		Evidence (what section of the plan and what page?)	Accepted?
G11	A Rehabilitation Management Plan proposing completion criteria for all mining areas must be developed by **31 May 2017** and submitted to the administering authority for review and comment. A Rehabilitation Management Plan for all mining domains must be developed by a **suitably qualified person** that includes the following:	The Ensham Coal Mine Rehabilitation Management Plan was submitted via email on 30 May 2017.	Yes
	a) a map existing of areas of rehabilitation including classification of stage (i.e. time since establishment) and quality;	Figure 2-3: Chronology of rehabilitation completion to date (page 10) details of areas of rehabilitation by year, for the period of 2001 to 2017. The quality of completed and in progress rehabilitation were not detailed within the Plan.	See point 1 in the feedback.
	b) a strategy for progressive rehabilitation, including a progressive rehabilitation schedule;	Table 2-1: Indicative rehabilitation schedule to end of mine life details the planned rehabilitation areas (in ha) per period (typically 2-3 years). A total area of 3,573ha has been planned for the period of 2017-2031 (14 years), with an average of 255.22ha per year.	Yes
	c) details of the design objectives for rehabilitation of each domain to achieve rehabilitation success criteria and the identified post mining land uses;	Section 4. Landform Design Objectives details the rehabilitation design objectives for each domain. Each of the proposed rehabilitation domain locations has been detailed in Figure 4-1: Location and extend of rehabilitation domains in the post-mining landscape (page 21).	Yes
	d) specify the spoil characteristics, soil analysis and soil separation for use on rehabilitation;	Section 3. Material Characteristics (page 13-19) details soil and spoil types and their distribution at the Ensham Coal Mine.	Yes
	e) specify the topsoil requirements for the site and how topsoil will be managed for use in rehabilitation;	Page 25 states that “Ensham currently holds about 3.5 million cubic metres (Mm^3) of topsoil in stockpiles, preserved for use in future rehabilitation (Table 5-1)”.	Yes

		Table 5-1 details the volume of preserved topsoil held within each designated pit location, with a total of 3,670,332m^3 topsoil held at the Ensham Coal Mine.	
	f) details of any topsoil deficit and how any deficit will be managed for successful rehabilitation;	Page 25 states that "If respreads to create a 200mm soil layer for rehabilitation this quantity is sufficient to cover approximately 1,800ha. This highlights a topsoil deficit of around 3,000ha. Ensham will manage this deficit by: • Strategically using topsoil to promote rapid groundcover establishment and stabilization of outer slopes that drain to the broader environment. • Ameliorating Permian overburden to create a plant growth media or 'topsoil substitute', e.g. by additions of organic matter, gypsum and/or fertilizer."	Yes – see point 3 listed in the feedback.
	g) details of rehabilitation methods to be applied to areas;	The details of the proposed rehabilitation methods to be applied to each domain have been included as section 6. Rehabilitation Methods (page 25 – 26).	Yes – see points 2, 4 and 5 listed in the feedback.
	h) details of landform design including end of mine design;	Land form designs, including end of mine design, have not been included in the rehabilitation management plan.	No – see feedback points 6 – 7.
	i) details of how landform design will be consistent with surrounding topography;	Page 28 states that "It is reasonably foreseeable that some rehabilitation may achieve the rehabilitation goals of safe, stable, non-polluting and sustainable land use, but remain 'different' in form and function to unmined reference sites". No additional information has been provided as to how the proposed landscape will be compatible and tied into the surrounding landscape from the surrounding topography.	Yes – see feedback point 7.

Page 3 redacted for the following reason:
- -
s.37(3)(d) Deferral of access

		• Re-evaluation of monitoring data; • Additional monitoring; • Amendments to rehabilitation planning and/or execution; and/or, • Redoing rehabilitation earthworks or parts thereof.	
	n) description of end of mine landform design planning and post mining land uses across the mine; and	Land form designs, including end of mine design, have not been included in the rehabilitation management plan.	No – see feedback points 6 – 7.
	o) include a triple bottom line assessment (or a comparative alternative assessment method) of the proposed final landform design criteria and alternatives.		

Feedback:

1. Provide further information regarding the stage and quality of the existing rehabilitation, including:
    - A breakdown of the stages of rehabilitation (i.e. shaped and contoured, topsoiled, seeded, requires monitoring); and,
    - A breakdown of rehabilitation quality (i.e. successful (requires monitoring), requires maintenance, requires rework).

    Ideally, in future updates of the Rehabilitation Management Plan, the quality of the existing rehabilitation should be linked to the achievement of the rehabilitation success criteria i.e. 4/5 of the success criteria categories have been achieved.

2. "Practice at Ensham and other mines in central Queensland shows that this material can be effectively rehabilitated with slope gradients of up to 15%. If steeper than this, than Permian overburdens should be clad with at least 1m of durable rock to prevent erosion" (page 19). Please note that slope gradients should be consistent with the approved rehabilitation success criteria (Appendix 4 of Environmental Authority EPML00732813).

3. "If respread to create a 200mm soil layer for rehabilitation this quantity is sufficient to cover approximately 1,800ha. This highlights a topsoil deficit of around 3,000ha. Ensham will manage this deficit by:

    - Strategically using topsoil to promote rapid groundcover establishment and stabilisation of outer slops that drain to the broader environment;

- Ameliorate Permian overburden to create a plant growth medium or 'topsoil substitute' e.g. by additions of organic matter, gypsum and/or fertiliser.

Describe the strategies in more detail, including research and demonstration of these techniques and how and where each technic might be applied at Ensham Coal Mine.

4. Rehabilitation methods relating to contaminated land are listed as "Complete contaminated land assessment and management". This should state contaminated land assessment, treatment and management.

5. "Spread hay mulch for immediate groundcover" has been listed in the rehabilitation methods for several of the domains. Hay has the potential to cause eutrophication, if washed into surface water environments. Describe the process of selection of suitable locations for hay mulch and accompanying methods to ensure integrity of hay mulch as groundcover.

6. Final landform designs, including end of mine design was not included in the rehabilitation management plan. Provide a commitment on when the final designs will be available for inclusion in the Rehabilitation Management Plan (e.g. on completion of the Residual Void Project).

7. "It is reasonably foreseeable that some rehabilitation may achieve the rehabilitation goals of safe, stable, non-polluting and sustainable land use, but remain 'different' in form and function to unmined reference sites". Whilst the department understands that the rehabilitated landforms will be 'different' in form and function to unmined reference sites, how will Ensham ensure that these landforms are compatible and tied into the surrounding landscape?

8. Provide a description of each of the rehabilitation reference sites detailed in Table 8-1: Details of reference sites for rehabilitation monitoring (GDA 94, Zone 55), including the topography, vegetation types, and existing and potential future impacts, and how the reference site is comparable with the rehabilitation success criteria.

9. It is recommended that the additional reference sites further afield of the Ensham Coal Mine be included to capture regional variation in the landscape and incorporate comparable landforms (i.e. slope, floodplains, etc.).

10. Table 9-1: Environmental value linkages to rehabilitation indicators and completion criteria and Table 1-2: Indicators and completion criteria should be amended to reflect the rehabilitation success criteria listed in Appendix 4: Rehabilitation Success Criteria of the EA.

REHABILITATION MANAGEMENT PLAN

Pursuant to condition G12 of permit
Environmental Authority EPML00732813

May 2017

Prepared by La Tierra Pty Limited for Ensham Resources

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ACRONYMS AND DEFINITIONS

ACARP	Australian Coal Association Research Program
CMLR	Centre for Mined Land Rehabilitation, Sustainable Minerals Institute, The University of Queensland
Completion criteria	These are the standards that are to be met by successful rehabilitation. They will generally be in the form of numerical values that can be verified by measurement of the indicators selected for the rehabilitation objectives.
Domain	Land management units for rehabilitation planning and execution
EA	Environmental Authority EPML00732813
EHP	Queensland Department of Environment and Heritage Protection
EMS	Environmental Management System
EP Act	Environmental Protection Act 1994
ESD	Ecologically sustainable development
FA	Financial assurance
Goals	Policy objectives for rehabilitation set by Government: • Safe • Stable • Non-polluting, and • Agreed land use
Indicator	Something that can be measured and audited according to an established protocol and used to evaluate changes in a system
ML	Mining lease
NRM	Queensland Department of Natural Resources and Mines
Plan	How we will do it
PoO	Plan of Operations
Reference site	A locality undisturbed by mining with similar land and soil attributes, vegetation characteristics and land use, which provides 'target conditions' for assessment of rehabilitation
Residual risk	As defined in schedule 4 of the EP Act, includes the risk that: • Rehabilitation will fail and need repair, replacement or maintenance; • Rehabilitation will need ongoing maintenance; or Potential environmental harm needs monitoring or management
RI	Recordable injury
RMP	Rehabilitation Management Plan (this document)
SHMS	Safety and Health Management System
Stakeholder	A person or organisation that is potentially affected by a decision, such as a resident, land owner, community group, government agency, company, traditional owner, or environmental group.
Strategy	What we will do

1 INTRODUCTION

This Rehabilitation Management Plan (RMP) describes rehabilitation at Ensham coal mine, located 40 kilometres (km) northeast of Emerald in central Queensland. Ensham is an open-cut and underground mining complex, producing high energy, low ash thermal coals from the Permian age Rangal Coal Measures. It operates on an aggregation of seven mining leases and in accordance with Environmental Authority (EA) EPML00732813 conditions.

Ensham Resources Pty Limited manages the mine on behalf of joint venture partners and Environmental Authority holders Bligh Coal Limited and Idemitsu Australia Resources Pty Limited (jointly 85%) and Natural Resources Investment (Australia) Pty Limited (15%). La Tierra Pty Limited, as independent consultants and an appropriately qualified person[1], has prepared this report for and on behalf of Ensham Resources.

1.1 Plan purpose

The purpose of this RMP is to describe rehabilitation at Ensham mine in accordance with requirements of condition G11 of the EA.

1.1.1 Plan structure

The RMP is structured as follows.

Section 1	Introductory context and purpose
Section 2	Strategy for progressive rehabilitation including schedule of works to end of mine life
Section 3	Material characteristics and management
Section 4	Landform design objectives
Section 5	Soil resource management
Section 6	Rehabilitation methods
Section 7	Native vegetation corridors
Section 8	Description of reference sites
Section 9	Objectives, indicators and completion criteria for each domain, including post-mining land use/s
Section 10	Continuous improvement
Section 11	Triple bottom line assessment – people, planet & profit
Section 12	Full references for all citations within the text of the RMP
Appendix A	Limitation subclass threshold limits for Land Suitability Assessment of rehabilitation for sustainable cattle grazing in central Queensland
Appendix B	Ensham risk matrix tool

[1] "Appropriately qualified person" has the same meaning as in EHP Guideline EM1122, version 2, dated 2014.

1.1.2 Complying with EA requirements

The RMP addresses each requirement of EA condition G11 (Table 1-1).

Table 1-1 Addressing EA requirements

	Relevant criteria	Where addressed
a)	A map existing of areas of rehabilitation including classification of stage (i.e. time since establishment) and quality	Section 2, Figure 2-3
b)	A strategy for progressive rehabilitation, including a progressive rehabilitation schedule	Section 2, Table 2-1
c)	Details of the design objectives for rehabilitation of each domain to achieve rehabilitation success criteria and the identified post mining land uses	Section 4, Section 9, Table 9-1
d)	Specify the spoil characteristics, soil analysis and soil separation for use on rehabilitation	Section 3, Section 5
e)	Specify the topsoil requirements for the site and how topsoil will be managed for use in rehabilitation	Section 5
f)	Details of any topsoil deficit and how any deficit will be managed for successful rehabilitation	Section 5
g)	Details of rehabilitation methods to be applied to areas	Section 6, Table 6-1
h)	Details of landform design including end of mine design	Section 4
i)	Details of how landform design will be consistent with surrounding topography	Section 4.5
j)	Identification of planned native vegetation rehabilitation areas and corridors	Section 7
k)	Identification of at least a minimum of three (3) reference sites for use in rehabilitation monitoring	Section 8
l)	Description of rehabilitation indicators and how these will be monitored	Section 9 Section 10, Table 10-1
m)	Description of management actions to address unsuccessful rehabilitation or redesign	Section 10
n)	Description of end of mine landform design planning and post mining land uses across the mine	Section 4, Section 9
o)	Include a triple bottom line assessment (or a comparative alternative assessment method) of the proposed final landform design criteria and alternatives	Section 11

2 STRATEGY FOR PROGRESSIVE REHABILITATION

Following is the overarching strategy for progressive rehabilitation at Ensham. The areas and timing of works nominated herein are indicative only and may vary due to operational and other requirements. Specific areas for rehabilitation will continue to be nominated in successive Plans of Operations.

2.1 Rehabilitation to date and life-of-mine forecast

To end-2016, Ensham had disturbed 4,591 hectares (ha) of land and rehabilitated 1,170 ha or 25% of this area (Figure 2-1, 2-2 and 2-3). By the time coal production ceases in 2029, a total disturbance footprint of 4,743 ha is forecast. Rehabilitation earthworks are scheduled for completion by 2031.

