUSLE2 relates primarily to annual cropping rotations, compared to the perennial nature of grazing. As such, incorporating a cropland vegetation management simulation would not be representative of the current or proposed 500-series post-mining land use.

3.3.6.6 Calculated rates of pre-and post-disturbance soil erosion using RUSLE2

Predicted soil loss rates for pre-and post-disturbance topography have been derived by applying the factors identified above to the RUSLE2 model across all 12 of the soil types that are relevant to the revised longwall 500-series mine plan. The slope profiles have been selected as being among the steepest (complex slope) gradients represented within each soil type map unit. It must be noted that the soil map unit boundaries are only approximate and do not directly correlate with the contour map of the extant topography (as they would on the ground), while the contour map of the post-disturbance scenario is based on mine subsidence predictions considered to be accurate. As discussed in Section 4.2.1 slope gradient changes post-disturbance do not go beyond ±2% with few absolute slope gradient increases to over 3%.

Soil loss estimates for the soil types within ML70481 covering the longwall 500-series panels are provided in Table 7 along with the calculated difference between pre-and post-disturbance soil loss predictions. The estimated pre-disturbance soil loss ranges from 1.3 to 13 t/ha/year with an average of 5.03 t/ha/year and estimated post-disturbance soil loss ranges from 2.4 to 16 t/ha/year with an average of 6.75 t/ha/year.

It can be seen from Table 7 that both these ranges include two soil/slope profiles (Bvsb and Krb) that have significantly higher values, of over 10 t/ha/yr, than the rest. The Bvsb soil/slope profile is a very shallow, comparatively erodible soil on a short, steep, stony slope and not mapped as SCL. The slope profile for this soil unit lessens in gradient but is less complex in the post-disturbance scenario. The Krb soil/slope profile is similarly short and steep within a small map unit (< 20 ha) and having a less complex, straighter slope but with the same average gradient in the post-disturbance topography. These soils/slopes would be expected to have high erosion rates compared to the rest of those assessed and can be considered as both uncommon and as 'risk zones'.

Without these two higher than average soil loss values, the estimated pre-disturbance soil loss ranges from 1.3 to 8.1 t/ha/year with an average of 3.76 t/ha/year while the estimated post-disturbance soil loss ranges from 2.4 to 9.0 t/ha/year with an average of 5.25 t/ha/year (refer Table 7). It should be noted that the derivation of these post-disturbance soil loss values is based on using worst case LS factors (refer Section 3.3.6.4) which have then been applied to the whole soil map unit. Consequently, the soil loss rates determined are unlikely to result in practice and will be further mediated by those areas within the soil map unit where slopes have decreased as a result of subsidence.

Erosion rates within this range are classed as 'medium', with 61% of Australia experiencing erosion within this range (Lu et al. 2001). When considering the 'low' erosion rate suggested by Lu et al. (2001), such a rate is established based on an undisturbed soil formation rate of 0.5 t/ha/year.

Considering grazing land specifically, a target erosion rate of 4.5-5 t/ha/year has been suggested as acceptable for such a land use (Landloch 2013; Howard and Loch 2019; McCormack et al. 1982; Rollins 1981).

An initial assessment of these soil erosion rates is considered best guided by Lu *et al.* (2001) and Roswell (1996), which have attempted to quantify erosion rates across Australia. Against an average Australian erosion rate of 6.3 t/ha/year, the study suggested that:

- a low rate of erosion could be defined as less than 0.5 t/ha/year; and
- a high erosion rate could be defined as greater than 10 t/ha/year.

Erosion rates for ML70481, would be categorised as moderate to low for both pre- and post-disturbance scenarios by this measure, without the two exceptional soil/slope profiles, and well below the average Australian erosion soil loss rate. Coupled with the soil erodibility data provided at Section 3.3.3 the erosion risk for the ML70481 area at Kestrel would be classified as moderately low in both scenarios.

It should be noted that none of the post-mining slope changes are sufficiently large or complex as to preclude the consideration and implementation of a contour bank conservation plan, with no out-of-the-ordinary requirements, should cropping/cultivation be considered in the future for post-mining land use (refer also Section 5.2.1).

Table 7: Pre- and post-disturbance predicted soil loss for each soil type slope profile

SMU	Soil Loss Pre-disturbance (t/ha/yr)	Soil Loss Post-disturbance (t/ha/yr)	Difference
A – Alluvium; Grey or Black Vertosols	1.3	2.8	1.5
Afs – Alluvium; Fine sandy or silty surfaced Black, Brown or Grey Vertosols and Dermosols	2.2	2.4	0.2
B – Basalt; Black, Brown and Grey Vertosols >0.6 m deep	4.1	5.1	1
Bs – Black, Brown and Grey Vertosols <0.6 m deep	4.1	5.4	1.3
Bvs –Shallow Basalt; Black or Brown Dermosols; and Black or Brown Vertosols	8.1	9	0.9
Bvsb – Very Shallow Basalt; Brown Dermosols or Brown Tenosols	13	16	3
C – Colluvium; Black or Grey Vertosols	1.4	4.1	2.7
Cg – Colluvium; Black or Grey Vertosols with gilgai	4.3	6.1	1.8
Cgc – Colluvium, Black and Grey Vertosols overlying mottled greenish- grey or green cracking clays	5.3	4.8	-0.5
CStc – Texture Contrast Soils on Cainozoic Sediments; Red and Brown Sodosols and Chromosols	5.1	6.8	1.7
Krb – Red and Brown Vertosols on Calcareous Materials	11	14	3
Ks – Shallow Calcareous; Brown Dermosols and Tenosols	4.8	6.1	1.3
Average	**5.03**	**6.75**	**1.72**
Average without Bvsb and Krb	**3.76**	**5.25**	**1.49**

4 Impacts from land disturbance activities

4.1 Background

For the purposes of this SCP, activities at Kestrel having the potential to cause land disturbance include:

- surface subsidence arising from underground longwall panel progression;
- disturbance associated with surface infrastructure development and operation; and
- non-resource activity related land management activities.

4.2 Longwall panel subsidence impacts

Within the 500-series panels, metallurgical coal is extracted from the German Creek Seam via longwall retreat mining methods. Depth of cover ranges from approximately 220 m in longwall panel LW510a up to 470 m in the central part of longwall panel LW500. Typical mining seam thickness ranges between 2.3–3.1 m with the longwall minimum extraction height being 2.4 m. Development mining activities commenced in November 2021 with longwall extraction planned to commence in late November2023.

The principal land disturbance impact associated with underground mining activities at Kestrel is subsidence arising as longwall panels progressively extract the coal seam. The extent of subsidence impacts is defined by the underground mining footprint, depth of the coal seam and the angle of draw to the surface. Subsidence predictions have been undertaken for all Kestrel longwall panel series out to completion of the 500-series and have been updated as and when mine planning changes occur. Subsidence monitoring of prior longwall panels is used to verify the relative accuracy of subsidence predictions as well as informing subsequent subsidence predictions. Data referred to in this SCP is taken from the most recent update for panels LW500 to LW510 (MSEC 2022).

Subsidence predictions for the 500-series have been undertaken by Mine Subsidence Engineering Consultants (MSEC 2022) using the Incremental Profile Method developed by Waddington and Kay (1995); being an empirical method used to predict subsidence, tilts, curvatures and strains likely to be experienced as longwall mining occurs and to assess the effects of mining on surface infrastructure.

A detailed description of the standard Incremental Profile Method is provided in background reports that can be found at www.minesubsidence.com. The prediction profiles are revised from time to time as more observed subsidence data is collected and can be calibrated to local conditions based on local monitoring data. The Incremental Profile Method has been reviewed and has been found acceptable in a number of Commissions of Inquiry, including those for the Dendrobium Mine and Tahmoor Colliery in the Southern Coalfield and the Cooronbong Life Extension Project in the Newcastle Coalfield. The method has also been reviewed and accepted many times in Development and Subsidence Management Plan Applications in New South Wales.

The Incremental Profile Method has been tested for Kestrel Mine at the time of each subsidence prediction by comparing predicted and ground surveyed movements during the mining of the 400-series of longwalls. For predictions undertaken in 2022, monitoring data from Longwalls 401–409 has been used for calibration of the model. The locations of the monitoring lines are shown in Figure 8.

Maximum vertical subsidence over the 500-series longwall panels is predicted to range from between 1.6–2.3 m mid-panel to 0.1–0.3 m over longwall inter-panel pillars. Longwall panel widths are either 396 m (LW500) or 424 m. Maximum slopes arising from subsidence typically occur within 100–150 m of the panel edge. As a conservative comparison, measured maximum slopes from the adjacent 400-series panels are approximately 1.5–2% (or approximately 1°). In accordance with the definitions provided in *RPI Act Statutory Guideline 11/16 – Companion Guide* (DSDMIP 2019b), and as potential impacts are confined to the application area, they are considered to be only of a property-scale; in other words, no SCA impacts occur at a regional scale.

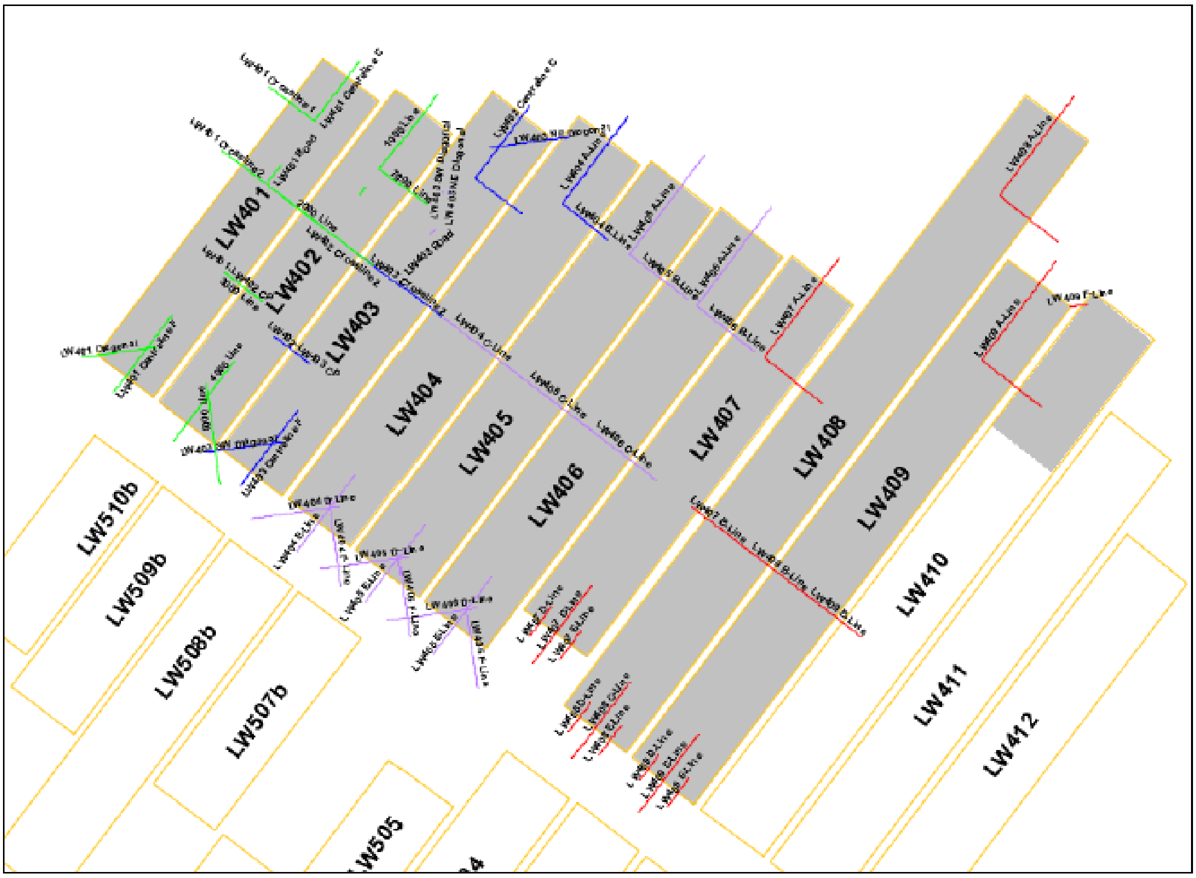


Figure 8: Locations of Kestrel Mine survey monitoring lines

Timing of subsidence at Kestrel is well understood from subsidence monitoring undertaken across the prior series longwall footprints. Monitoring indicates that at mining rates of 80–100 m per week, the majority of the subsidence on the surface occurs about 300 m behind the mining face with minor residual subsidence (subsoil settlement) of approximately 20–30 mm thereafter. At these rates of longwall retreat, 97% of maximum subsidence is achieved between four and six weeks of the longwall face retreating past any given point on the surface.

The slopes and troughs formed as a result of subsidence are subtle and not easily distinguishable from the surrounding topography, as the range of movement associated with subsidence is well within the range of natural elevation variation. In other words, the topography of subsided areas is not inconsistent with the surrounding un-subsided topography (i.e. gently rolling country with low relief).

Potential land impacts associated with subsidence include localised changes in slope, surface tensile cracking, and changed drainage systems including, in some areas, localised ponding. Where waterways traverse subsidence areas, localised longitudinal slope increases and waterway re-alignment may occur. These impacts are discussed in the following subsections.

4.2.1 Subsidence-induced erosion impacts

With respect to slope change impacts to SCL, an assessment by AARC (2022) indicated that pre-mining, 69 ha of trigger-mapped SCL within ML70481 exceeded the 3% slope criterion for SCL within the Western Cropping Zone (within which Kestrel is located), refer Figure 9 (and, incidentally, should therefore not be SCL). The assessment identified 26.1 ha where, post-mining, slope had increased to greater than 3% as a consequence of subsidence. In other terms, approximately 1.5% of the 1,747 ha of trigger-mapped SCL within ML70481 would be impacted to the point of failing the SCL slope criteria test as a consequence of slope change (refer Figure 10).

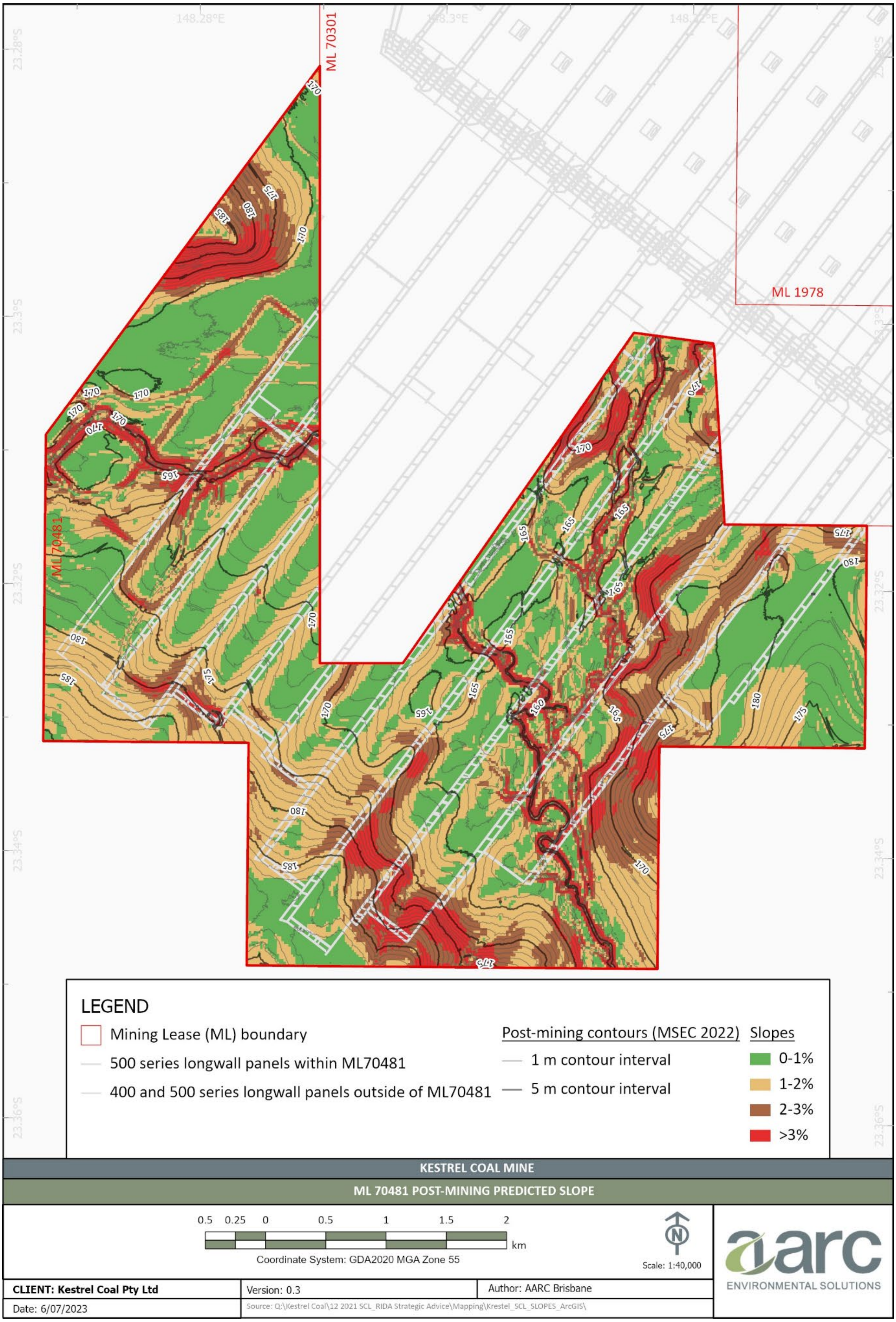


Figure 9: Inferred slope gradient classes post-mining (MSEC [2022] predicted subsidence DEM)

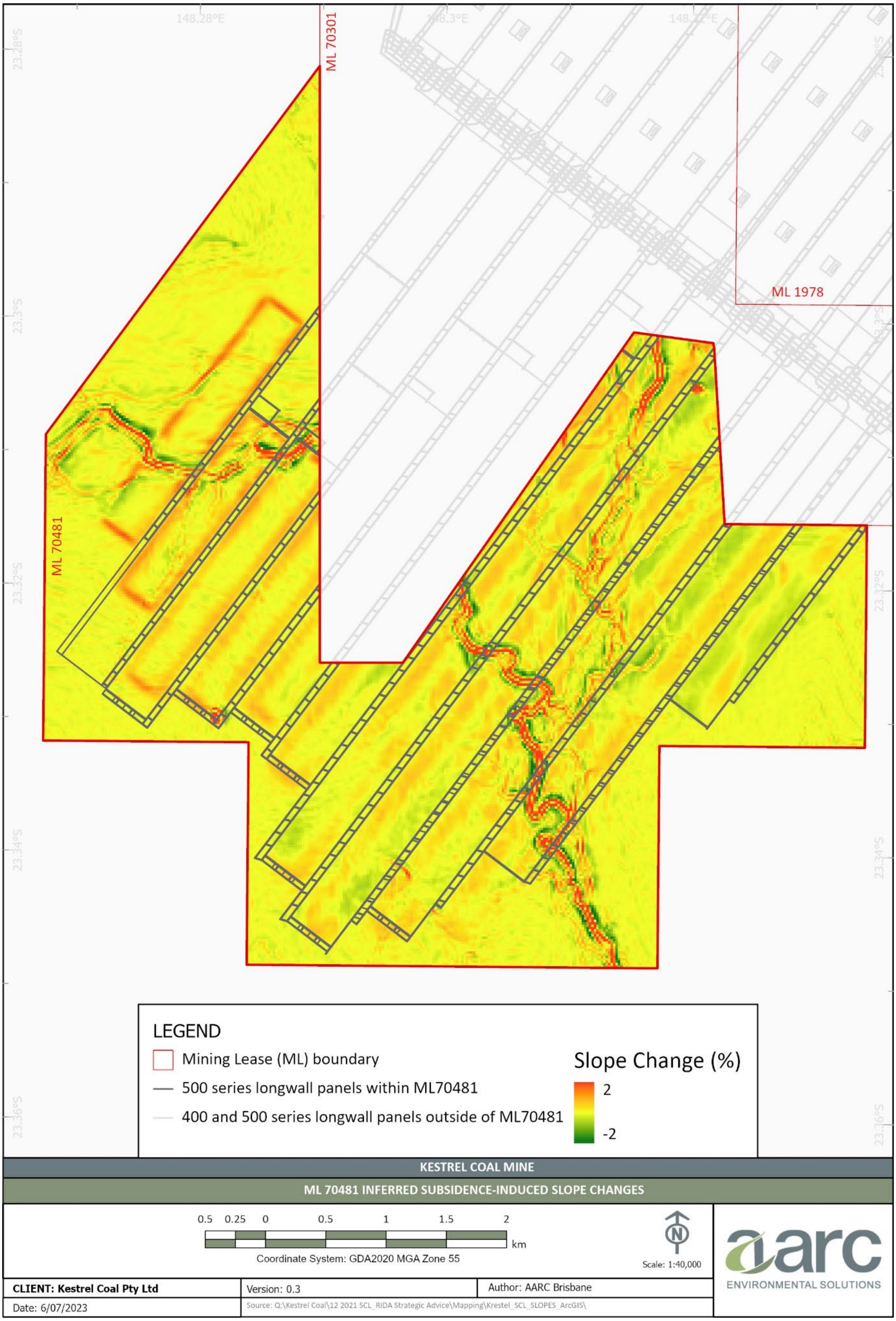


Figure 10: Inferred subsidence-induced slope changes between +2% and -2%

Erosion impacting both land and/or watercourses is a potential outcome from subsidence induced increases in slope. The soil types located within the MLs are predominantly well-structured, high shrink-swell clays throughout their profile with low erodibility (K factor) and calculated low rates of soil loss. Site experience and subsidence monitoring observations to date reinforce the current understanding that these soils are resilient to movement and, at the low, comparatively short slopes present in ML70481, under the current grazing land use, have demonstrated low rates of erosion (refer Section 3.3.6).