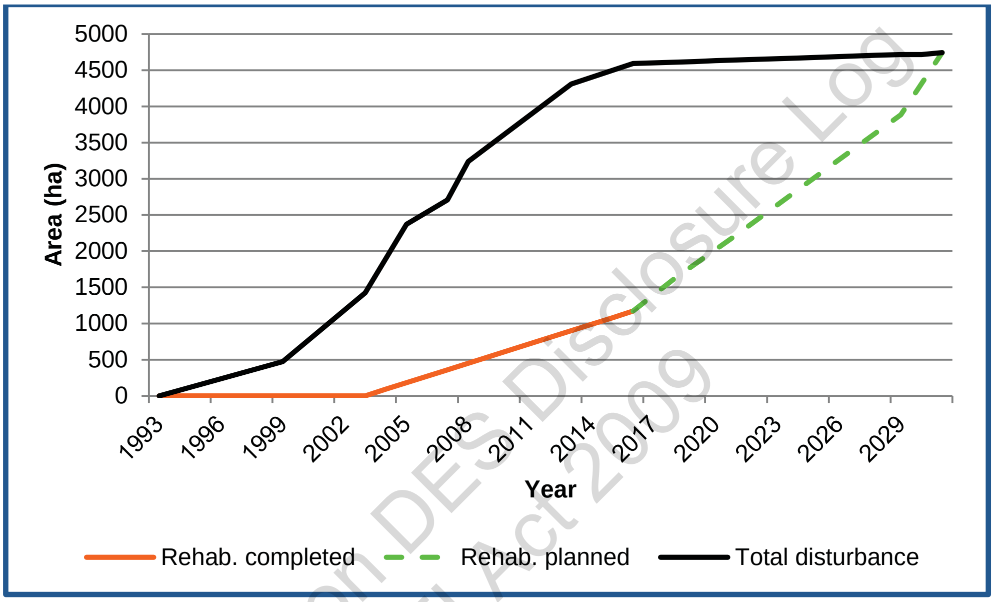

Figure 2-1 Life-of-mine disturbance and rehabilitation

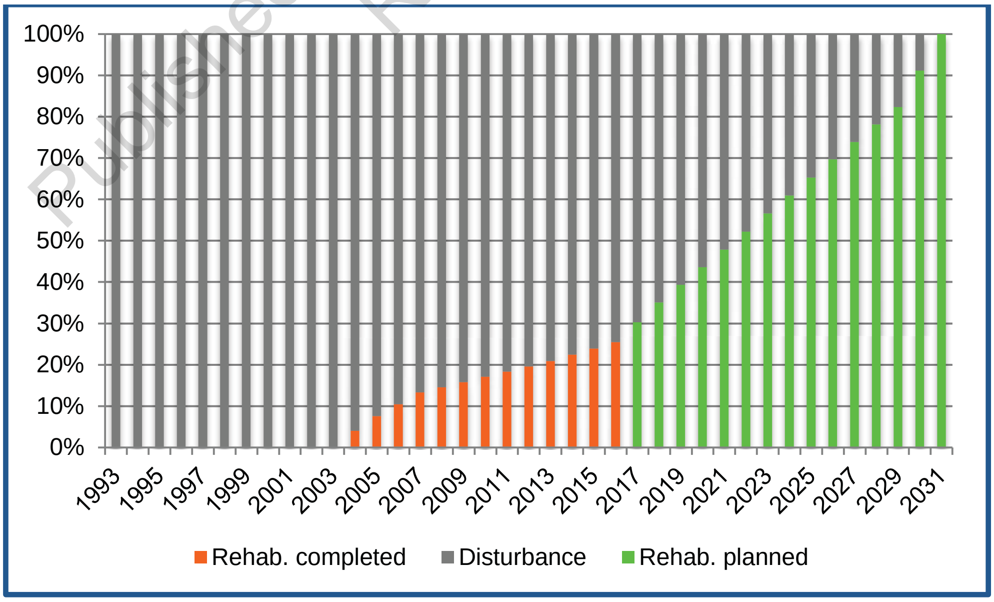

Figure 2-2 Rehabilitation as a percentage of disturbance over life-of-mine

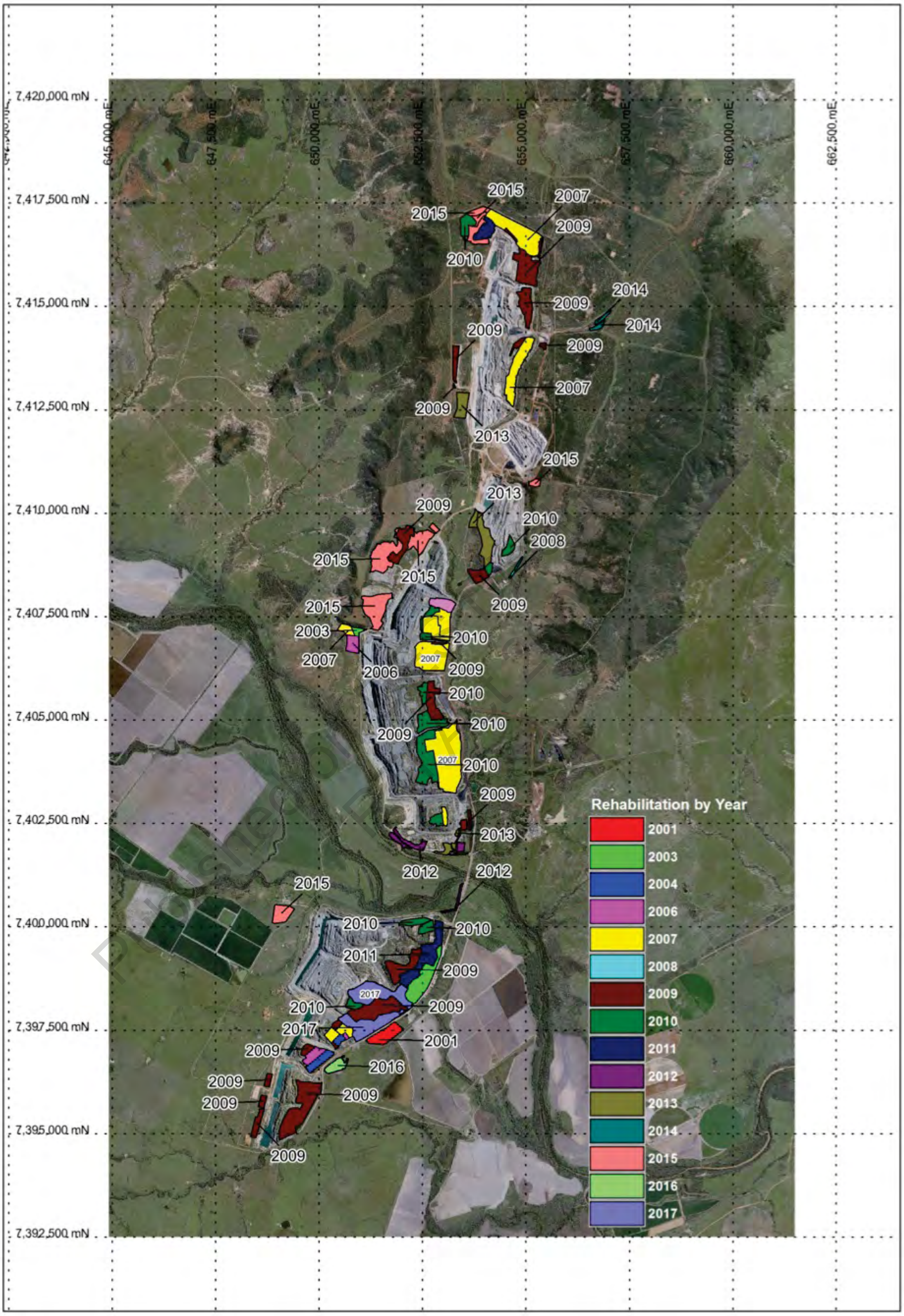

Figure 2-3 Chronology of rehabilitation completed to date

Completion of all rehabilitation requirements has been forecast based on the following constraints:

- Complete as much rehabilitation as is possible before coal production ceases and spread this more or less evenly across the 13-year period from 2017 to 2029;
- There is 861 ha associated with the safe and efficient operation of the open-cut and underground and this area is not available for rehabilitation until after production ceases in 2029; and,
- Finish rehabilitation as soon as practicable after production ceases and within two years.

This rehabilitation forecast highlights several important matters for Ensham:

- Little permanent rehabilitation was completed in the first 10 years of operation. Permanent rehabilitation commenced in 2004.
- The gap between disturbance and rehabilitation has widened, year-on-year from 1993 to 2016. This has deferred rehabilitation on-ground and costs.
- In the next 5 years from 2017 to 2021, the plan is to complete 1,050 ha of rehabilitation. This is almost as much rehabilitation as has been completed in the preceding 24 years (1,170 ha).
- The rehabilitation rate required from 2017 to 2029 is about 210 ha/y (mean).
- In the final two years of the rehabilitation program, i.e. 2030-31, the required rehabilitation rate is 431 ha/y.

2.2 Strategy

Rehabilitation works have been scheduled to end of mine life at strategic time intervals (Table 2-1). Based on constraints listed (see previous section) all disturbance, current and forecast, has been allocated a time period for rehabilitation (Figure 2-4).

Table 2-1 Indicative rehabilitation schedule to end of mine life

Interval (years)	Year	Period	Note	Area (ha)
Historic	End-2016	1993-2016	Period to date	1,170
2	End-2018	2017-2018	Rolling period for detailed planning	447
5	End-2021	2019-2021	Rolling period for conceptual planning	603
10	End-2026	2022-2026	Rolling period for conceptual planning	1,046
13	End-2029	2027-2029	Fixed period, end of planned production	616
15	End-2031	2030-2031	Fixed period, all rehabilitation completed	861
			TOTAL	**4,743**

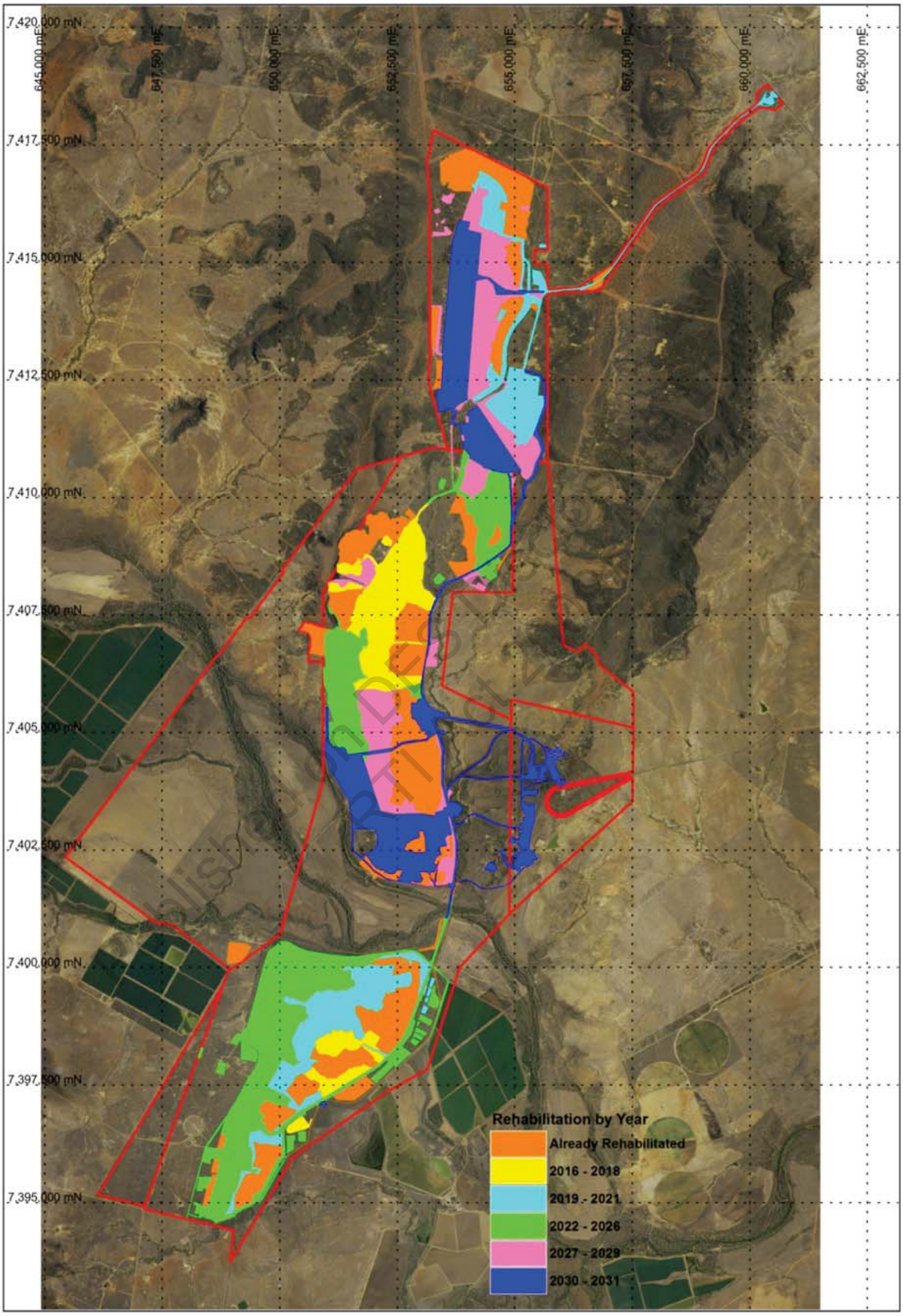

Figure 2-4 Indicative forecast progressive rehabilitation to end of mine life

3 MATERIAL CHARACTERISTICS

To determine appropriate landform design parameters for rehabilitation, it is crucial to understand material characteristics. Several reports have described materials at Ensham to varying extents, e.g. Loch (2015), URS (2005), URS (2015) and CMLR (2005), and each contain some useful information. Reports demonstrate that spoils and soils are typically sodic and saline, and non-acid forming.

3.1 Overburden types and distribution

CMLR (2005) provides a simple and practical classification of overburdens based on geology and measured physical and chemical parameters. Four distinct spoils were identified, described and mapped throughout the mine (Table 3-1).

Table 3-1 Spoil types and their distribution (adapted from CMLR, 2005)

Era	Period	Group	Description	Ensham pit						
				A	B	C	D	E	F	Y
Cainozoic	Quaternary	n/a	Alluvial sands, silt gravel	Q						
	Tertiary	n/a	Sandstone, siltstone, claystone			T2			T2	
				T1						
Palaeozoic	Upper Permian	Blackwater	Rangal coal measures	P						
				COAL						

A description of each overburden type follows.

3.1.1 Quaternary (Q) overburden

Pale brown to yellow alluvial sands and gravels (Figure 3-1). Low clay content means material has little water or nutrient holding capacity. Non-saline but sodic with low surface cohesion, this overburden is highly dispersive and prone to excessive erosive when exposed to rainfall.

Figure 3-1 Quaternary overburden in B Pit is screened for gravel and sand for use around site (left) and erosion of in situ Quaternary overburden on B Pit endwall (right)

3.1.2 Tertiary (T2) overburden

This overburden is Tertiary age material that appears above T1 overburden in B, C, F and Y pits. It is distinguishable from T1 by its darker colour but is otherwise physically and chemically similar.

3.1.3 Tertiary (T1) overburden

Overlying the Permian overburden, this material is derived from Tertiary age alluvium or colluvium (Figure 3-2). It is consistently saline to extremely saline, with chloride levels toxic to plants at Y Pit, and consistently sodic to extremely sodic. This material is extremely dispersive.

Figure 3-2 Tertiary overburden overlying Permian overburden in Y Pit (left) and F Pit (right)

3.1.4 Permian (P) overburden

Easily distinguished by its bluish grey colour, consisting on rapidly weathering mudstones and siltstones, with orange/yellow resistant sandstone fragments (Figure 3-3). Derived from Permian sedimentary rocks of the Blackwater Group, it is generally non-saline to saline and sodic.

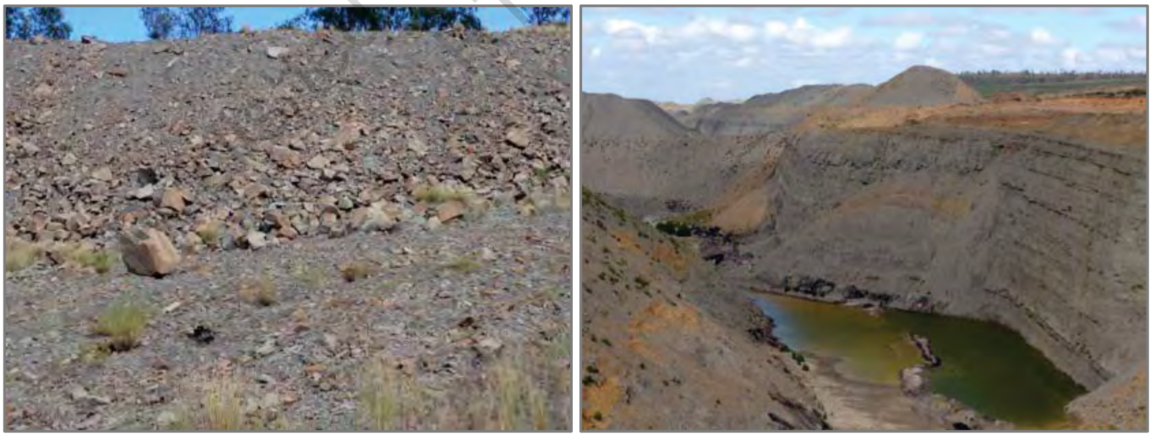

Figure 3-3 Permian overburden in D Pit emplacement (left) and E Pit highwall (right)

3.2 Soil types and distribution

A range of soil types is present at Ensham and these have previously been grouped into six major types (Hansen 2006):

- *Soil Group (1) – Shallow Rocky Soils* (Rudosols) that occur on low rocky hills and steep escarpment slopes and eroded plateau remnants. These soils are shallow (<0.5m), exhibit very little profile development and contain gravel and rock cobbles from various geological formations.

- *Soil Group (2) – Moderately Shallow Gravelly Sands, Loams and Clay Soils* (Rudosols and Tenosols) that occur on eroded middle and lower slopes and broad low gravelly rises. These soils are shallow to medium depth and comprise uniform or weakly gradational sands, loamy sands or sandy loams, loams or clayey soils with varying amounts of ferrundinous and siliceous gravel or stone. These soils exhibit low soil fertility and water storage capacity.
- *Soil Group (3) – Gradational Red and Yellow Earth Soils* (Kandosols-Tenosols, Kandosols and Ferrosols) present on the elevated dissected and eroded Tertiary plateau remnants and undulating plains associated with the Tertiary Emerald Formation. These soils include sandy, sandy loam or loamy surface soils grading to red, reddish brown or yellowish brown sandy loam to light to medium massive or structured clay subsoils often with appreciable amounts of ferruginous gravel.
- *Soil Group (4) – Texture Contrast (Duplex) Soils* (Sodosols) that have formed on Permo- Triassic sedimentary rocks, on gently inclined slopes, dissection slope interfluves, broad low rises and plains and on alluvial terraces and drainage flats. These soils are sandy, silty or loamy on the surface with a clear to abrupt change to a clayey subsoil horizon.
- *Soil Group (5) – Uniform Fine-textured (non-cracking) Clay Soils* (Dermosols) present on erosional plains, levees and high terraces along stream systems, undulating alluvial plains and associated with cracking clays of Soil Group 6. These soils exhibit uniform profiles or weakly gradational profiles where clay content may increase slightly with depth.
- *Soil Group (6) – Cracking Clay Soils (Vertosols)* that form the dominant soil type within the alluvial plains associated with the Nogoa River and its tributaries. These soils have uniform medium to high clay content, pronounced swelling and shrinkage properties and commonly feature gilgai.

Most soils are highly weathered, chemically and physically poor, and can be saline and sodic at depth.

3.3 Effect of salinity and sodicity

Salinity is the presence of soluble salts in soil solution, while sodicity is the relative percentage of Na^+ attached to clay particles, i.e. on the cation exchange surfaces. Salinity and sodicity are opposing forces in soil / overburden stability: salinity is aggregating and sodicity is dispersing. Salinity and sodicity often occur together and salt affected materials have historically been grouped as saline, non-saline and sodic, or saline and sodic, depending on the relative composition of the salts present. Using available data, Ensham overburdens and soils can be grouped into these categories (Figures 3-4 and 3-5). Here, a saturated electrical conductivity (ECe) >4 (dS/m) and an exchangeable sodium percentage (ESP) >6 are the generally

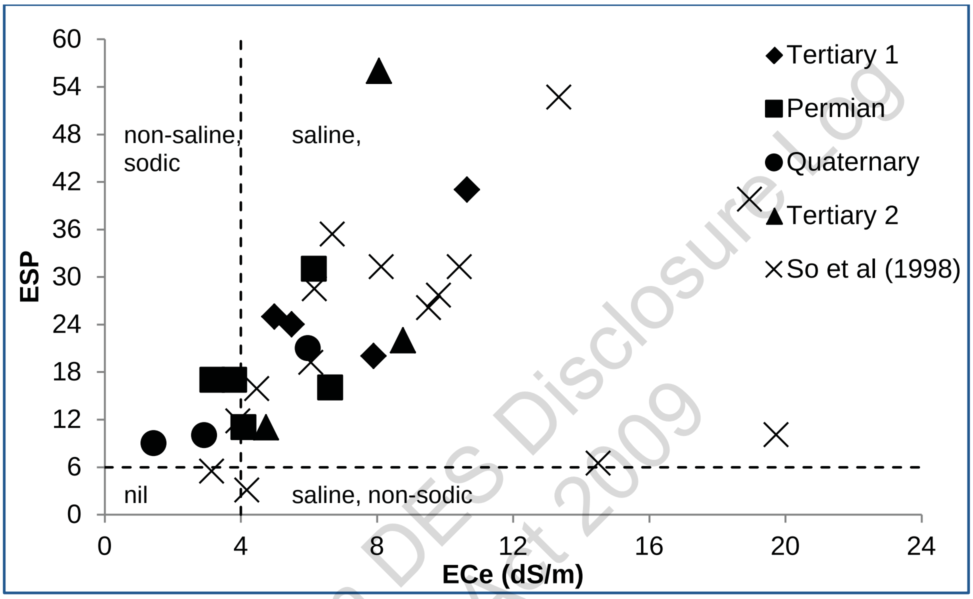

Figure 3-4 Salinity and sodicity categorisation of Ensham overburdens (after CMLR 2005) and 16 central Queensland overburdens by ACARP C4011 (So *et al* 1998)

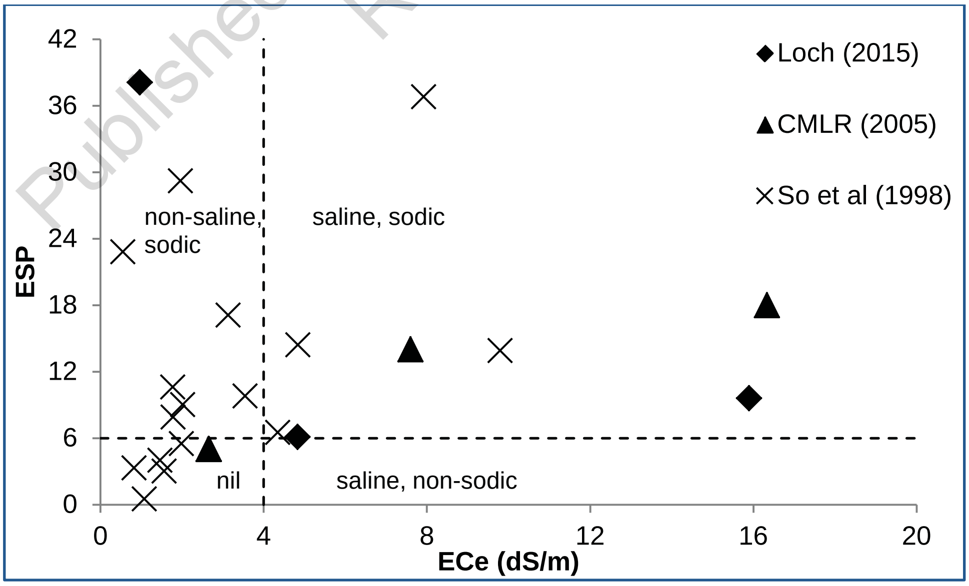

Figure 3-5 Salinity and sodicity categorisation of Ensham soils (after Loch 2015 and CMLR 2005) and 16 central Queensland soils by ACARP C4011 (So *et al* 1998)

accepted threshold limits for salinity impacts on plants and sodicity impacts on soil structure. For regional context, the 32 central Queensland soils and overburdens assessed by So *et al* (1998) in ACARP Project C4011 are included.

However, for a given sodicity value, as EC increases soil dispersion decreases. Conversely, very low EC values mean that a soil may become dispersive where the ESP is very low, e.g. ESP of 2. The relationship between salinity and sodicity is the electrochemical stability index (ESI). ESI is determined by calculating the ratio of EC to ESP, i.e. ESI = EC1:5/ESP. The adopted critical ESI value for Australian soils is 0.05 (McKenzie 1998). Materials with an ESI less than the critical value will be prone to dispersion. Most of the Ensham overburdens and soils are highly dispersive (Figures 3-6 and 3-7).

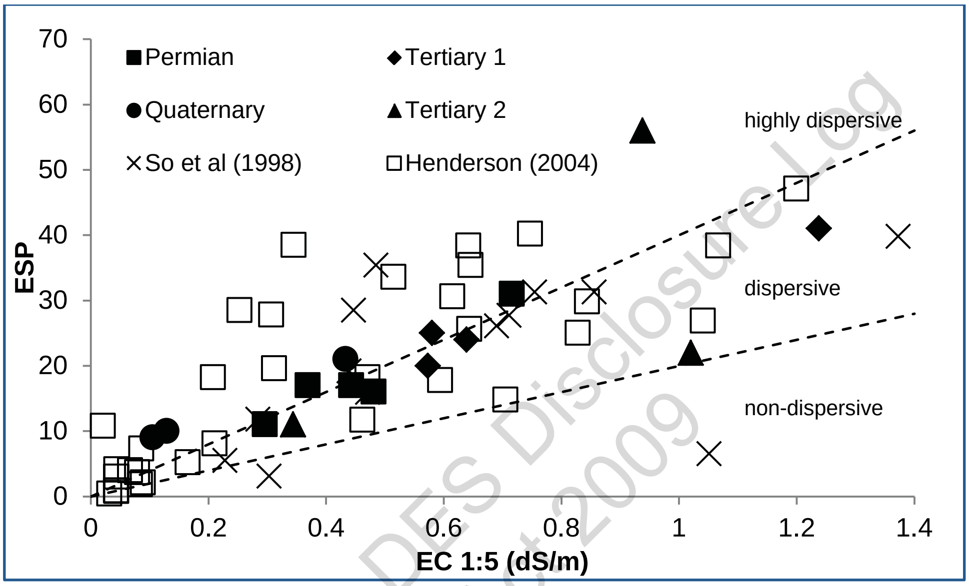

Figure 3-6 Classification of dispersive materials showing Ensham overburdens (after CMLR 2005), 16 central Queensland overburdens by ACARP C4011 (So *et al* 1998) and 40 central Queensland overburdens by ACARP C12031 (Henderson 2004)

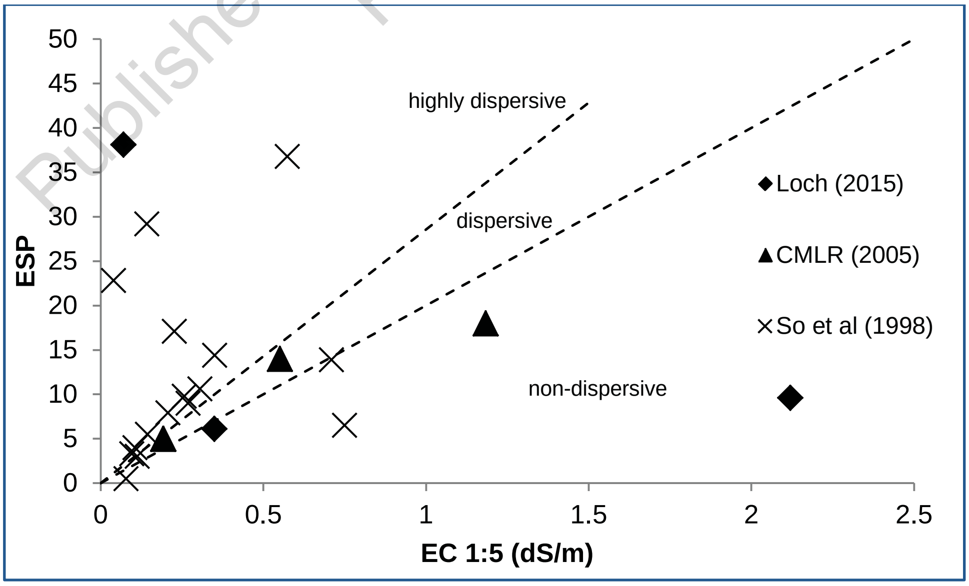

Figure 3-7 Classification of dispersive materials showing Ensham soils (after CMLR 2005 and Loch 2015) and 16 soils by ACARP C4011 (So *et al* 1998)

ESI explains the extremely dispersive nature of some overburdens, particularly Tertiary age materials. Although also highly saline, this salinity is insufficient to counter the effects of extreme sodicity, and the material disperses readily and is prone to excessive erosion.