Despite the favourable inherent characteristics of the soils, increases in localised erosion rates occurring post-disturbance is still a risk that requires monitoring and that may, in some cases require remediation. Certain surface landforms that are naturally more prone to erosion, for example watercourses and steeper slopes, and soils of known higher erodibility, may require additional attention. Management measures are outlined in Section 5.2.1.

While the whole of the subsidence impacted area will be observed and monitored during and after longwall panel progress, the slopes predicted to change by up to ±2% (refer Figure 10) will be a particular focus of post-mining monitoring activities to ensure any resultant erosion is addressed as outlined in Section 5.2.1.

It should be noted that, at the time of drafting this SCP revision, a subsidence prediction that incorporated the minor extensions to panels LW503 to LW509 was not available. Figure 10 provides the slope changes for a partially revised mine plan including the LW500 panel. It should also be noted that subsidence associated with LW510 is shown even though this panel is now proposed to be excluded from the RIDA. The omission of the LW503 to LW509 panel extension areas does not change the disturbance but simply displaces the subsidence disturbance to the west. The slope impacts associated with the panel extensions are not expected to differ significantly from those associated with the panels shown on the original RIDA. Panels LW507 and LW508 however, will now commence within slightly steeper pre-disturbance slopes falling to the north. There is some potential for these southern panel ends to exceed the 3% criterion associated with the Western Cropping Zone post-disturbance. However, these areas are expected not to exceed one (1) ha in size.

4.2.2 Subsidence-induced hydrological impacts

Kestrel is located in the upper to mid reaches of the Crinum Creek catchment and is drained by a number of small ephemeral gullies and tributaries of Crinum, Belcong and Homestead Creeks. Gilbert and Associates have been undertaking regular stream condition surveys across the whole of the Kestrel ML areas using an Index of Diversion Condition method since 2003 which provides an historic record of watercourse condition pre-mining and impact post-subsidence.

It must be noted here that watercourses and riparian zones are not mapped as SCL as presented in the SCL Trigger Map (refer to Figure 2). Therefore, any impact to creeks and waterways with associated riparian zones defined by the SCL Trigger Map are not within SCL and thus are not relevant to the RIDA conditions.

The observed impacts to overland flow and watercourses arising from subsidence related to earlier longwall panels have included:

- Localised re-direction of overland flow and changes to minor drainage paths, disruption to remnant contour banks, localised changes to runoff patterns and creation of surface ponding areas.
- Changes to flood prone areas in the flood plains of major drainage lines (e.g. Crinum Creek).
- Changes to the longitudinal slopes of watercourses. Where watercourses lie generally perpendicular to the panel direction, potential exists for ponding to occur immediately upstream of an inter-panel pillar, with increased potential for scouring immediately downstream of an inter-panel pillar due to localised increases in slope. This can have subsequent impacts on the sediment transport regime and geomorphological stability of a watercourse; in turn affecting the movement of bed/bank sediment and creek channel stability. It should be noted though that the overall longitudinal slope of the watercourse will not change.

Minor depressions may occur in areas of flatter topography and which are isolated from the mainstream channels during low flows. These depressions may retain localised rainfall runoff and form ponds following rainfall events. Ponded areas may partially waterlog soils during summer events of high rainfall, but this is likely to be temporary where there is no gilgai; and is less likely during the rest of the year when rainfall is typically low.

Predictions of subsidence changes on the existing topography provide an indication of areas where ponding may occur for ML70481, refer Figure 11. This clearly indicates that no ponding is predicted to occur in response to resource activities associated with LW500, or the panel extensions proposed for LW503–LW509. It should be noted that all of the predicted areas of ponding occur on the Grey or Black Vertosols formed on alluvia located within the floodplain of Belcong Creek and Crinum Creek. Any ponding on these Black Vertosols is deemed to be temporary (EMM 2014).

The specific location of ponded areas, soil drainage characteristics, and depth of ponding are factors influencing the duration and extent of ponding. Proposed management measures are outlined in Section 5.2.1. While changes to local drainage patterns are anticipated, they are predicted to be limited to minor realignment of first order drainage lines.

Changes to local drainages are likely limited to minor realignment of first order drainage lines and there are not likely to be any significant ponds created outside the floodplain as a result of subsidence. The loss of water through evaporation and infiltration will still dominate the hydrological processes over time (EMM 2014).

4.2.3 Subsidence-induced surface cracking

It is recognised that surface tension cracks may occur as a result of longwall panel subsidence from underground mining. The specific extent and potential impact of surface tension cracks at Kestrel Mine is naturally mitigated by a range of operational parameters and existing environmental conditions.

The majority of the Kestrel MLs are dominated by Vertosols, as all but the Lascelles Soil Landscape are mapped as cracking clay soils (Highlands Environmental 2022), which are characterised as expansive clay-rich soils with a high shrink-swell potential that change volume with changes in soil water content. The nature of these expansive cracking clays is such that, typically over one to two seasons, natural soil movement will compensate for any subsidence-induced cracking, resulting in no measurable impact on the soil.

The cracking clay soils naturally open, crack and shrink when dry, with the cracks then closing when wet as part of the soils inherent characteristics of pedoturbation. Thus, though cracks may result when subsidence first occurs, this natural characteristic of pedoturbation has been observed to lead to crack closure over one or two seasonal wetting and drying cycles.

Observations have demonstrated that, in many cases, tension cracks open as a function of the longwall panel face passing, closing up again as the panel progresses. Tension cracks are more likely to remain along the line of the inter-panel pillars and at the ends of each longwall panel. Hinchcliffe et al. (2002) state that 'obvious visual effects of a subsidence event are sometimes seen as surface tension cracks. Cracks may open up when the mining of the coal face is nearby and may close up once the face has moved on, yet some cracks may remain, especially along the edges of the panel'.

Tension cracks have been observed over the earlier 300-series longwall panels in areas with Vertosols. These areas were monitored and observed to either self-heal or were able to be restored by cross-ripping with scarifiers. It should be noted that the 300 panels were mined at 100 m to 280 m depth, and therefore the surface expression of subsidence was greater than is expected in the deeper 500-series panels.

Subsidence monitoring was undertaken at Kestrel in August 2008 as part of ACARP project C15013 (Frazier et al 2010), designed to quantify the impacts of mine subsidence on the production and quality of agricultural vegetated environments. Monitoring was undertaken above longwall panels 301 to 305, comparing pillars, transition areas and areas of maximum subsidence within the panels. The research program employed a variety of traditional ground-based sampling techniques including biomass harvests and techniques, Leaf Area Index, pasture height, species composition and soil sampling along with proximal sensor data capture using a proximal crop reflectance sensor. Satellite imagery was also collected, and the high-resolution imagery used to monitor large areas of subsidence-affected areas and adjacent unmined land. A forage Sorghum site and an improved pasture were monitored. The outcomes of the research concluded there was no variance between subsided and unmined areas with respect to soil physical and chemical characteristics.

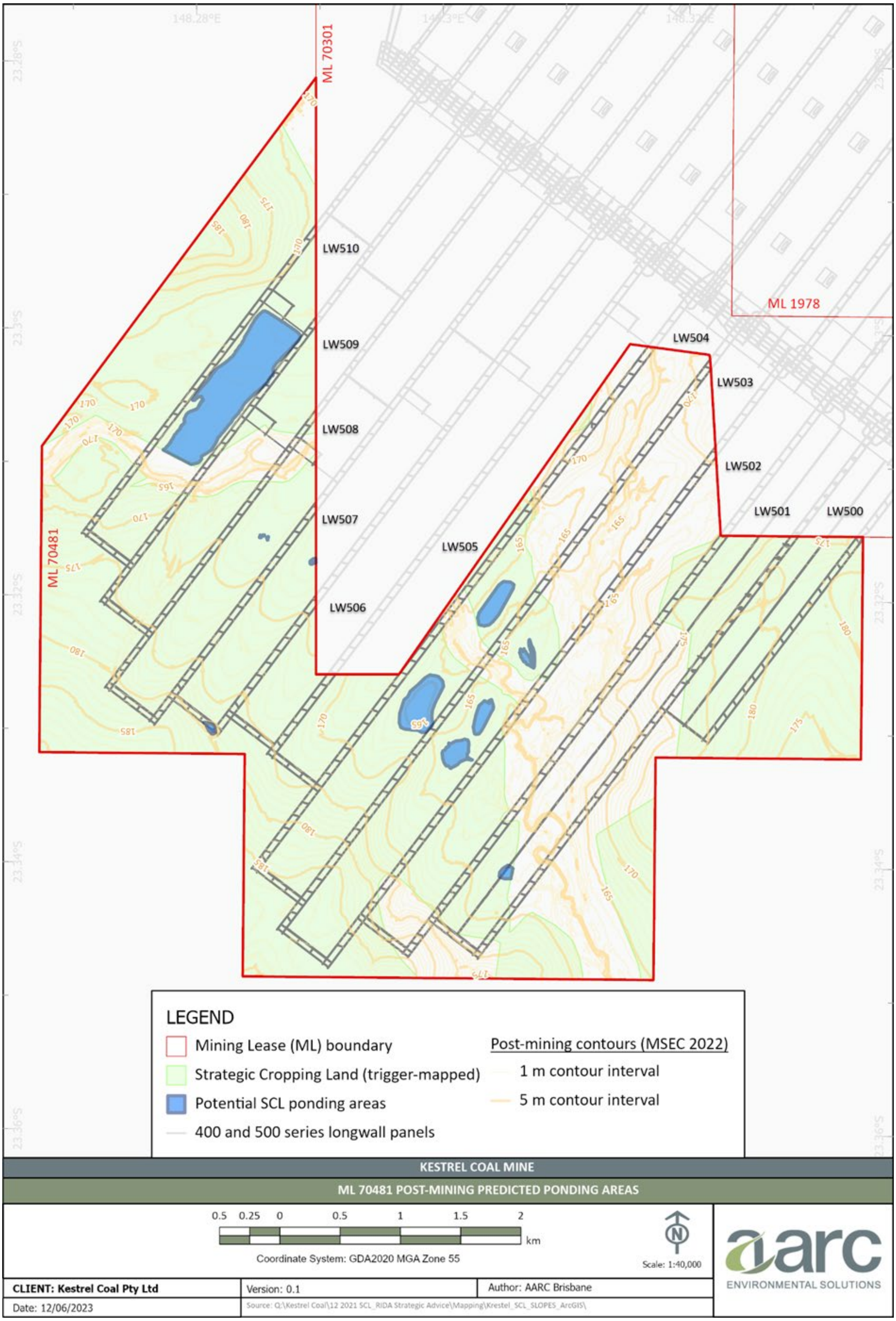


Figure 11: Inferred ponding subsequent to subsidence (revised mine plan incl. LW510)

Over 90% by area of the soils contained within ML70481 are Vertosols having a low risk of long-term impact from subsidence-induced surface cracking. The remainder will be subject to management measures as described in Section 5.1.1.