Ensham overburdens can be ranked in terms of salinity, sodicity and dispersivity (Figure 3-8).

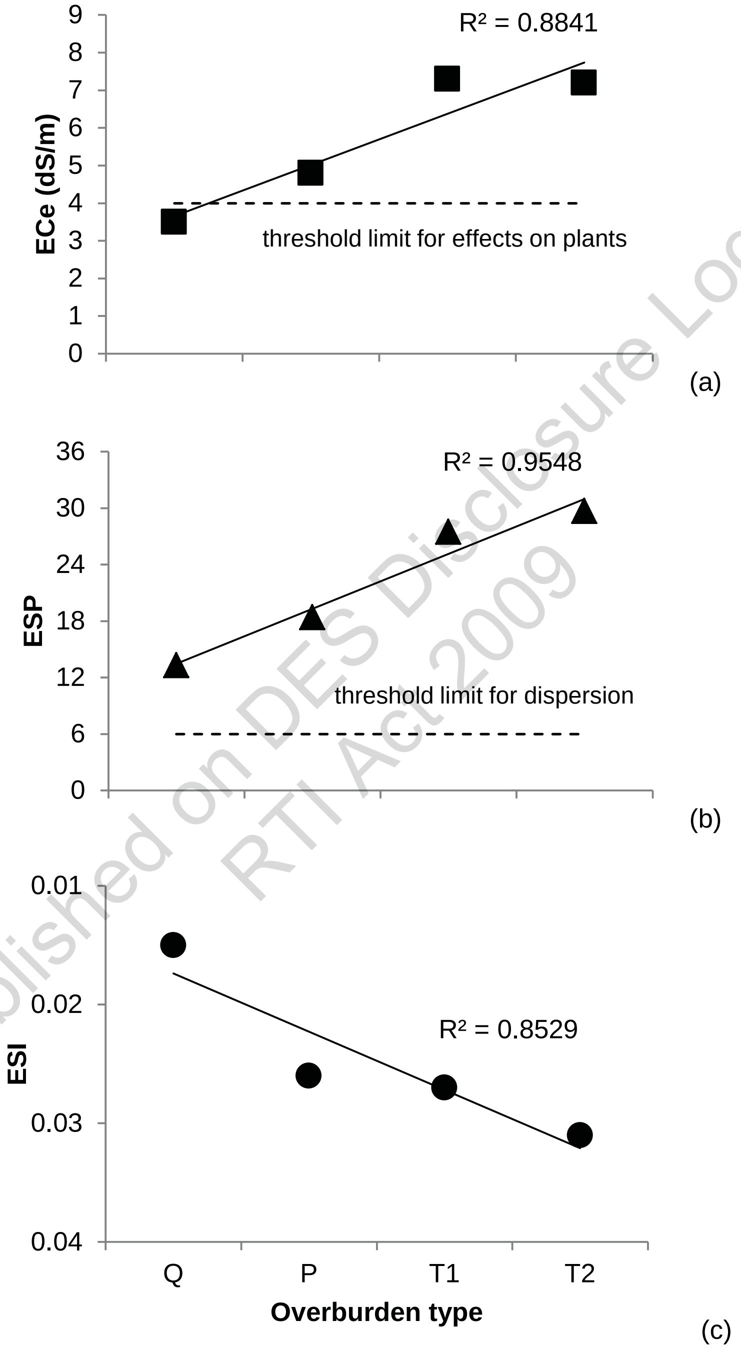

Figure 3-8 Relative salinity (a), sodicity (b) and dispersivity (c) of Ensham overburdens (after CMLR 2005)

This analysis shows that:

- Quaternary overburden is the most dispersive, but Tertiary overburdens are the most saline and most sodic;
- Tertiary overburdens are about twice as saline as Permian overburdens; and,

- All overburdens are highly dispersive.

3.4 Management of overburdens in rehabilitation landscapes

3.4.1 Quaternary (Q) overburden

Quaternary overburden is the most dispersive and least cohesive overburden at Ensham, making it prone to excessive tunnel and gully erosion. This material will be selectively placed and buried beneath other material to ensure it does not present at or near the surface of final landforms. It is not suitable for topsoil application and rehabilitation.

3.4.2 Tertiary (T1 and T2) overburden

Tertiary overburdens are the most saline and sodic, are prone to excessive dispersion and erosion, and occur in every pit at Ensham. Common throughout central Queensland mines, Tertiary overburdens have been extensively studied by ACARP and other industry-led research.

For example, ACARP C12031 *Rehabilitation of Dispersive Tertiary Spoil in the Bowen Basin* by Henderson (2004) made the following recommendations in ascending order of risk of poor outcome, i.e. decreasing hazard control effectiveness.

- Bury under another spoil type.
- Cover with at least a metre of rocky spoil to create a '<u>store and release</u>' cover system.
- Topsoil and grass cover at slope angles that avoid sliding failure along the soil/spoil interface when wet. Provide measures to assist erosion control until grass is established.

Practice at Ensham and other mines in central Queensland shows that conservative slope gradients are required to control erosion of Tertiary overburden. The common approach is to limit slope gradients to not more than 10%. Ensham can demonstrate appropriate hazard control effectiveness with respect to dispersion and erosion risks when:

- Slope gradients of Tertiary overburden do not exceed 10% maximum gradient;
- Slope lengths do not exceed 200m;
- Contour banks and rock-lined waterways are not used; and,
- Hay mulch is applied at the time of sowing.

3.4.3 Permian (P) overburden

Permian overburden is about 50% less saline and 50% less sodic than Tertiary overburdens. Though similarly dispersive, the material is favoured for rehabilitation because it is:

- Less hostile to the establishment and growth of plants; and,
- More erosion resistant, due in part to its variable content of course sandstone fragments.

Practice at Ensham and other mines in central Queensland shows that this material can be effectively rehabilitated with slope gradients of up to 15%. If steeper than this, than Permian overburdens should be clad with at least 1m of durable rock to prevent erosion.

4 LANDFORM DESIGN OBJECTIVES

Ensham has developed an innovative rehabilitation domain model and determined rehabilitation objectives for each area. The overarching objectives for rehabilitation are:

1. Conduct safe operations;
2. Meet regulatory requirements;
3. Minimise social and environmental risk; and,
4. Control costs.

Specific objectives for each rehabilitation domain are detailed as follows.

4.1 Rehabilitation domains

Ensham has developed an enhanced domain model in which there are two types of domains to consider for rehabilitation, i.e. primary and secondary domains (Table 4-1). All areas to be rehabilitated have been assigned primary and secondary domains that describe the type of mining disturbance and a target post-mining land use.

Primary domains are areas of mining disturbance with unique operational purpose or function and therefore similar geophysical characteristics and rehabilitation treatment requirements. Secondary domains are areas in the post-mining landscape with the same sustainable land use objective, e.g. sustainable cattle grazing. It is possible that a primary domain could have more than one secondary domain, e.g. 3A (sustainable cattle grazing on mine infrastructure areas) and 3E (landholder retained infrastructure on mine infrastructure areas), in different areas at Ensham. Whilst secondary domains may exist adjacent to each other, they are mutually exclusive on-ground and not overlapping. This allows clear and unambiguous indicators and criteria to be nominated for each combination of primary and secondary domains.

Table 4-1 Ensham rehabilitation domain model

Code	Primary domains	Code	Secondary domains
1	Overburden emplacement	**A**	Sustainable cattle grazing
2	Mining pit	**B**	Water storage
3	Mining infrastructure	**C**	Remnant mining voids
4	Boggy creek diversion	**D**	Watercourse bed, banks and riparian vegetation
		E	Landholder retained infrastructure

The location and extent of each rehabilitation domain in the post-mining landscape has been determined (Figure 4-1).

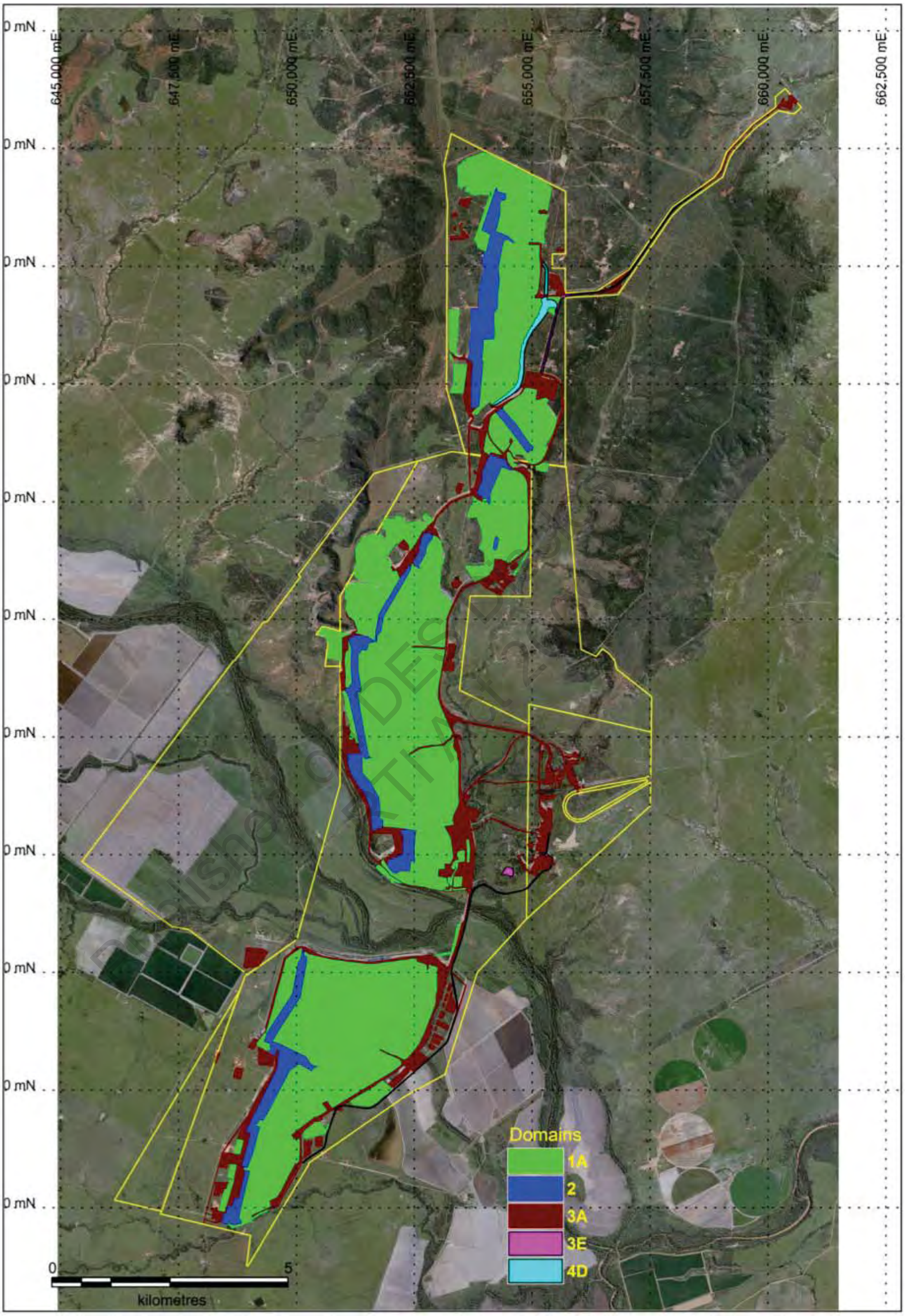

Figure 4-1 Location and extent of rehabilitation domains in the post-mining landscape

4.2 Rehabilitation goals

In accordance with EHP *Guideline - Rehabilitation requirements for mining projects* (EM1122)[2], Ensham has adopted the Government's policy objectives for rehabilitation and called these 'rehabilitation goals'. These goals are:

1. Safe to humans and wildlife
2. Non-polluting;
3. Stable; and
4. Able to sustain an agreed post-mining land use.

Ensham has determined that there are no additional goals that are relevant to the site.