4.3 Supporting surface infrastructure

Underground mining operations at Kestrel are supported by a range of surface-located services and infrastructure including:

- Exploration and pre-production drilling infrastructure including gas drainage and dewatering works. Pre-production dewatering and gas drainage occurs via wells drilled to intersect the working coal seam to ensure safe operating conditions during mining. Associated surface works consist of vertical wells drilled along each longwall panel alignment, and connected via a pipeline, gas pump and flare unit. Disturbance is surficial and limited to that area required for drill rigs and ancillary equipment as well as interconnecting pipelines and access tracks.
- A personal emergency device (PED) surface line is required to be installed along the line of each longwall panel.
- Portal, coal handling infrastructure (coal stockpiles, conveyors, overland conveyor, bins etc.), CHPP, co-disposal facility, vent shafts and ancillary equipment (generators and access tracks), surface to underground mine services boreholes, and environmental monitoring equipment.
- Workshops, administration offices, access roads, and warehousing facilities; and
- Water management infrastructure including a mine affected water dam, a raw water dam, a rejects return water dam, a holding dam and an environmental dam; various watercourse diversions along with associated pipework, access tracks and control infrastructure.

ML70481 will only be impacted by the following infrastructure types:

- Exploration and pre-production drilling including gas drainage and dewatering works, along with associated surface works consisting of vertical wells and connected via a pipeline, gas pump and flare unit.
- PED surface lines installed along the line of each longwall panel.
- Vent shafts and ancillary equipment (generators and access tracks), surface to underground mine services boreholes, and environmental monitoring equipment.

Within ML70481, surface to inseam drilling is required to de-gas some of the 500-series longwall panels that cannot be de-gassed using underground inseam de-watering/ de-gassing methods. Gas drainage activities are currently occurring within ML70481.

Surface infrastructure will remain either for the life of mine, the life of the panel series, or the life of the panel. Removal of infrastructure is undertaken once the service life of the infrastructure has passed, and the area is then subject to restoration to return the land to its former productive capacity.

Surface infrastructure development has the potential to result in localised impacts to land; most commonly soil erosion or degradation of land suitability classification as a consequence of topsoil loss or compaction. Apart from major infrastructure, most disturbance is surficial and readily able to be restored. To facilitate this, topsoil is removed and stockpiled for later restoration. In some instances, potential exists for limited and highly localised contamination through hydrocarbon use in permanent and semi-permanent equipment installations. Instances of potential contamination are identified through inspections, site reviews and spill response.

4.4 Land management activities not related to resource activities

As detailed in Section 3.2, prior to mining, regional and local land use included grazing of native and improved pastures, and cropping. In 1983 approximately 4% of ML70481 was subject to cropping activity, increasing in 1993 to approximately 13% and again in 2004 to approximately 21%. Since 2004, cropping activity has diminished such that there is not currently any cropping activity occurring in ML70481. The property is now predominantly used for grazing based on native and naturalised grasses, as well as the forage crop Leucaena (*Leucaena leucocephala*).

Where land is not required for mining purposes, the land continues to be operated as pastoral stock farming or dryland agricultural farming.

The key objective for Kestrel is to manage non-mined lands in a responsible, sustainable and contemporary manner. Kestrel currently leases all lands to a large reputable, commercial agricultural enterprise. The lease requires regular property maintenance, weed control and land improvement programs. Agricultural activities are required to be managed in accordance with land suitability and in a manner compatible with the intent of its SCL classification.

5 Management and restoration

This section describes the management and restoration measures used to address the potential impacts to land identified and described in Section 3.3 and, specifically, to address regulatory requirements of the RIDA.

It should be noted that the implementation of restoration activities is contingent on a particular potential impact actually occurring. The subsidence impacts having the potential to occur within the longwall 500-series of panels have been identified and discussed at Section 4.2, and are based on the extensive experience associated with subsidence and other impacts on previous longwall panel series, as well as subsidence prediction assessments for the 500-series. For supporting surface infrastructure disturbance on the longwall 500-series panels, the disturbance footprints and locations are well known in advance of the impact occurring.

For supporting surface infrastructure disturbance, the following general procedure for restoring land to pre-activity condition includes:

- infrastructural removal;
- surface preparation, including topsoil replacement (where required);
- revegetation activities (where required);
- ongoing monitoring of the effectiveness of restoration; and
- final assessment against restoration criteria.

For potential subsidence impacts, the following general procedure includes:

- Where an impact is identified, record the location, establish a monitoring regime, and complete an investigation to determine the cause of the impact and identify the appropriate management and/or restoration approach.
- Where an impact is identified along an established monitoring transect, note the location and complete an investigation to determine the cause of the impact and identify the appropriate management and/or restoration approach.

In addition to the restoration measures described in Section 5.2, a range of operational management measures (Section 5.1) will be implemented both to mitigate the risk of impacts occurring as well as to manage any potential downstream impacts arising (e.g. downstream sedimentation or water quality impacts).

5.1 Management measures

5.1.1 Underground mining subsidence

The following general management measures relevant to subsidence related impacts will be employed, as applicable, for ML70481:

- Subsidence prediction assessments will continue to be undertaken, at a minimum in advance of each new panel series and updated as required to align with mine planning changes or where monitoring identifies a variation from predicted subsidence behaviour.
- Pre- and post-subsidence survey monitoring will continue to be undertaken to assess and validate subsidence predictions.
- Where longwall panels pass under watercourses, and for areas where slopes are predicted to increase to greater than 3% (refer Figure 10); these areas are to be observed and monitored (refer Section 6) during and following passage of the longwall face (see Section 6.2).
- While not relevant to areas of SCL, in areas where subsidence movements are predicted to result in moderate or high risk of instability to the bed and banks of a watercourse, stock are to be excluded from the immediate bed, bank and overbank areas, as recommended by Gilbert & Associates (2012). Fencing is

to be installed where required around the identified unstable areas to restrict stock movement from these areas.

- Agricultural activities will be managed in consultation with the lessee for at least 12 months in advance of subsidence occurring to ensure that a sufficiently high level of pasture cover exists, such that erosion potential is minimised.
- Any existing agricultural soil conservation infrastructure in the path of subsidence will be removed or, if required to be retained, subject to observation and monitoring to identify any potential soil erosion or drainage risk.

5.1.2 Supporting surface infrastructure

5.1.2.1 Ground disturbance permit (GDP)

Given that underground mining does not require any vegetation clearing or surface land disturbance to allow the actual mining activity to occur, land disturbance is restricted to surface infrastructure development; which is controlled through the Kestrel Mine Ground Disturbance Permit (GDP) system (PA-SH-0065). The GDP system is designed to ensure that all statutory compliance and environmental risks are properly assessed, and that targeted management measures are developed and implemented.

The key components assessed by the GDP process include:

- Disturbance location: confirming that any proposed disturbance only occurs within the approved area, and meets any applicable permitting conditions e.g. EA conditions, RIDA conditions, EPBC conditions.
- Communication: ensuring that all relevant parties (including the agricultural lessee) are aware of the proposed disturbance and have been adequately consulted.
- Environmental aspects: ensuring that environmentally sensitive locations (e.g. watercourses) have been identified and appropriate mitigation measures instigated.
- Cultural heritage (CH) aspects: specific focus is given to ensure that appropriate cultural heritage management activities (including CH surveys, salvage of identified artefacts, protection zones around areas of high significance) are undertaken and that Clearance Notices are provided where required by the recognised Native Title applicants, the Western Kangoulu people.
- Permitting: the GDP is provided to all parties involved with the works, with all agreed locations (including maps) and management details to ensure that controls are in place, agreed and communicated to the relevant people undertaking the works.
- Operational aspects, for example:
  - ensuring that topsoil is recovered, stockpiled, and managed in accordance with site management plans; and
  - ensuring that all other relevant requirements of Kestrel's ESCPs for the 500-series are adhered to.

5.1.2.2 Topsoil management

Topsoil stripping

Topsoil must be stripped prior to any disturbance that may lead to the loss or destruction of topsoil and stored in either windrows or stockpiles. Kestrel's topsoil management conforms to the following process:

- Topsoil will be stripped to the depth determined by the site Environmental Superintendent and stated on the GDP. The depth of stripping shall be such that no subsoil is stripped.
- Machinery movement over soil should be kept to a minimum during stripping operations to avoid compaction and loss of soil structure.

For any minor surface infrastructure associated with the 500-series area, and where topsoil stripping is required for drill pads, monitoring or gas flaring bores, topsoil will be windrowed adjacent to the infrastructure area and allowed to revegetate.

Topsoil stockpiles

Topsoil stockpiles for larger scale infrastructure projects, likely to be in place for longer than 12 months, are to be located in designated areas and constructed to a shape and depth as specified by the Environmental Superintendent in the GDP and not greater than 2.5 m. Soil stockpiles should be located:

- as close as practicable and readily accessible to respreading areas;
- where they will not interfere with present and future mining and ancillary operations;
- out of the flood zone of watercourses (at least 20 m from the bank of a watercourse) and not in floodplain areas; and
- not on steeply sloping land.

Stockpiles from large infrastructure projects – greater than 1 m in height and in place for longer than 12 months – will be shaped and revegetated with a cover crop specified by the Environmental Superintendent to provide initial stability, maintain soil viability and minimise erosion.

Topsoil inventory

The Mine Surveyor will survey and record the location and volume of each stockpile, and the Environmental Superintendent shall maintain a site topsoil inventory of all surveyed topsoil stockpiles. For the minor infrastructure associated with the LW500 area, it is considered unlikely that any topsoil stockpiles will be added into the existing site topsoil inventory.

For the minor infrastructure disturbances associated with the LW500 area, windrowed topsoil will be replaced as soon as practicable after the activity has been completed.

5.1.3 Land management activities not related to resource activities

Unless lands are required for mining, Kestrel's preferred land management approach is to maintain agricultural production wherever possible as a pre-mining existing land use. Kestrel will maintain both regular and as-needed communications with the lessee concerning agricultural land performance and sustainability as part of the lease.