4.3 Objectives

Ensham has developed objectives that clearly describe desired rehabilitation outcomes within each domain on the mine site (Table 4-2). Objectives recognise the general rehabilitation goals and ESD principles set by government. The overarching objectives for rehabilitation at Ensham are to ensure safety hazards are not greater than those that exist in the surrounding landscape, and to establish a structurally stable, non-polluting landscape that maximises potential for a sustainable grazing land use. Reinstating the previous land use of grazing is fourth on the rehabilitation hierarchy, and this is the highest practicable level for rehabilitation at Ensham.

Table 4-2 Rehabilitation objectives for each domain

<table>
<tr><th rowspan="2">Domain</th><th rowspan="2">Description</th><th colspan="4">Objectives based on goals</th></tr>
<tr><th>Safe to humans and wildlife</th><th>Non-polluting</th><th>Stable</th><th>Able to sustain an agreed post-mining land use</th></tr>
<tr><td>1A</td><td>Sustainable cattle grazing on overburden emplacement areas</td><td rowspan="2">Safety hazards in rehabilitation are similar to surrounding unmined landscapes[3].</td><td rowspan="3">Surface runoff leaving domain is non-polluting to receiving waters (Nogoa River).</td><td rowspan="2">Landforms are both geo-technically and erosionally stable.</td><td rowspan="2">Rehabilitation is suitable for sustainable cattle grazing.</td></tr>
<tr><td>3A</td><td>Sustainable cattle grazing on mining infrastructure areas</td></tr>
<tr><td>3E</td><td>Landholder retained infrastructure on mining infrastructure areas</td><td>Safety hazards accepted by landholder.</td><td>Landholder accepts the condition of infrastructure, including its structural integrity.</td><td>Landholder formally accepts infrastructure for his/her ongoing beneficial use.</td></tr>
</table>

[2] Guideline, Resource Activities, Rehabilitation requirements for mining resource activities, EM1122 Version 2, Department of Environment and Heritage Protection, 2014.
[3] The surrounding landscape, particularly landform, has been comprehensively described in EIS, EMOS and EMP documentation.

Domain	Description	Objectives based on goals			
		Safe to humans and wildlife	*Non-polluting*	*Stable*	*Able to sustain an agreed post-mining land use*
4D	Watercourse bed, banks and riparian vegetation of the Boggy creek diversion	Safety hazards in rehabilitation are similar to surrounding unmined landscapes.		Landforms are both geo-technically and erosionally stable.	Riparian vegetation is suitable for conservation of rehabilitated creek diversion areas.
2(x[4])	Per condition G6, this information is to be provided by 31 March 2019.				

4.4 Design objectives for slope gradients and lengths

With respect to slope gradient and length, the basic design objective for all rehabilitation is to control erosion risk. So *et al* (1998) measured the rate of erosion-derived sediment delivery from 32 bare soils and overburdens in central Queensland at slope gradients from 5 to 30%. Unremarkably, sediment delivery rates increased linearly with slope (Figure 4-2) and also with slope length. The effect of increasing slope gradient from 5% to 30% was a 12-fold and 4-fold increase in sediment delivery rates for soils and spoils, respectively. Soils and spoils with 20-30% silt tended to form strong raindrop impact seals (hard surface crusts) under rainfall and consequently had very low erodibilities.

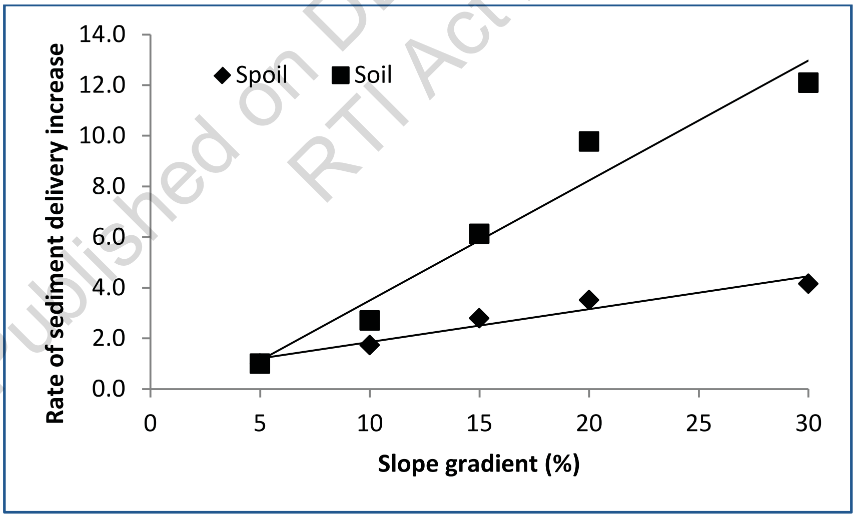

Figure 4-2 Effect of slope gradient on the rate of sediment delivery for central Queensland soils and overburdens (after So *et al* 1998)

There is no guideline that provides the optimal slope gradient and length combination for rehabilitation. Erosion is a function of not only slope gradient and length, but also of material properties, surface condition and groundcover, and rainfall. For example, the impact of vegetation on erosion from rehabilitated soils in central Queensland has been described as “enormous” (So *et al* 1998) and the single most important control on erosion (Grigg *et al* 2001).

[4] To be determined and provided in accordance with EA condition G6 by 31 March 2019.

With consideration to material characteristics (see section 3) and more than 40 years of industry-led research and practice, Ensham has determined the following design objective for slopes.

1. Tertiary overburden slopes, regardless of soil type, will have:
   - Gradients ≤10%, and
   - Lengths ≤200m, variable depending on the size of the contributing upper catchment.
2. Permian overburden slops, regardless of soil type, will have:
   - Gradients ≤15%, and
   - Lengths ≤100m, variable depending on the size of the contributing upper catchment.

4.5 Design objectives for aesthetics and sympathy to the surrounding landscape

The visual appeal and/or natural appearance of rehabilitation are not rehabilitation goals. The notion that form and function are closely linked and hence mining landscapes should be fashioned to look natural, as though they are the product of natural geomorphic processes, can not displace operational safety, cost and stability considerations in rehabilitation.

Mining is transformative in the landscape, and in central Queensland unconsolidated overburden emplacements are inherently more erodible than natural landforms. However, form (landscape attributes) and function (flow of energy, material and species) must be matched in rehabilitation too. This will likely be a fundamental characteristic of successful post-mining landscapes.

Ensham accepts that a 'natural appearance' may be important to some stakeholders and will endeavour to design landforms within the natural range of geometries of regional landforms. Natural landforms in the vicinity of Ensham are described as follows (Ensham Resources, 1996):

- Terrain in the northern half of the mine comprises mainly mildly dissected gently to moderately sloping and undulating lands, which form slopes and outwash plains flanking Boggy Creek. Erosion has occurred below the elevated plateau remnants that occur in the north.
  Plateau remnants feature steep escarpments, with sloes in the order of 33% to 66% gradient or more, with local relief up to 50 m between plateau crests and adjacent escarpment foot slopes.
- In the southern half, terrain is essentially gently sloping. This encompasses the extensive floodplain area of the Nogoa River.

Key post-mining landform design parameters for rehabilitation are within the natural range of geometries of local landforms, e.g. slope gradients and lengths.

5 TOPSOIL MANAGEMENT

Topsoil is salvaged in advance of mining disturbance and preserved for use in rehabilitation.

5.1 Topsoil quantity

Ensham currently holds about 3.5 million cubic metres (Mm^3) of topsoil in stockpiles, preserved for use in future rehabilitation (Table 5-1).

Table 5-1 Location and volume of preserved topsoil

Location (pits)	Volume (m^3)
A and B	2,491,370
C, D and E	362,038
F	342,271
Y	474,635
TOTAL	3,670,332

If respread to create a 200mm soil layer for rehabilitation this quantity is sufficient to cover approximately 1,800ha. This highlights a topsoil deficit of around 3,000 ha. Ensham will manage this deficit by:

- Strategically using topsoil to promote rapid groundcover establishment and stabilisation of outer slopes that drain to the broader environment.
- Ameliorating Permian overburden to create a plant growth media or 'topsoil substitute', e.g. by additions of organic matter, gypsum and/or fertiliser.

6 REHABILITATION METHODS

Following is a summary of on-ground rehabilitation methods used at Ensham (Table 6-1).

Table 6-1 Rehabilitation methods for each domain

Domain		Rehabilitation methods
1A	Sustainable cattle grazing on overburden emplacement areas	1. Reshape to achieve post-mining landform design parameters using draglines, dozers or truck/shovel equipment; 2. Apply ameliorants such as gypsum, if needed; 3. Respread topsoil to 200mm depth (average); 4. Deep rip to 600mm on 2m centres using the 'Ensham ripper'; 5. Sow seed and spread fertiliser; 6. Spread hay mulch for immediate groundcover; 7. Monitor and maintain rehabilitation domains; 8. Erect fencing and supply stockwater then establish post-mining grazing land use.
3A	Sustainable cattle grazing on mining infrastructure areas	1. Remove infrastructure; 2. Complete contaminated land assessment and management; 3. Reshape to achieve post-mining landform design

Domain		Rehabilitation methods
		parameters, if required; 4. Apply ameliorants such as gypsum, if needed; 5. Respread topsoil to 200mm depth (average); 6. Deep rip to 600mm on 2m centres using the 'Ensham ripper'; 7. Sow seed and spread fertiliser; 8. Spread hay mulch for immediate groundcover; 9. Monitor and maintain rehabilitation domains; 10. Erect fencing and supply stockwater then establish post-mining grazing land use.
3E	Landholder retained infrastructure on mining infrastructure areas	1. Remove unwanted infrastructure; 2. Complete contaminated land assessment and management; 3. Monitor and maintain rehabilitation domains.
4D	Watercourse bed, banks and riparian vegetation of the Boggy Creek diversion	1. Reshape to achieve post-mining landform design parameters based on ACARP research; 2. Apply ameliorants such as gypsum, if needed; 3. Strategically respread topsoil to 200mm depth (average); 4. Where vegetation is to be established, i.e. banks, then a. Deep rip to 600mm on 2m centres using the 'Ensham ripper'; b. Sow seed and spread fertiliser; c. Spread hay mulch for immediate groundcover; 5. Monitor and maintain rehabilitation domains; 6. Erect fencing to exclude domestic stock for the protection of riparian vegetation.

7 NATIVE VEGETATION CORRIDORS

Much of the native vegetation surrounding Ensham has been extensively cleared for agricultural land development. Existing vegetation corridors mainly associated with the Nogoa River and its tributaries will remain in the post-mining landscape (Figure 7-1). As the most appropriate post-mining land use for Ensham is sustainable cattle grazing, no additional native vegetation corridors will be constructed in rehabilitation.

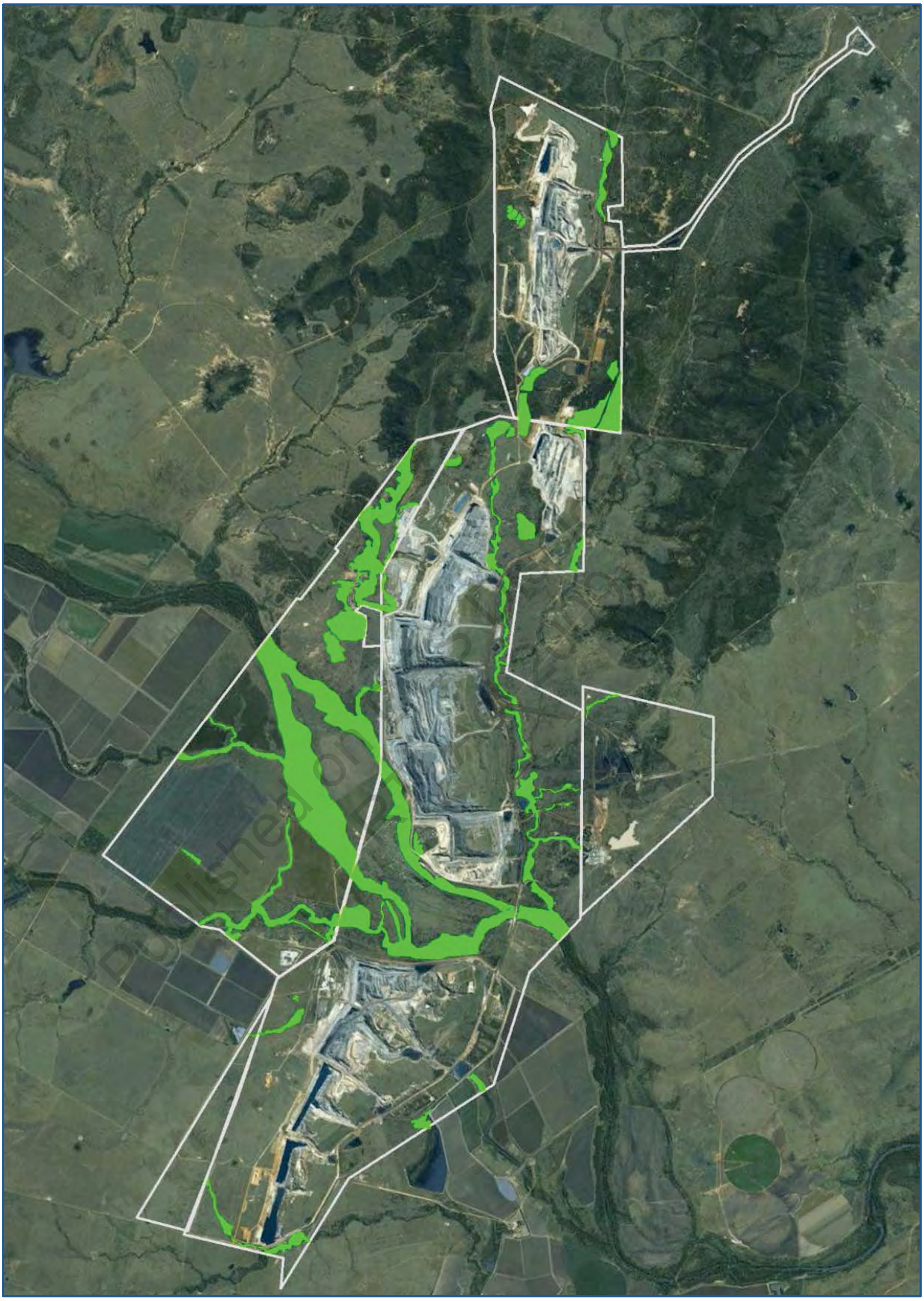

Figure 7-1 Native vegetation corridors

8 REFERENCE SITES

Since 2005, rehabilitation monitoring has included assessment and comparison of rehabilitation outcomes to reference sites. Reference sites are selected to provide 'target conditions' for rehabilitation and therefore, have should comparative:

- Soil, landform and land suitability;
- Vegetation form;
- Species assemblages;
- Land use.