5.2 Restoration

5.2.1 Underground mining subsidence

Restoration of subsided land at Kestrel is undertaken where subsidence-induced geomorphological changes in the landform result in erosion, ponding or cracking that are unacceptable in extent or effect. Technical studies and experience to date have demonstrated that the majority of subsided land at Kestrel does not require extensive restoration works to be undertaken i.e. where earthworks of significant scale is required. Where active restoration is required, the objective is the return of the land to its pre-mining agricultural capability as required by the relevant conditions of the RIDA and EA.

Restoration is planned and implemented in response to any observations of adverse impact(s) arising following the passage of a longwall panel or panels.

Unless observations indicate that earlier intervention is required, land subject to subsidence is observed for a period of at least two wet seasons to ensure that:

- all expected settlement has occurred;
- immediately adjacent areas will not be subject to further subsidence;
- any potential for erosion impacts has had time to present; and
- a practical package of aggregated works can be compiled for contract administration purposes.

The restoration activities required will be contingent on soils, slopes, the land use of the impacted area, and the impact type i.e. erosion, excessive cracking, or ponding. The following restoration activities may be required either alone or sequentially as a component of a larger restoration program:

Where slope increases initiate erosion, or exacerbate erosion of degraded areas

The following restoration sequence will be used:

- Review and modify fencing as required to pre-emptively ensure stock are excluded from the area and/or manage grazing as appropriate in consultation with the agricultural lessee.
- Undertake amelioration works and/or earthworks as appropriate (e.g. reprofiling, scarifying, topsoiling).
- Revegetate the area as soon as practicable, using either traditional seeding methods or more intensive revegetation methods (e.g. hydromulching), as required.
- Monitor revegetation works and assess restoration program success.
- Plan the re-introduction of cattle and future grazing activities with the agricultural lessee.

As outlined at Section 3.3.5, some parts of the Kestrel property were historically subject to the construction of soil conservation works – predominantly contour banks – in areas where cropping activities were planned or carried out. Where these structures have been subject to subsidence, some repair or relocation of the structures would be required to maintain their capacity to function as intended. The current land use for ML70481 areas (refer Section 3.2) is grazing and forage cropping, as is specified within the EA. At this time, although the land could support limited cropping as a post-mining land use, there is no intention to revert to a cropping land use. As such, no agricultural soil conservation works are planned to be reinstated.

In the event that a cropping land use was to be implemented, recent regulatory changes require an EA application to be submitted which will trigger an assessment of requirements for soil conservation measures and works. Any required for soil conservation measures and/or works would be designed and implemented in accordance with accepted design standards. An assessment of slope gradient changes (Figure 10) indicates that there are no slope changes that would preclude the construction of contour banks or other soil conservation works. To demonstrate this, a hypothetical contour bank plan was developed and is provided at Appendix B. As there is no intent to introduce cropping, this SCP does not include any details related to soil conservation works or measures. Should this situation change, as well as meeting all regulatory requirements, an amended SCP would be submitted for endorsement by the Chief Executive in accordance with requirements of the RIDA.

Where watercourses are observed to have been adversely impacted by subsidence

Watercourses are specifically removed from SCL trigger mapping, so any impacts to water courses per se do not create any impacts to SCL. It is only where an impact to a water course has potential to extend into SCL that they may become relevant for this SCP.

An adverse impact to watercourses is likely to be exhibited as creek bed slope gradient changes and associated erosion and sedimentation; and/ or bank erosion and associated bank steepening or undercutting. Within ML70481, the lower reach of Belcong Creek where it traverses the ML and prior to its confluence with Crinum Creek has the greatest risk of bed shallowing and steepening. Other watercourses traversing ML70481 will be subject to lesser substantial shallowing and steepening as they cross inter-panel pillars.

Where monitoring identifies sequential pooling and scouring of streambeds due to increased variation in longitudinal bed slope, watercourse monitoring will be initiated to ensure that detailed monitoring of the impacted sections is occurring. It is considered most beneficial to carefully monitor the natural re-establishment of the watercourse bed and banks and only intervene if an area of pooling or scouring is observed to be on deteriorating trajectory. In this event, relevant expertise will be obtained to develop an appropriate restoration strategy and program. Restoration works may utilise one or more of:

- regrading of bed and banks to produce stable profiles;
- vegetation re-establishment on watercourse banks; and
- construction of rock armouring where high energy sections have resulted.

Where ponding of water occurs

Figure 11 indicates the predicted locations of ponding within the 500-series panels. The following restoration measures will be implemented, with a scale appropriate to the severity of observed ponding:

- Based on assessments already undertaken areas predicted to be subject to potential ponding will be surveyed and pegged. Pre- and post-subsidence ground survey will be carried out to confirm that surface movement is as per predictions and to determine the extent, depth, duration and frequency of ponding based on hydrological assessment. An appropriate strategy to restore or mitigate will be developed based on ground survey results. In some cases it may be possible to drain ponded areas to existing watercourses either by reprofiling or regrading of the modified topography. In some cases shallow ephemeral pools may serve a useful ecological and/or agricultural (e.g. stock watering) function and, where suitable water quality can be demonstrated a decision may be made to retain the pond.
- for larger semi-permanent or permanent pools which degrade ecological and/or agricultural use, drainage works will be undertaken to either mitigate or eliminate ponding and pasture/vegetation cover re-established as required.

5.2.2 Supporting surface infrastructure

Restoration required for any surface infrastructure development will be defined via the GDP process, which will identify the restoration requirements specific to that development. Typical restoration requirements identified may include:

- regrading of the disturbed area to pre-disturbance grades, wherever practicable;
- reinstatement of any drainage paths that may have been diverted;
- respreading of recovered topsoil, topsoil surface preparation and revegetation;
- implementation of appropriate erosion and sediment control works (e.g. silt fences, sediment traps etc.) as per Kestrel's existing ESC plan (KES-0000-PL-OC-0009); and
- temporary or permanent fencing to enable stock exclusion and manage stock re-introduction.

While previous assessments and studies indicate that subsidence impacts to mapped SCL areas are likely to be minor and/or temporary, where impacts occur within mapped SCL areas, restoration activities will be undertaken with a determination of SCL status undertaken to verify that land has been able to be restored to the original condition of the land, including its productive capacity.

6 Monitoring and maintenance

This monitoring and reporting program has been developed to identify any actual impact(s) of the resource activities within the disturbance footprint area against the pre-activity land condition.

In summary, the approach to be taken comprises the following steps:

1) Complete a pre-activity assessment to establish the condition of the land that is predicted to be disturbed by mining activities. This is detailed in the Highlands Environmental report of the Soil and Land Suitability (SLSA) and SCL assessments.

2) As part of the pre-activity assessment , identify any 'risk zones' within the predicted disturbance area based on subsidence predictions and any known surface disturbance activities; and establish monitoring transects, sufficient to establish the statistical validity of monitoring results once restoration and monitoring has been completed. Risk zones will be a key focus of monitoring efforts.

3) Conduct impact monitoring during longwall mining activity of the identified risk zones and transects in accordance with this monitoring program.

4) Where impacts are identified from monitoring activities, plan and implement restoration activities as detailed in Section 5.1 and 5.2.

5) Where restoration activities are required, conduct restoration monitoring as part of the annual monitoring inspections until the area has been stabilised. (Section 6.2.2.2).

6) Following the cessation of all longwall mining activities and the completion of restoration and monitoring activities, compile an assessment report of all monitoring data acquired. The report is also to include a post-mining activity SCL validation study that identifies the extent of any residual permanent impacts to SCL located within the disturbed area.

6.1 Subsidence

6.1.1 Landform change

Kestrel has previously developed subsidence reports that outline the areas of Kestrel impacted by longwall subsidence, the results of subsidence monitoring and any impacts on groundwater resources. Predictions of subsidence profiles and magnitudes are made in addition to projected impacts on agriculture, irrigation and drainage structures.

Impacts on slope are identified by ground survey traverses and more recently using airborne light detection and ranging (lidar) sensing technology which provides high accuracy topographic survey enabling landform changes to be tracked over time, including creek slope, width and depth.

6.1.2 Hillslope erosion and ponding

Identification of active erosion, instances of ponding and tension cracking will initially be based on subsidence predictions and pre and post mining lidar, followed up by physical observations of the subsided areas for a period of at least two wet seasons (typically 30–36 months) following the passage of a longwall face (see Section 6.2.2.2). Where subsidence-induced erosion is either indicated (by modelling and/or lidar) or observed to have initiated, more detailed erosion surveys will be undertaken using a standard transect methodology, and a mitigation plan developed. To date, more detailed monitoring specifically for erosion has not been required for any of the previous longwall panel series at Kestrel, and is not anticipated for ML70481.

Similarly, instances of ponding will be monitored to ensure that data defining the depth and duration of ponding can be captured, with rainfall records to be maintained and inspections of predicted ponding areas to occur following major rainfall events.

Observations will also include monitoring of areas where active restoration works have been undertaken including maintenance of a photographic record.

6.1.3 Watercourses

Kestrel has maintained a regular stream condition survey program since the early 2000s, as part of the EA Receiving Environment Monitoring Program, which provides a detailed assessment of all watercourses crossing the MLs. The monitoring program is based on the Index of Diversion Condition as outlined in ACARP Project Report C9068 for categorising stream diversion condition. The technique used categorises, or scores, the condition of the watercourse before and after subsidence, and can also be used to assess the effectiveness of natural or engineered remedial measures to enhance post subsidence stability and condition. Kestrel intends to maintain this program of monitoring.

Kestrel also collects flow data from established gauging stations in the region to allow analysis and assessment where this is required.

6.2 Monitoring program

The main elements and sequence of the monitoring program are outlined in Figure 12.

6.2.1 Monitoring frequency

The monitoring program components will have the following frequencies:

- **Pre-activity** Assessment). This assessment comprises the complete body of knowledge in relation to land use, soils characterisation, topography and other aspects relevant to SCL. While much of this information has already been assessed and reported, the establishment of on-ground monitoring transects for both impact observations and ground truthing of subsidence movement will be undertaken progressively in advance of longwall panel operations within the longwall mining disturbance area (refer Section 6.2.2.1).
- **Impact monitoring**. Aside from ground survey of subsidence movement which will be undertaken progressively, **annual** monitoring inspections will be undertaken prior to the onset of each wet season to identify any areas of observable or measurable impact that might be associated with longwall panel subsidence or associated surface disturbance. Monitoring will be accomplished by observations along set transects as well as any identified zones more at risk to subsidence impacts. Monitoring events will continue from commencement of longwall mining activities within ML70481 until material subsidence is considered to have finalised following completion of 500-series mining activities (expected to be no longer than 2 wet season cycles following completion of mining activities), refer Section 6.2.2.
- **Lidar surveys** to occur:
  - prior to commencement of longwall panel operations within ML70481 (this data has already been acquired); and
  - once subsidence associated with 500-series mining activities is considered to have ended (likely to be at approximately 12 – 24 months from completion of longwall mining activities (Section 6.2.2.3). These requirements do not preclude additional lidar survey work being undertaken within this stated period.
- **Restoration monitoring.** Where impact monitoring identifies impacts requiring restoration, **annual** monitoring/inspections will occur from the date of completion of restoration activities until those areas are considered to have been stabilised (Section 6.2.2.2).
- **Post-restoration SCL and land suitability assessment:** to be undertaken as a final assessment following the completion of all 500-series mining activities, along with any associated restoration activities. Progressive assessments may also be undertaken on a panel by panel basis to address operational requirements.