However, it is difficult to select reference sites to compare rehabilitation due to the transformative impacts of mining on hydrology, topography and geology of the land. This may ultimately limit the usefulness of reference sites in benchmarking rehabilitation outcomes. For example, it is reasonably foreseeable that some rehabilitation may achieve the rehabilitation goals of safe, stable, non-polluting and sustainable land use, but remain *'different'* in form and function to unmined reference sites.

Despite recognised difficulties with this approach, a number of reference sites have been established and monitored at Ensham (Table 8-1). As an objective for most rehabilitation is sustainable cattle grazing land use, selection of reference sites has been skewed towards unmined areas used for pasture and/or grazing.

Table 8-1 Details of reference sites for rehabilitation monitoring (GDA 94, Zone 55)

Site ID	Description	Easting	Northing
DPREF1	Alluvial plain, ungrazed	650976	7402880
DPREF2	Alluvial plain, grazed	649302	7403072
ENREF1	Ungrazed grassland	654151	7408247
ENREF2	Grazed grassland	654063	7408087
Ironbark REF5	Open woodland	655590	7411002
Yapunyah REF6	Open woodland	650168	7406780

9 VALUES, INDICATORS AND COMPLETION CRITERIA

Rehabilitation goals and objectives (refer to section 4) and indicators and completion criteria are interdependent with environmental values. The following describes environmental values, identifies indicators and completion criteria, and outlines linkages between environmental values and rehabilitation indicators and completion criteria.

9.1 Environmental values

Ensham has previously identified environmental values (EVs) for air, groundwater, surface water, noise, ground vibration and air-blast overpressure, waste, land, community, nature conservation and cultural heritage (Hanson Bailey 2009). Some of these are not relevant to the post-mining landscape, e.g. noise, ground vibration and air-blast overpressure, and cultural heritage.

EVs relevant to rehabilitation are:

Air - In accordance with the *Environmental Protection (Air) Policy 2008 (EPP Air)*, the environmental values of the air environment to be enhanced or protected are the qualities of the air environment that are conducive to suitability for the life, health and wellbeing of humans.

Groundwater - The environmental values associated with groundwater resources that may potentially be affected by Ensham include the water level and water quality of the Nogoa River alluvial aquifer and the coal seam aquifer.

Surface water - The surface water environmental values which may potentially be affected by Ensham Mine include the following:

- Surface water quality, including the Nogoa River and tributary streams;
- The Nogoa Mackenzie Water Supply Scheme, which includes conveyance of allocated water supply flows via the reach of the Nogoa River traversing the mine site; and

Land - The environmental values to be protected or enhanced are the:

- The suitability of the project site for agricultural activities; and
- The aesthetic qualities of the landscape.

Community - The environmental values to be enhanced or protected are those that relate to the existing lifestyle of the surrounding community, including the general wealth, health, safety and wellbeing of the community.

The potential impacts of rehabilitation indictors and completion criteria on relevant EVs, the risks of those impacts and mitigation measures have been identified (Table 9-1). As indicators and criteria set the standards that rehabilitation must achieve, and these standards must ensure protection of the environment, these also constitute mitigation measures for EV risk management. The robust scientific bases of criteria are found in references provided as footnotes where each criterion appears for the first time in table text. Risk evaluation was performed in accordance with the Ensham Risk Matrix Tool (Appendix B).

Ensham RESOURCES

Table 9-1 Environmental value linkages to rehabilitation indicators and completion criteria

EV	Potential impacts[5]	Rehabilitation objective	Mitigation measures		Final risk[6]
			Indicators	Completion criteria	
Air	Dust Odour	Landforms are both geotechnically and erosionally stable	Dust - Groundcover percentage Odour – none proposed	≥50%	L24 (low)
Groundwater	Deep drainage (seepage) of contaminants	Deep drainage (seepage) from domain is non-polluting to recognised groundwater resources	Contaminated land assessment	Zero contaminated sites	L25 (low)
			Per condition G6 of the EA		
Surface water	Runoff containing contaminants	Surface runoff leaving domain is non-polluting to receiving surface waters (Nogoa River)	pH	7.5 – 8.3[7]	L21 (low)
			EC (salinity)	125 - 1250 µS/cm[8]	L21 (low)
			TSS (sed. loss)	85 mg/L (max)[9]	L21 (low)
			Sulphate	2.2-22.0 mg/L[10]	L25 (low)

[5] As relevant to each domain, refer to Table 9-2
[6] Risk assessed in accord with Ensham risk matrix (Appendix B)
[7] 10^{th} and 90^{th} Percentiles of pH from Government water sampling for Nogoa River upstream at Duckponds (141 samples, 1993-2015 period), see *"Water sample analysis summary report"*, available at https://water-monitoring.information.qld.gov.au. Values derived in accordance with Section 4.3 of Queensland Water Quality Guidelines 2009, DEHP, State of Queensland, 2013
[8] 10^{th} and 90^{th} Percentiles of EC for the Nogoa Basin north of Emerald, highly disturbed system (regulated river), from Queensland Water Quality Guidelines 2009, DEHP, State of Queensland, 2013
[9] Total suspended solids (TSS) post-construction phase, from Queensland Water Quality Guidelines 2009, DEHP, State of Queensland, 2013
[10] 10^{th} and 90^{th} Percentiles of sulphate from Government water sampling for Nogoa River upstream at Duckponds (70 samples, 1993-2016 period), see *"Water sample analysis summary report"*, available at https://water-monitoring.information.qld.gov.au. Values derived in accordance with Section 4.3 of Queensland Water Quality Guidelines 2009, DEHP, State of Queensland, 2013

EV	Potential impacts[5]	Rehabilitation objective	Mitigation measures		Final risk[6]
			Indicators	Completion criteria	
		Riparian vegetation is suitable for conservation of rehabilitated creek diversion areas.	Index of diversion condition (IDC)	>10[11]	L23 (low)
Land	Changes to land suitability Changes to land use	Rehabilitation is suitable for sustainable cattle grazing	Land suitability assessment	Land suitability classes 2-4[12]	L23 (low)
	Land contamination		Contaminated land assessment	Zero contaminated sites[13]	L25 (low)
	Loss of aesthetic qualities	Landforms are erosionally stable	Groundcover	50%[14]	L23 (low)
			Slope gradient	15% (max) [15]	L25 (low)
Community	Additional safety hazards in the post-mining landscape.	Safety hazards in rehabilitation are similar to surrounding unmined landscapes.	Hazard assessment	No difference pre- and post-mining[16]	L25 (low)
	Land instability	Landforms are geotechnically	Factor of safety	≥1.5[17]	L23 (low)

[11] White K, Moar D, Hardie R, Blackham D and Lucas R 2014, 'Criteria for functioning river landscape units in mining and post-mining landscapes', final report of ACARP Project number C20017, Australian Coal Research Limited, Brisbane.
[12] Guidelines for Agricultural Land Evaluation in Queensland, second edition, DNRM and DSITIA, State of Queensland 2013 (about 15 land and soil attributes are assessed to determine land suitability class)
[13] In accordance with statutory requirements for the identification and management of contaminated land in Queensland
[14] Many studies have demonstrated that with groundcover >50% erosional soil loss from rehabilitation is negligible, e.g. see Carroll, C and Tucker, A 2000, 'Effects of pasture cover on soil erosion and water quality on central Queensland coal mine rehabilitation', Tropical Grasslands, vol. 34, pp 254-262; Carroll C, Tucker A, Merton P, Burger P and Pink L 2001, 'Sustainability indicators for coal mine rehabilitation, ACARP Project Number C7006, Australian Coal Research Limited, Brisbane; Loch, R 2000, 'Effects of vegetation cover on runoff and erosion under simulated rain and overland flow on a rehabilitated site on the Meandu Mine, Tarong, Queensland'. *Australian Journal of Soil Research*, vol. 38, pp 299-312; So H, Sheridan G, Loch R, Carroll C, Willgoose G, Short M and Grabski A 1998, 'Post-mining landscape parameters for erosion and water quality control', final report of ACARP Project Numbers C1629 and C4011, Australian Coal Research Limited, Brisbane.
[15] In accordance with the Ensham Rehabilitation Management Plan
[16] Methodology in accordance with AS/NZS ISO 13000:2009 Risk Management (this standard is currently applied in risk management at Ensham)

EV	Potential impacts[5]	Rehabilitation objective	Mitigation measures		Final risk[6]
			Indicators	Completion criteria	
		stable			
	Landholders may benefit from retaining some mining infrastructure.	Landholder formally accepts rehabilitation for his/her ongoing beneficial use.	Legally binding agreement	Executed by each party	L25 (low)

9.2 Rehabilitation indicators and completion criteria

Ensham has identified meaningful indictors to provide robust and defensible measurements of progress towards rehabilitation objectives and protection of environmental values. Every domain has been assigned indicators (Table 9-2). Each indicator has a valid scientific basis and a practical and reliable method of measurement, and also reveals something important about the rehabilitation domain.

Criteria are the threshold limits or benchmarks against which indicators will be assessed to determine if rehabilitation objectives have been met. Every indicator has been allocated a relevant criterion or set of criteria. Importantly, criteria are numeric and will be measured to form a set of statistical metrics for on-going analysis during the period of rehabilitation monitoring and evaluation.

Table 1-2 Indicators and completion criteria

Mine domain	Rehabilitation feature name	Goals	Objective	Indicators	Completion criteria
1A	Sustainable cattle grazing on overburden emplacement areas	Safe	Safety hazards in rehabilitation are similar to surrounding unmined landscapes.	Hazard assessment	0 (zero) significant difference
		Non-polluting	Surface runoff leaving domain is non-polluting to receiving surface waters (Nogoa River).	pH	7.5 – 8.3
				EC (salinity)	125 - 1250 µS/cm
				TSS (sed. loss)	85 mg/L (max)
				Sulphate	2.2-22.0 mg/L

[17] Geotechnical slope stability, DME, State of Queensland 1995; Geotechnical considerations in open pit mines, guideline, version 1, DME, State of Western Australia 1999

Mine domain	Rehabilitation feature name	Goals	Objective	Indicators	Completion criteria
			Deep drainage (seepage) from domain is non-polluting to recognised groundwater resources	Per condition G6, this table is to be updated by 31 March 2019 to include indicators and criteria for any potential groundwater impacts, as this may be influenced by residual mining voids.	
		Stable	Landforms are both geo-technically and erosionally stable.	Factor of safety	≥1.5
				Slope gradient	15% (max)
				Groundcover	≥50%
		Land use	Rehabilitation is suitable for sustainable cattle grazing.	Land suitability assessment	Classes 2 to 4
2x	Remnant mining voids on mining pit areas	Per condition G6, this table is to be updated by 31 March 2019 to include indicators and criteria for residual mining voids.			
3A	Sustainable cattle grazing on mining infrastructure areas	Safe	Safety hazards in rehabilitation are similar to surrounding unmined landscapes.	Hazard assessment	0 (zero) significant difference
		Non-polluting	Surface runoff leaving domain is non-polluting to receiving surface waters (Nogoa River).	pH	7.5 – 8.3
				EC (salinity)	125 - 1250 µS/cm
				TSS (sed. loss)	85 mg/L (max)
				Sulphate	2.2-22.0 mg/L
				Contaminated land assessment	0 (zero) contaminated sites
		Stable	Landforms are both geo-technically and erosionally stable.	Factor of safety	≥1.5
				Slope gradient	15% (max)
				Groundcover	≥50%
		Land use	Rehabilitation is suitable for sustainable cattle grazing.	Land suitability assessment	Classes 2 to 4

Mine domain	Rehabilitation feature name	Goals	Objective	Indicators	Completion criteria
3E	Landholder retained infrastructure on mining infrastructure areas	Safe	Safety hazards accepted by landholder.	Legally binding agreement	Executed by each party
		Non-polluting	Surface runoff leaving domain is non-polluting to receiving surface waters (Nogoa River).	pH	7.5 – 8.3
				EC (salinity)	125 - 1250 µS/cm
				TSS (sed. loss)	85 mg/L (max)
				Sulphate	2.2-22.0 mg/L
				Contaminated land assessment	0 (zero) contaminated sites
		Stable	Landholder accepts the condition of infrastructure, including its structural integrity.	Legally binding agreement	Executed by each party
		Land use	Landholder formally accepts infrastructure for his/her ongoing beneficial use.	Legally binding agreement	Executed by each party
4D	Watercourse bed, banks and riparian vegetation of the Boggy creek diversion	Safe	Safety hazards in rehabilitation are similar to surrounding unmined landscapes.	Hazard assessment	0 (zero) significant difference
		Non-polluting	Surface runoff leaving domain is non-polluting to receiving surface waters (Nogoa River).	pH	7.5 – 8.3
				EC (salinity)	125 - 1250 µS/cm
				TSS (sed. loss)	85 mg/L (max)
				Sulphate	2.2-22.0 mg/L
		Stable	Landforms are both geo-technically and erosionally stable.	Factor of safety	≥1.5
				Index of diversion condition	>10
		Land use	Riparian vegetation is suitable for conservation of rehabilitated creek diversion areas.	Index of diversion condition	>10

9.3 Land suitability class as an indicator for sustainable cattle grazing as a post-mining land use

The vast majority of rehabilitation at Ensham is focussed to establishing sustainable cattle grazing as a post-mining land use. Land Suitability Assessment has been identified as the best indicator to determine progress towards this rehabilitation objective. This will be of primary interest to stakeholders and is therefore, worthy of further explanation.