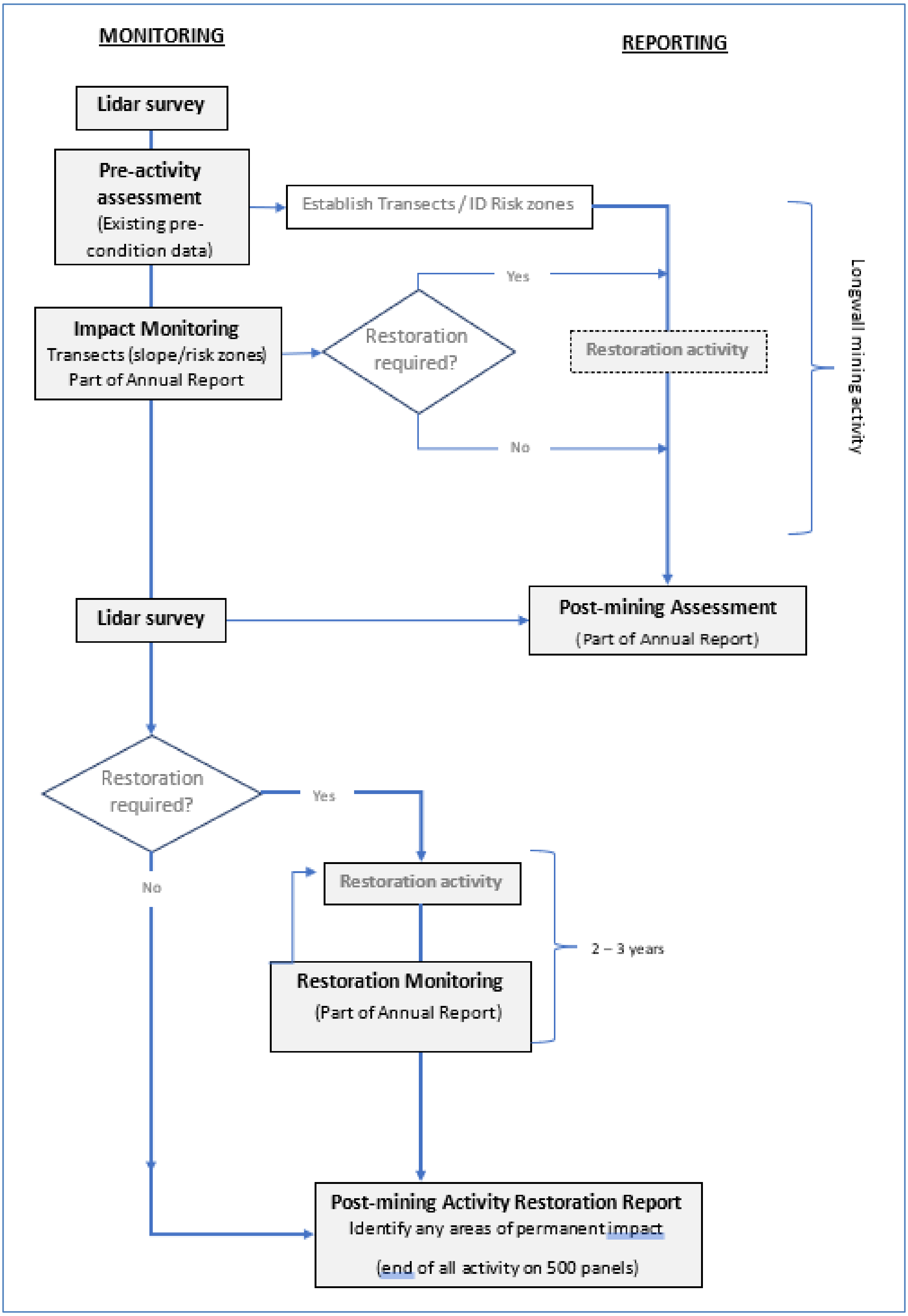


Figure 12: Diagrammatic view of the monitoring and reporting process

6.2.2 Monitoring assessment method

6.2.2.1 Pre-activity assessment)

This assessment for specific subsidence impact criteria applies to the areas that are mapped as SCL. The assessment comprises the complete body of knowledge in relation to land use, soils characterisation, topography and other aspects relevant to SCL within ML70481.

While much of this information has already been assessed and reported, the establishment of on-ground monitoring transects for impact observations and ground truthing of subsidence movement will be undertaken progressively in advance of longwall panel operations within the mining disturbance area. (see Figure 12).

The body of information relevant to define the pre-activity condition of SCL within ML70481, along with baseline ground survey information acquired ahead of advancing 500-series mining activities will be collated and retained for use in assessing any identified impacts.

6.2.2.2 Annual impact monitoring

Impact monitoring inspections will be undertaken annually from the commencement of longwall mining activities to identify any areas of observable or measurable impact that might be associated with longwall panel subsidence or associated surface disturbance.

To focus monitoring efforts, risk zones will be identified within the disturbed area that include areas of predicted maximum slope, any existing drainage lines and areas of surface disturbance. Within the risk zones, random transects or meandering survey will be established where appropriate.

Monitoring will be accomplished by observations along set transects and any identified zones more at risk to subsidence impacts. Monitoring events will continue until material subsidence is considered to have finalised (expected to be no more than two wet season cycles following completion of longwall mining activities). While monitoring transects and high risk zones are required to be established/ identified within mapped SCL, there may be other higher risk zones identified that area also subject to monitoring activities.

Impact monitoring will also identify areas requiring some level and type of restoration that can be initiated during mining activities if necessary. Any areas requiring restoration activities will be identified and a plan for undertaking the restoration works will be developed. Subsequent monitoring events will assess the ongoing effectiveness and impacts of the restoration activities.

Longwall transects

Transects will be established primarily utilising the ground survey transects used by KCR surveyors for their annual subsidence report both parallel to the progressing longwall panel on either side of the panel, and perpendicular to the progressing panel. Eight (8) observation sites will be used for each transect. Each monitoring event will include:

- Observations along specific transects, using a specific check-sheet, to identify:
  - instances of erosion, cracking, ponding or drainage impediment;
  - rockiness photographic record at each observation site and estimate of rockiness (as per RPI Act Guideline 08/14: DSDMIP 2019c);
  - Instances of vegetation change or other impacts including a description and photographic record.
- Ground survey along transects to identify/ confirm:
  - elevation and slope changes;
  - location of any surface cracking or other impacts.
- A photographic record to be made at each observation site i) along the line of transect, ii) perpendicular to line of transect, iii) land surface condition, cracking, and rockiness at all four cardinal points.

Risk zones

Risk zones will be identified within the disturbed area based on areas expected to have a greater risk of impact from subsidence or surface disturbance. These zones will include areas where slope changes are predicted to be greatest or where existing surface conditions (slope, drainage) may be more susceptible to impacts. Any areas where specific mitigation or restoration works are deemed to be required and undertaken will be included as a risk zone and mapped accordingly.

Risk zones will be subject to random meander surveys and observations with each monitoring event comprising:

- Observations made during random meander surveys to identify:
  - instances of erosion, including a description and photographic record;
  - Instances of vegetation change or other impacts including a description and photographic record;
  - Instances of surface cracking, including survey of initial large cracks observed, and photographic record; and
  - surface ponding, prolonged wetness or drainage impediment, including marking of the occurrence and estimation of areal extent, and photographic record.
- A photographic record to be made where any instances of potential impact are identified.
- Any changes effected by ongoing restoration activities.

Results and outcomes from this sequence of monitoring events and any resulting restoration activities will be collated and reported following completion of longwall mining activities in the area.

6.2.2.3 Lidar survey

Airborne laser scanning (ALS) is to be undertaken at the following frequencies (or more frequently):

- prior to commencement of longwall panel operations within ML70481 (this data has already been acquired); and
- once subsidence and restoration activities associated with 500-series mining activities is considered to have ended (likely to be a minimum of two (2) years from completion of longwall mining activities. These requirements do not preclude lidar survey work being undertaken within this stated period; and,
- Progressive assessments may also be undertaken on a panel by panel basis to address operational requirements.

Slope changes and areas of surface soil loss or gain by can be determined my DEM of Difference (DoD) analysis from this ALS data in comparison with that of the pre-mining condition ALS survey for the Initial Assessment (Section 6.2.2.3).

6.2.3 Post-mining activity and restoration monitoring

As a part of the annual monitoring program, any areas where mining is completed and/or that have had restoration activities undertaken, will continue to be monitored for an expected period of approximately two (2) years.

The post-mining activity restoration monitoring consists of:

- annual monitoring events along the original transects in areas relevant to the restoration activity; and
- annual monitoring events in the relevant risk zones subject to restoration.

6.2.4 Post-mining activity and restoration report

Land suitability assessment to be conducted once the following conditions have been met:

- annual subsidence monitoring, including transects, risk areas and restoration monitoring, indicates that no further management or mitigation activities required; and
- following a minimum of at least two consecutive wet seasons post any restoration activities.

Kestrel will undertake the land suitability assessment (SLSA), including an SCL assessment, in accordance with the requirements of RPI Guidelines 09/14 (DSDMIP 2019a) and 08/14 (DSDMIP 2019c) at the appropriate scale and intensity. This survey will set the post-mining activity soil characteristics and land productive capacity and will be compared with the pre-mining activity SLSA/SCL reporting from the initial assessment.

6.3 Supporting surface infrastructure

The GDP for any surface infrastructure development will identify the ongoing restoration monitoring requirements specific to that development. Monitoring requirements are likely to include:

- disturbance restoration inspections;
- regular observation schedules;
- maintenance revegetation or seeding as determined to be required; and
- vegetation transects and photographic monitoring points as required.

6.4 Land management activities not related to resource activities

Non-mined land management activities will be monitored in accordance with requirements of the current lease agreement and Kestrel land productivity approaches. Land improvement plans are reviewed regularly, with adjustments as required.

7 Administration

7.1 Delegation of authority

Implementation, review and update of the SCP is the responsibility of the Kestrel Mine General Manager.

7.2 Incident and complaint management

Kestrel's established incident management process will be implemented for any incidents or non-compliances related to the RIDA. This procedure outlines:

- Response to any complaints made regarding matters that are subject of the RIDA.
- Process to resolve any disputes with lessees, property owners, landowners or other persons.
- Process to respond to any non-compliances with the RIDA.
- Process to respond to any emergencies related to matters that are the subject of the RIDA.

In accordance with Schedule 3(b) of the RIDA, any incident, or serious non-compliance with the SCP will be reported in writing to the Chief Executive (of the Department administering the RPI Act) within 10 business days. The information to be reported to the DSDILGP includes:

- details of the nature of the incident or serious non-compliance;
- results and interpretation of any samples taken and analysed;
- outcome of actions taken to rectify the incident or serious non-compliance, and the associated impacts;
- details of the actions proposed to prevent a recurrence of the incident or serious non-compliance.

7.3 Annual report

In accordance with Schedule 3(a) of the RIDA, an annual report will be prepared by the 13th June (i.e. within 12 weeks following the anniversary date of the issuing of ML70481; the EA was issued 15 March 2016, while ML70481 was granted 21 March 2016).

The annual report will be made available to the Chief Executive (of the DSDILGP) or affected property owners, if requested.

The annual report will include:

- details and timing of all relevant mining activities undertaken in the preceding year;
- details and timing of the proposed mining activities for the current year;
- location and description of restoration activities undertaken in the year;
- location and design of any soil conservation works (new and/or remedial works);
- details of any changes in practices or expected outcomes contained within this SCP;
- description of monitoring activities undertaken and an analysis and interpretation ofthe monitoring results;
- summary details of any incidents recorded or complaints received regarding soilconservation and subsidence related matters, including the resolution of the complaint;
- details of measures proposed to address any underperformance or non-compliancewith the RIDA for ML70481 relevant to the reporting period; and
- details of all measures proposed to manage any significant, unpredicted impacts notaddressed by this SCP.

An annual report as required by EA condition G9 will also be prepared.

7.4 Review

Changes to mining plans or potential impacts detailed in this SCP will result in a revised SCP being resubmitted for the endorsement of the Chief Executive.

The SCP will be reviewed annually, and if necessary revised and resubmitted for endorsement by the Chief Executive.

7.5 Plan preparation competency statement

This Soil Conservation Plan for RIDA amendment has been prepared by Dr Robin Thwaites (PhD, CPSS); based on information from various soil studies, soil assessments, soil sampling programs and environmental assessment reports, which are stated to have been prepared by suitably qualified persons.

I declare that I meet the requirements of a suitably qualified person as per the definition included within Amended RIDA RPI16/002/RIO TINTO – Kestrel EXTENSION #4 Coal Project.

Robin Thwaites, Principal Environmental Scientist
AARC Environmental Solutions

Dated 10 July 2023

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9 Accountabilities

The following accountabilities have been identified for this Management Plan:

Role	Accountability
General Manager & SSE	• Ensure compliance with the requirements of this Management Plan • Provide resources and systems to enable: • Managers, Supervisors, Employees Contractors and Visitors are aware of their responsibilities under this Management Plan • this Management Plan to be implemented in all applicable areas of the coal mine • Training for personnel to meet requirements of this Management Plan
Area Managers	• Familiarity with requirements of this Management Plan • Maintain working knowledge of GDP procedure and system • Maintain working knowledge of ESC Plan requirements
Technical Services Manager	• Ensure that all works and activities under their control or influence are conducted in accordance with the requirements of this Management Plan
Superintendent Environment	• Maintain familiarity with this Management Plan • Responsibility for correct operation and maintenance of GDP procedure and system, including review and sign-off of GDPs • Knowledge of and accountability for implementation of ESC Plan requirements • Maintain this Management Plan within the Site Document Register • Initiate review of this Plan at intervals not exceeding 3 years • Communication of the requirements of this Management Plan to relevant personnel.
Environment Team	• Maintain familiarity with this Management Plan and its operation • Initiate restoration and monitoring requirements of this Management Plan • Maintain regular monitoring of works being undertaken within the jurisdiction of this Management Plan
General workforce (employees and contractors)	• Familiarisation with requirements of SCP and management through GDP process and obligations • Ensure all persons are competent to perform the tasks they are assigned.
Supervisors	• Have familiarity with the requirements of this Management Plan sufficient to identify Plan application and to report non- compliances

10 Glossary of terms

Best possible [in reference to the restoration of land] class of agricultural land	When rehabilitating the strategic cropping area, all reasonable and practicable measures must be applied to return that land to a class of agricultural land that is at least equivalent to that prior to the subject development taking place.
Chief Executive	The chief executive of the department administering the RPI Act.
Class of agricultural land	Agricultural land class and subclass are as defined in Table 7 of the Guidelines for Agricultural Land Evaluation in Queensland (DNRM & DSITIA 2013) or a future edition of that publication.
Disturbed/Disturbance [of land or soil]	Includes but is not limited to the following: • compacting, removing, covering, exposing or stockpiling of earth; • removal or destruction of vegetation or topsoil or both to an extent where the land has been made susceptible to erosion; • subsidence of land; • submersion of areas resulting from the capture or holding of water or other liquids in storages, dams, tanks, impoundments, etc., or any ponding associated with the subsidence of land; • earthworks associated with the construction, maintenance or removal of any mine surface infrastructure; or • releasing of contaminants into the soil or land.
Environmental Authority	As defined in Schedule 4 of the *Environmental Protection Act 1994*
Erodibility [of soil]	For the purposes of satisfying these conditions, the erodibility of a soil is to be assessed by determining the applicable value (for Australian conditions) of 'K' factor' in versions of the Revised Universal Soil Loss Equation (RUSLE), or any other means agreed to by the Chief Executive.
Impact	An influence or effect, either direct or indirect, resulting from a change, whether adverse or beneficial
Incident	An event or occurrence involving the degradation of soil or land, that the Chief Executive would reasonably consider a serious or material impact on the affected soil or land (N.B. the impact may be an indirect one, and not necessarily take place on the strategic cropping area).
Land Capability	Land capability classification evaluates the potential of land for broadly defined land uses, e.g. cropping, pastoral, non-agricultural. In Queensland, it is generally only used for broad scale assessment of land.
Land Suitability	Land suitability classification assesses the potential of land for a specific land use e.g. is the land suitable for furrow irrigated cotton, dryland maize, trickle irrigated apples. The specific land use is assessed against a range of limitations e.g. soil water availability, soil moisture, rockiness, slope, flooding.
Mine surface infrastructure	Surface structures intended for or to support underground mining activities, including ventilation shafts, mine portals, drifts, and adits.

Mine-affected water	• Means the following types of water: mine and pit water, tailings dam water, processing plant water and workshop water; • run-off which has been in contact with any areas disturbed by mining activities which have not yet been restored, excluding run-off discharging through release points associated with soil conservation structures that have been installed in accordance with the standards and requirements of the Soil Conservation Plan or an approved Erosion and Sedimentation Control Plan, provided that this water has not been mixed with mine and pit water, tailings dam water, processing plant water and workshop water; • groundwater which has been in contact with any areas disturbed by mining activities, or generated through the mine's dewatering activities; and • a mix of mine-affected water-as defined under any of the preceding dot points in this definition-and any other water.
Mitigation deed	As defined in Section 64, Part 4 of the RPI Act.
Monitor [in reference to a management plan or managed activity]	The collection of information and data on parameters that characterise the nature or condition of something of relevance or potential relevance to a management plan or activity.
Permanent Impact	A resource activity has a permanent impact on strategic cropping land if, because of carrying out the activity, the land cannot be restored to its pre-activity condition.
Pre-disturbance	A point in time preceding disturbance by a resource activity and reasonably close to its occurrence
Promptly [in reference to restoration or rehabilitation of land]	Without unnecessary delay, or as soon as possible, so as to minimise the amount of time land is out of production or not in a suitably stable form, restoration or rehabilitation must commence as soon as it safe and practical to do so after the causative disturbance has ceased, and once there are no further physical or biological impediments to the successful restoration or rehabilitation of the subject area of land. Restoration or rehabilitation work is (1) to be progressive, and (2) must be completed within 50 years of the granting of the Environmental Authority for the subject mine.
Restore [the strategic cropping area]	The return of disturbed strategic cropping area to a stable, productive and self-sustaining condition that supports the best possible class of agricultural land.
Resource activity/ies	Resource activity as defined under the RPI Act
Run-off water	Water which accumulates on the soil surface as a result of rainfall or other natural inflows and flows over the soil surface from higher to lower land.
SCL Protection Decision	As defined in s91 of the *Strategic Cropping Land Act 2011* (now repealed)
Criteria for land	As detailed in Schedule 3 of the RPI Act.
Sewage	Domestic and/or commercial wastewater that contains, or may contain, faecal, urinary or other human waste, or a wastewater defined as sewage under the *Plumbing and Drainage Act 2002*.
Soil conservation measures	Works, land management practices, undertakings, acts, proposals and prohibitions designed, built or proposed to be carried out for the

	purpose of controlling soil erosion, soil conservation, capture of sediment, or controlling or directing the flow of run-off water.
Soil conservation works	Structures intended for soil conservation and sediment control.
Soil erosion	The natural or accelerated removal or deposition of soil which may be detrimental to agricultural, pastoral, or forestry activities, or public or private structures, works or infrastructure.
Strategic cropping area	As defined in Section 10(1) of the RPI Act
Strategic cropping land	Means land that is, or is likely to be, highly suitable for cropping because of a combination of the land's soil, climate and landscape features.
Subject mining lease	ML70481 as depicted in the registered survey plan.
Subsoil	Soil material from below the 'A' horizon or horizons of a soil profile but above bedrock, weathered rock, a hard pan or continuous gravel layer. Usually the 'B' horizon of a soil profile.
Suitably qualified person	A person who has professional qualifications, training, skills or experience relevant to the nominated subject matter and who can give a competent assessment, advice and analysis of pertinent data and information using protocols, standards, guidelines, methods and literature that are acceptable to the Chief Executive.
Summary details [as pertains to Reporting conditions]	The provision of sufficient information to identify the nature of any consultations, complaints or similar interactions, but not sufficient to identify the persons involved in those interactions or making any complaints.
Topsoil	Soil of the 'A' horizon or horizons of a soil profile.
Wastewater	An aqueous waste, including contaminated stormwater, as defined under Environmental Protection (Water) Policy 2009.