In Queensland, five land suitability classes are defined (DNRM/DSITIA 2013a), with land suitability decreasing progressively from Class 1 to Class 5. These classes are used to describe an area of land in terms of suitability for a particular land use which allows optimum, sustainable production with current technology, while minimising degradation to the land resource in the short, medium or long-term. Land is considered less suitable as the severity of limitations affecting a particular land use increases, reflecting either:

- Reduced potential for production; and/or,
- Increased inputs required to achieve an acceptable level of production; and/or,
- Increased inputs required to prepare the land for successful production; and/or,
- Increased inputs required to prevent land degradation.

The five land suitability classes defined for Queensland are as follows.

Class 1 - Suitable land with negligible limitations – land that is well suited to a proposed use;

Class 2 - Suitable land with minor limitations – land that is suited to a proposed use but which may require minor changes in management to sustain the use;

Class 3 - Suitable land with moderate limitations – land that is moderately suited to a proposed use but which requires significant inputs to ensure sustainable use;

Class 4 - Marginally suitable land with severe limitations – land which is marginally suited for a proposed use and would require major inputs to ensure sustainability; often the inputs required may not be justified in terms of the benefits to be gained from using the land for a proposed use and the land is considered presently unsuitable for that use; and

Class 5 - Unsuitable land with extreme limitations – land that is unsuited and cannot be sustainably used for a proposed use.

Classes 1 to 3 are considered suitable for a specified land use because the benefits from using the land (for that particular use) outweigh the inputs required to initiate and maintain production.

Typically, the benefits from using Class 4 land are similar in magnitude to the level of inputs required to achieve production and its long-term suitability for the specified land use is doubtful. Class 4 is also used in situations where reducing the effect of a particular limitation may indicate production is possible, but additional studies are needed to determine the feasibility of such actions, e.g. fertilisation.

In contrast, there is no doubt regarding the long-term suitability of Class 1–3 lands or the unsuitability of Class 5 land. Class 5 land has limitations that in aggregate are so severe that the benefits do not justify the inputs required to initiate and maintain production. It would require a major change in economics, technology or management expertise before the land could be considered suitable for the land use being considered. Many Class 5 lands have physical characteristics that totally preclude any form of development, e.g. very steep slops, and will always remain unsuitable for agriculture.

9.3.1 Suitability for grazing

The suitability classification for grazing evaluates soils in terms of the potential to graze and finish cattle on improved pastures (QDME 1995, Shields and Williams 1991). Typically, grazing systems in inland Central Queensland aim to produce young, finished, grassfed, export quality cattle without inputs other than pasture development. Most production is based around improved grass-legume pastures. Improved pasture development in many areas is dominated by buffel grass, although Rhodes grass, introduced bluegrasses (Indian bluegrass, creeping bluegrass), purple pigeon grass and panic species all have a role in certain situations. Legume establishment and species vary significantly depending on soil characteristics and microclimates. Commonly used legumes include shrubby stylos species, Desmanthus species, Wynn cassia (sandy soils), butterfly pea (clay soils), siratro, medics and leucaena (cropping soils).

Class 1 and 2 land is considered suitable for grazing improved pastures and is capable of attaining maximum grazing productivity (QDME 1995, Shields and Williams 1991). In inland Central Queensland this can be defined as the production of young, finished, grassfed, export quality cattle in most seasons, and such country is termed 'fattening country'.

Class 3 land is suitable for grazing improved pastures but is generally less productive than Classes 1 and 2 and encompasses a range in productivity. Land in this class is often termed *'growing country'* and is defined as country on which younger cattle perform well but may be difficult to finish at a young age, depending on seasonal conditions, i.e. cattle on Class 3 land may take longer to achieve the desired weight class or finished grade than equivalent cattle on Classes 1 and 2 land.

Class 4 land is considered marginal for grazing improved pastures, but is generally considered suitable for grazing native pastures of varying quality all year round, depending on soil characteristics, (QDME 1995, Shields and Williams 1991). In inland Central Queensland such country is typically termed 'breeding country'. It encompasses a range in productivity from the lower end of Class 3 growing country through to the poorer end of Class 4 breeding country. Shields and Williams (1991) suggest 3 possible subclasses exist within Class 4:

- Land with native pasture of low productivity, which while physically capable of being developed to improved pasture, is subject to low soil fertility and doubtful long term productivity;
- Land with high quality native pasture (typically black soil downs) on which improved pasture establishment is marginal because of unfavourable soil characteristics and limited species; and
- Land with native pasture of low productivity, which has physical limitations that preclude fully improved pasture development, but allow over-sowing of legumes such as shrubby stylo.

Class 5 land is unsuitable for any form of pasture improvement and land use is limited to extensive grazing of native pastures of low productivity. In many cases, lands are of such poor quality they are considered marginal as breeding country and may be destocked in the winter/dry season, unless grazed in conjunction with better quality country. Land in this class is mostly used as breeding country during the summer/wet season when planes of nutrition are higher.

9.3.2 Land use requirements and limitations

Following DNRM/DSITIA (2013a, 2013b), QDME (1995), and Shields and Williams (1991), a set of 15 land use requirements and associated limitations has been identified as important for sustainable grazing of land rehabilitated after mining in central Queensland (Table 9-2). Limitation subclass threshold limits have been defined (Appendix A).

Table 1-3 Land use requirements and limitations for sustainable grazing of rehabilitated land in central Queensland

Count	Land use requirement	Limitations	Code	Attributes to assess each limitation
1	Appropriate slope gradients for particular soil types	Surface soil erodibility	Ea	Slope, ESI, ESP, salinity
2		Subsoil erodibility	Eb	Slope, ESI, ESP, salinity

Count	Land use requirement	Limitations	Code	Attributes to assess each limitation
3	Adequate water supply	Soil water availability	M	PAWC, ERD, deep drainage losses, infiltration rate
4	Ease of pasture establishment	Surface condition	Ps	Soil structure, condition, texture
5	Rock free surface soils	Rockiness	R	Size and content of coarse fragments, % rock outcrop
6	Level land	Micro-relief	Tm	Size and frequency of micro-relief
7	Adequate soil aeration	Wetness	W	Soil drainage (field observation)
8	Not affected by AMD or acid sulphate soils	Acid drainage water hazard, real	Ar	Depth to buried PAF materials, water pH
9		Acid drainage water hazard, potential	Ap	Depth to buried PAF materials, water pH
10	Adequate nutrient supply	Nutrient deficiency	Nd	Levels of P (mg/kg) in surface soils (0-10cm)
11	Absence of elemental enrichment in surface soils	Element toxicity	Tx	pH (1:5 water) in surface soils (0-10cm)
12	Adequate soil depth to support vegetation	Soil depth	Sd	Measurement to rooting impediment
13	Salinity free root zone	Root zone salinity	Sa	EC, chloride level
14	Absence of undesirable vegetation	Vegetation	V	Vegetation type, regrowth potential
15	Practical land area available	Landscape complexity	Lc	Contiguous land area

10 CONTINUOUS IMPROVEMENT

Continuous improvement is an essential part of rehabilitation management at Ensham. The continuous improvement cycle has four interrelated phases, otherwise known as the Plan, Do, Check, Act cycle (Figure 10-1):

1. **PLAN –** establish the actions and resources necessary to implement the RMP.
2. **DO –** implement the RMP and allocate resources, including time.
3. **CHECK –** monitor, measure and report on rehabilitation outcomes, and compare and contrast these with 'completion criteria'.
4. **ACT –** incorporate actions for improvement into planning and/or execution to maximise rehabilitation success.

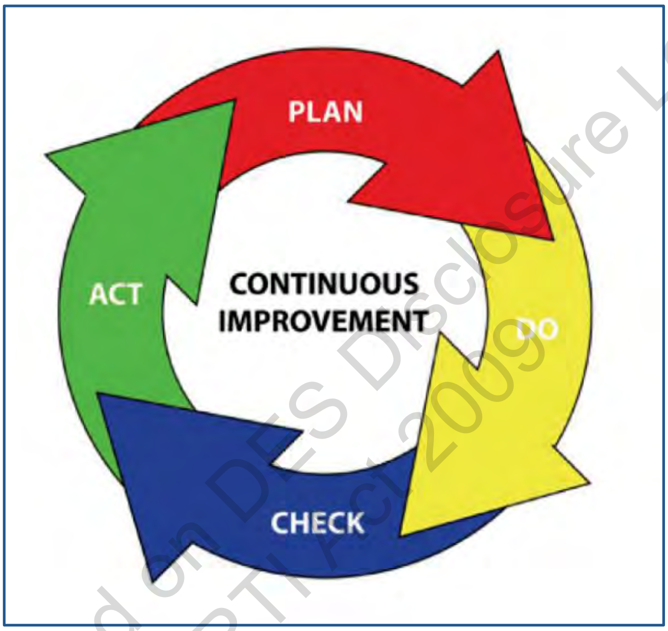

Figure 10-1 Continuous improvement cycle for rehabilitation

PLAN and DO are discussed elsewhere in this document. CHECK and ACT are detailed as follows.

10.1 Monitoring (check)

Monitoring will be required at various intervals for a range of indicators to ensure that completion criteria are met. It may take several years of monitoring to produce a statistically valid data set to do this. This relies on information being collected in a consistent manner to allow multi-year comparison of trends and assessment of outcomes against completion criteria and/or specific actions.

Monitoring methods and intervals for each indicator are provided (Table 10-1). This is considered the minimum data requirement and additional ad hoc monitoring may be performed. Some statistical analysis of monitoring data will be needed to determine if differences are significant or not. This will help to determine if management intervention is required to adjust performance trajectories. However, in most cases, data analysis will be simple and restricted to plotting of trends, calculation of averages, standard deviations and basic statistics.

Table 10-1 Monitoring methods and intervals for each indicator

Objective	Indicator	Completion criteria	Monitoring method	Monitoring frequency	By whom
Safety hazards in rehabilitation are similar to surrounding unmined landscapes.	Hazard assessment	Zero significant difference between rehabilitation and surrounding landscape	AS/NZS ISO 13000:2009 Risk Management	5 years	Appropriately qualified person[18]
Safety hazard accepted by landholder	Legally binding agreement	Executed document	Qualitative (yes/no)	Once following cessation of mining	Legal document executed by EA holder and landholder/s
Surface runoff leaving domain is non-polluting to receiving surface waters (Nogoa River).	pH	7.5 – 8.3	Water sampling of receiving waters upstream and downstream, and point of release from domains	Monthly and also at each rainfall runoff event	Sampling by technical personnel, data review and reporting by appropriately qualified person
	EC (salinity)	125 - 1250 µS/cm			
	TSS (sed. loss)	85 mg/L (max)			
	Sulphate	2.2-22.0 mg/L			
	Contaminated land assessment	Zero contaminated sites	Contaminated land assessment	Once following cessation of mining	Suitably qualified person[19]
Landforms are both geo-technically and erosionally stable.	Factor of safety	≥1.5	Engineering calculation	5 years	Registered Professional Engineer Queensland (RPEQ)[20]
	Slope gradient	15% (max)	Remote sensing, e.g. LIDAR survey, or On-ground survey	As constructed	Registered Surveyor Queensland[21]
	Groundcover	≥50%	Grass Check by NRM	2 years	Appropriately qualified person

18 "Appropriately qualified person" has the same meaning as in EHP Guideline EM1122
19 "Suitably qualified person" has the same meaning as in EHP Guideline ESR/2016/1938
20 "RPEQ" by Board of Professional Engineers Queensland
21 "Registered Surveyor" by Surveyors Board Queensland

Objective	Indicator	Completion criteria	Monitoring method	Monitoring frequency	By whom
Landholder accepts the condition of infrastructure, including its structural integrity.	Legally binding agreement	Executed document	Qualitative (yes/no)	Once following cessation of mining	Legal document executed by EA holder and landholder/s
Landholder formally accepts infrastructure for his/her ongoing beneficial use.	Legally binding agreement	Executed document	Qualitative (yes/no)	Once following cessation of mining	Legal document executed by EA holder and landholder/s
Rehabilitation is suitable for sustainable grazing by cattle	Land suitability assessment	Classes 2 - 4	Land suitability assessment by NRM	Within 2 years of construction	Appropriately qualified person
Riparian vegetation is suitable for conservation of rehabilitated creek diversion areas.	Index of Diversion Condition (IDC)	IDC score >10	ACARP C9068 and C20017	Annually	Appropriately qualified person

10.2 Corrective actions (act)

Monitoring data will be used in conjunction with completion criteria to determine when and where corrective interventions are needed. This may include:

- Re-evaluation of monitoring data;
- Additional monitoring;
- Amendments to rehabilitation planning and/or execution; and/or
- Redoing rehabilitation earthworks or parts thereof.