Appendix A. RUSLE2 parameters

Table 8: Climate Model Parameters

Month	Average Temperature (°C)	Monthly Precipitation (m)	Erosion Density (SI Units)
January	34	0.094	6.05
February	34	0.075	7.06
March	32	0.088	3.00
April	30	0.029	0.4878
May	26	0.020	0.705
June	23	0.017	0.850
July	24	0.026	0.632
August	26	0.014	1.06
September	29	0.026	0.553
October	32	0.041	0.349
November	33	0.057	2.50
December	34	0.083	4.67
10-year 24-hour rainfall event (m)		**0.12**	

Table 9: RUSLE2 R and K factors for each ML70481 soil type

Soil Type	Rainfall Erosivity Factor (R) MJ/mm per ha/hr/yr	Soil Erodibility Factor (K) ((t.ha.h)/(ha.MJ.mm))
A – Alluvium	2,031	0.039
Afs – Fine Sandy or Silty Surfaced Alluvium	2,048	0.037
C – Colluvium	2,070	0.044
Cgc – Colluvium, Soils overlying mottled greenish-grey or green smectite clays	2,127	0.038
CS – Cainozoic Sediments	2,060	0.035
CStc – Texture Contrast Soils on Cainozoic Sediments	2,093	0.040
Krb – Read and Brown Soils on Calcareous Materials	2,164	0.036
Ks – Shallow Calcareous	2,115	0.038
B – Basalt	2,098	0.034
Bvsb – Brown Very Shallow Basalt	2,072	0.039

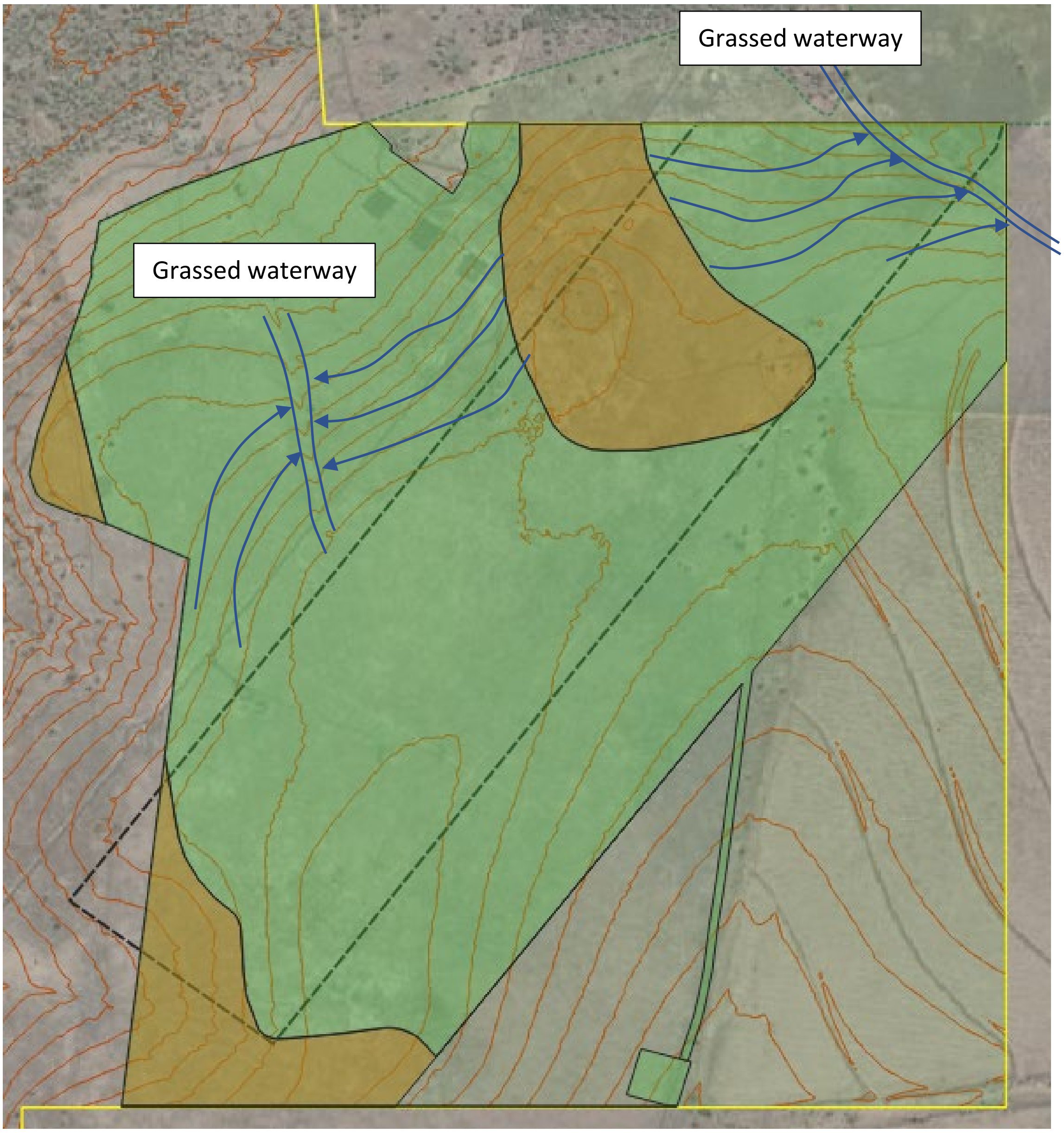
Appendix B. Hypothetical conservation works

A contour bank and grass waterway design has been developed based on the projected post-mining topographic landscape where slopes have been modified in demonstrated SCL land (Highlands Environmental 2022) from post-mining subsidence.

The design would be for broad-based top-side banks, with a 5 m base and 1:4 bank batter, spaced at approximately 100 m over slopes from 1.5% to a maximum of 2%. There is very little catchment above either of the sets of contour banks with slope no more than 2% for a maximum of 50 m.

Waterways will be of standard parabolic base design running into natural drainage features. A base width of 10 m and bank heights of 40 cm would be sufficient.

This plan is designed with a minimum tillage and controlled traffic cultivation management assumed and is appropriate for the cracking clay soils in this area.



Appendix C. Robyn Thwaites – CV

ENVIRONMENTAL SOLUTIONS

ROBIN THWAITES

PRINCIPAL ENVIRONMENTAL SCIENTIST

Robin is a soil and geomorphology scientist with over 35 years of experience as a professional within state and national governments, universities, and the private sector, both in Australia and internationally.

QUALIFICATIONS:

PhD in Geographical Science (University of Queensland)

MSc in Land Resource Management (Cranfield University, UK)

BSc (Hons) in Geographical Science (Aberystwyth University, UK)

CPSS Certified Practicing Soil Scientist (since 1997)

FRGSQ Fellow Royal Geographical Society of Queensland Inc.

EXPERTISE:

- pedology – soil science
- soil & geomorphological survey & analysis
- land resource assessment
- land resource management
- spatial analysis & GIS
- soil geomorphology
- soil conservation
- landscape ecology
- agroforestry

Robin has worked in soils and geomorphology research and development for private and state forestry planning and management (S Africa and Tasmania), and land resource assessment with the Queensland State Government, before moving into university teaching and research. He specialised in pedology, soil conservation, land resource assessment, landscape ecology and agroforestry while convening the Land Resource Science degree programs at The University of Queensland (UQ), and in soils, geomorphology, geology, resource assessment, and spatial analysis while convening the Environmental Science major at the Queensland University of Technology (QUT). He has also spent time specialising in GIS and remote sensing at James Cook University, far north Queensland.

Robin has published journal articles, book chapters, and conference papers on soil geomorphology, paleogeomorphology, landscape evolution, land resource assessment, forest site assessment, digital terrain analysis, and soil and gully erosion and rehabilitation.

PROJECTS:

- Undertaking consultancy work since 2011 in soil and land resources assessments for EIA, SCL, BSAL, and Ag Impact Statements, surveys for erosion and sediment control management, mined land rehabilitation, and geomorphological monitoring of waterways. More recently Robin has been a soils spatial analyst and modeller to identify regions and localities for targeting soil carbon sequestration management in southern and eastern Australia.
- Undertaking research at Griffith University in large alluvial gully erosion and rehabilitation with hi-resolution lidar in the Great Barrier Reef catchments of Queensland as part of the Precision Erosion and Sediment Management (PrESM) Research Group, and contributing to the Reef Credits Scheme.

PROJECTS (cont.)	• Undertaking consultancy work since 2011 in soil and land resources assessments for EIA, SCL, BSAL, and Ag Impact Statements, surveys for erosion and sediment control management, mined land rehabilitation, and geomorphological monitoring of waterways. More recently Robin has been a soils spatial analyst and modeller to identify regions and localities for targeting soil carbon sequestration management in southern and eastern Australia. • undertaking research at Griffith University in large alluvial gully erosion and rehabilitation with hi-resolution lidar in the Great Barrier Reef catchments of Queensland as part of the Precision Erosion and Sediment Management (PrESM) Research Group, and contributing to the Reef Credits Scheme. • Also teaching at Griffith University in soils, geomorphology, and catchment management post-graduate programs, and presenting micro-credential short courses in applied soil science, soil survey, and soil hazards management. **Current:** • Kestrel Coal Resources – Kestrel West Soil and Land Suitability Assessment – Reviewer. • Kestrel Coal Resources – Kestrel West Strategic Cropping Land Assessment – Reviewer/Technical manager. • Kestrel Coal Resources – Kestrel South LW500 RIDA application – Technical Consultant. **Previous (selected):** • Goonyella – Bowen Rail corridor, central Qld: SCL & Land Suitability assessment (for GHD; BMA) – Technical Director / Reviewer. • Moranbah South ML, central Qld: SCL & Land Suitability assessment (for Hansen Bailey Qld; Anglo Coal) – Technical Director / Reviewer. • Baralaba South ML & Moura Load Out, central Qld: SCL and land suitability assessment (MEMS; Cockatoo Coal) – Technical Director / Reviewer, Field Scientist and Trainer. • Doyles Creek ML, Savoy Hill ML, Plashett ML, Dellworth ML, Hunter Valley, NSW: Land Capability assessment and digital soil mapping for AIS/EIS (Parsons Brinckerhof NSW; NuCoal) – Project Director / Technical Director. • Goondicum Ilmenite ML, SE Qld: Topsoil and tailings suitability assessment for rehabilitation, (Belridge Enterprises) – Project Manager / Field Scientist. • Erosion & Sediment Control plan & Training course development, Cloncurry, western Qld (MMG) – Project Director.
MEMBERSHIPS:	• Member Soil Science Australia (Australian Soil Science Society Inc.) (Qld division); and Past President (2004-05) • Member International Soil Science Society • Past President (1996-98) and Fellow Royal Geographical Society of Queensland Inc. • Member Environment Institute of Australia and New Zealand • Member River Basin Management Society • Past committee member Institute of Foresters of Australia (Qld Division) • Past Fellow of the Royal Geographical Society (London) (FRGS)