11 PEOPLE, PLANET AND PROFIT

Assessing different rehabilitation options as part of the triple bottom line framework means giving consideration to the people (social), environmental (planet) and economic (profit) outcomes of the different options. This means that our rehabilitation will achieve outcomes that support a strong and viable post-mining land use, do not cause environmental harm and are feasible for Ensham to deliver. This approach has been developed based on best practice approaches in the literature and is considered fit for purpose (Figure 11-1).

ACCOUNTABILITY AND TRANSPARENCY

LEGISLATIVE NEED:	**PRACTICAL NEED:**
Environmental Protection Act 1994	Complex evidence base, facilitating understanding amongst stakeholders

TRIPLE BOTTOM LINE ASSESSMENT FRAMEWORK

↓

Acceptable rehabilitation outcomes are based on comprehensive assessments of **economic, social** and **environmental** outcomes

Figure 11-1 The legislative and practical need for a triple bottom line framework, guided by an overarching principle of accountability and transparency

11.1 Legislative need

The object of the EP Act is to *protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends (ecologically sustainable development)* (Section 3). The act is implemented in several ways, including environmental strategies and integrating them into efficient resource management. The reasons for rehabilitation are to remedy potential impacts on environmental values and to minimise the potential for future environmental harm. Therefore, rehabilitation of land disturbed by resource activities assists to achieve the objectives of the EP Act.

11.2 Practical need

Setting rehabilitation indictors and completion criteria is a highly complex process that requires the specialised skill set of an appropriately qualified person. There are quantitative and qualitative outcomes of different options to compare across economic, social and environmental dimensions, as well as differing spatial and temporal settings. There is a large amount of information to weigh and process, and no definitive formula for the 'acceptable rehabilitation'. There are also multiple stakeholders to consider – government, community and us – with potentially conflicting views on what are acceptable outcomes.

11.3 Process steps

The steps in the triple bottom line assessment for rehabilitation at Ensham were:

1. Goals: confirm the appropriateness of rehabilitation goals.
2. Domains: decide rehabilitation domains, and their projected location and extent.
3. Objectives: set rehabilitation objectives.
4. Indicators and completion criteria: determine appropriate indicators and set threshold limits as completion criteria.
5. Alternatives: explore different combinations of completion criteria for rehabilitation.
6. Triple bottom line assessment: assess the evidence base to compare the economic, social and environmental outcomes for each alternative. Interpret information and evaluate outcomes.
7. Propose amendment: confirm rehabilitation indicators and completion criteria.

11.4 Assessment summary

Ensham is a mature mining operation and has a large and complex information base relating to rehabilitation. This information supported selection of indicators and associated completion criteria. The types of information used has been summarised (Figure 11-2).

	SUMMARY PAPERS		
	Economic	**Social**	**Environment**
Indicators	Cost to complete, land use economics	Qualitative narrative - perceptions of land use by agricultural sector, land suitability assessment	Per Table 9-1 in section 9 of this report
Detailed evidence	Rehabilitation cost modelling by Ensham, annual budgets, FA calculations	Stakeholder feedback, land suitability assessments, EIS documentation	ACARP reports, rehabilitation monitoring reports, various site specific technical studies

Figure 11-2 Summary of the detailed economic, social and environmental evidence base and overarching indicators used in the triple bottom line assessment

Process steps 1 through 4 have been defined in sections 4 and 9 of this report. A process summary table of relevant considerations for the triple bottom line assessment is provided (Table 11-1).

11.4.1 Conclusions

The triple bottom line assessment for rehabilitation followed sound principles in setting rehabilitation objectives, indicators and completion criteria. It enabled a complex evidence base to be logically and clearly understood. The development of indicators allowed for an iterative process of assessing alternatives and outcomes. Each scenario was considered against all others to ensure there was consistent deliberation. Selected indicators are meaningful and, when monitored and reported, will inform stakeholders about the rehabilitation and allow good decisions.

While the triple bottom line framework facilitated effective decision making, it did not remove the need for considered judgement in decision-making. This highlights the important and on-going role of appropriately qualified persons in the assessment, interpretation and communication of rehabilitation outcomes at Ensham and elsewhere.

Ensham RESOURCES

Table 11-1 Qualitative process summary for rehabilitation indicators (TBL Assessment)

Objective	Indicator	Considerations		
		Economic	**Social**	**Environmental**
Safety hazards in rehabilitation are similar to surrounding unmined landscapes.	Hazard assessment	Indirect costs may apply if this delays closure.	Stakeholder expectations will be that hazards in the rehabilitation are no greater than those in the surrounding landscape. Use Australian Standard for risk management to ensure robust, valid process.	n/a
Safety hazard accepted by landholder	Legally binding agreement	Agreements for landholders to retain mining infrastructure may reduce rehabilitation costs.	Failure to reach agreement may cause reputational damage and unrest with other stakeholders.	n/a
Surface runoff leaving domain is non-polluting to receiving surface waters (Nogoa River).	pH	Water monitoring is a long-term cost associated with rehabilitation.	Stakeholder expectations will be that rehabilitation is free of contamination and not a source of environmental pollutants.	Use NRM provided upstream river water quality data and Queensland Water Quality Guidelines to determine completion criteria. Indicators should be consistent with EA conditions.
	EC (salinity)			
	TSS (sed. loss)			
	Sulphate			
	Contaminated land assessment	One off cost at end of mine life. Remediation may add significant costs if necessary.		Must comply with EP Act and requirements for contaminated land assessment and management in

Objective	Indicator	Considerations		
		Economic	Social	Environmental
				Queensland.
Landforms are both geo-technically and erosionally stable.	Factor of safety	Different FoS can require different volumes of materials to be moved and therefore, can add significantly to cost.	Stakeholder will expect rehabilitation is geotechnically stable.	Geotechnical stability is different to erosional stability, and rehabilitation must demonstrate both.
	Slope gradient	Different slope gradients require different volumes of materials to be moved and therefore, can add significantly to cost. Rehabilitation construction must be optimised to available equipment.	Slopes will need to be appropriate to proposed grazing land use, i.e. <20%.	Slope gradients (and lengths) need to recognise inherent material characteristics, e.g. propensity to dispersion and erosion.
	Groundcover	n/a	Stakeholders are aware of the role of groundcover in controlling erosion.	ACARP reports indicate minimum groundcover requirements for control of erosion.
Landholder accepts the condition of infrastructure, including its structural integrity.	Legally binding agreement	Agreements for landholders to retain mining infrastructure may reduce rehabilitation costs.	Failure to reach agreement may cause reputational damage and unrest with other stakeholders.	n/a
Landholder formally accepts infrastructure for his/her ongoing beneficial use.	Legally binding agreement	Agreements for landholders to retain mining infrastructure may reduce rehabilitation costs.	Failure to reach agreement may cause reputational damage and unrest with other stakeholders.	Must ensure this is non-polluting.
Rehabilitation is suitable for	Land suitability assessment	Rehabilitation must have an	Stakeholders are aware of	Rehabilitation will need to

Objective	Indicator	Considerations		
		Economic	Social	Environmental
sustainable grazing by cattle		appropriate land suitability class to have a post-mining land use, i.e. anthropic land use.	previous commitments to return rehabilitation to grazing land use.	meet a suite of land use limitations to achieve an appropriate land suitability class.
Riparian vegetation is suitable for conservation of rehabilitated creek diversion areas.	Index of Diversion Condition (IDC)	Rehabilitation of the Boggy Creek diversion will likely be the most costly rehabilitation on a 'per hectare' basis.	Stakeholders will expect the Boggy Creek diversion to function as though it were a natural watercourse.	ACARP C9068 and C20017 provide a sound technical basis for creek diversion rehabilitation, monitoring and assessment.

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APPENDIX A – LAND USE LIMITATION SUBCLASS THRESHOLD LIMITS

Limitation	Land suitability class				
	1	2	3	4	5
Surface soil erodibility, Ea	Moderately stable soils, <5% Non-cohesive soils, <5% Dispersive soils, <3% Highly erodible soils, <1%	Moderately stable soils, 5-10% Non-cohesive soils, 5-8% Dispersive soils, 3-5% Highly erodible soils, 1-3%	Moderately stable soils, 10-15% Non-cohesive soils, 8-10% Dispersive soils, 5-8% Highly erodible soils, 3-5%	Moderately stable soils,15-20% Non-cohesive soils, 10-15% Dispersive soils, 8-10% Highly erodible soils, 5-8%	Moderately stable soils, >20% Non-cohesive soils, >15% Dispersive soils, >10% Highly erodible soils, >8%
Subsoil erodibility, Eb	Non-dispersive, <5%; Non-cohesive, <1%; Dispersive, <0.5%; Extremely dispersive, n/a	Non-dispersive, 5-10%; Non-cohesive, 1-5%; Dispersive, 0.5-1%; Extremely dispersive, <0.5%	Non-dispersive, 10-15%; Non-cohesive, 5-10%; Dispersive, 1-5%; Extremely dispersive, 0.5-3%	Non-dispersive, 15-20%; Non-cohesive, 10-15%; Dispersive, 5-10%; Extremely dispersive, 3-8%	Non-dispersive, >20%; Non-cohesive, >15%; Dispersive, >10%; Extremely dispersive, >8%
Soil water availability, M	PAWC >125mm/m	PAWC 100-125mm/m	PAWC 75-100mm/m	PAWC 50-75mm/m	PAWC <50mm/m
Surface condition, Ps	Soft or loose sandy to sandy loam; or Very fine self-mulching clays (peds less than 2mm)	Soils with soft, firm or only weakly had setting, sandy to loamy surface; or Fine self-mulching clays (peds 2-5mm) or Course self-mulching clays (peds >5-10mm)	Clay soils with hard setting, firm pedal or weakly self-mulching surface; or Very coarse self-mulching clays (peds >10mm)	Loamy, fine sand, silty or clayey surface, extremely hard setting, massive or crusting	
Rockiness, R	<20% pebbles <60mm and rock outcrop	20-50% pebbles <60mm and rock outcrop	>50% pebbles <60mm; or 20-50% cobbles 60-200mm	>50% cobbles 60-200mm; or 20-50% stone >200mm	>50% stone or rock outcrop
Micro-relief, Tm	Normal linear gilgai, 0.1-0.3m), <30% surface area	Shallow melonhole gilgai, 0.3-0.6m, 30-70% surface area	Strong, deep melonhole gilgai, 0.6-1.5m, <30% surface area	Strong, deep melonhole gilgai (0.6-1.5m), 30-70% of land surface	Strong, deep melonhole gilgai (0.6-1.5m), >70% of land surface

Limitation	Land suitability class				
	1	2	3	4	5
Wetness, W	Rapid draining to moderately well drained and slowly permeable	Imperfectly drained and highly permeable	Imperfectly drained and moderately permeable	Imperfectly drained and slowly permeable	Poorly to very poorly drained
Acid drainage water hazard, actual, Ar	AASS (pH<4) not present or present at depths >2m	AASS present at depths 1-2m	AASS present at depths 0.5-1m	AASS present <0.5m	
Acid drainage water hazard, potential, Ap	PASS (%S > action threshold) not present or at depths >3m	PASS present at depths 1-2m	PASS present at depths 0.5-1m	PASS present <0.5m	
Nutrient deficiency, Nd	P >20mg/kg	P 10-20mg/kg	P 5-10mg/kg	P <5mg/kg	
Element toxicity, Tx	pH 6.6-7.3	pH 6.0-6.5	pH 5.1-5.5 or pH 7.4-8.4	pH <5 or pH>8.5	
Soil depth, Sd	>0.75m	0.5-0.75m	0.25-0.5m	<0.25m	
Salinity, Sa	ECe <2dS/m	ECe 2-4dS/m	ECe 4-8dS/m	ECe >8dS/m	
Vegetation, V	Improved pastures (grass and legumes) with Eucalypt dominated overstory on non-gilgai forming soils	Improved pastures (grass and legumes) with or without overstory species on non-gilgai forming soils	Native pastures with or without Acacia dominated overstory on non-gilgai forming soils	Native pastures with Acacia dominated overstory on gilgai forming soils	None
Landscape complexity, Lc	>10ha	5-10ha	2.5-5ha	<2.5ha	

APPENDIX B – ENSHAM RISK MATRIX TOOL

Consequence / Severity Descriptions

Rating	Consequence Note: Consequence may consist of a single event or may represent a cumulative impact over a period of 12 months					
	Personal Injury (PI)	Impact to Annual Business Plan (EBIT)	Business Interruption (BI)	Legal (L)	Reputation/ Community (R)	Environment (E)
1. Catastrophic	Multiple fatalities / Irreversible health impacts >50 workers	>$50m	> 2 months production	Prolonged litigation, heavy fines, potential jail term	Extended negative national media coverage. Socially irresponsible image	Serious environmental harm that is irreversible. Legal / regulatory impact.
2. Major	Single fatality and/or severe irreversible disability (>30%) to one or more workers	$10m - $50m	1 to 2 months production	Major breach/ major litigation	Longer term State wide and national negative media coverage > 1 week (State)	Material environmental harm –that requires extensive time & resources to remediate)
3. Moderate	Lost Time Injury / Illness / moderate irreversible disability (<30%) to one or more workers	$5m - $10m	1 week to 1 month production	Serious breach of regulation. prosecution/ fine	Short term State wide or extensive negative media coverage < 1 week.	Moderate (reversible) environmental effects – remedial in LOM
4. Minor	Medical Treatment Injury / Illness. Reversible disability / impairment	$1m - $5m	1 day to 1 week production	Non-compliance, breaches in regulation	Series of articles in local press, including radio or other media.	Minor damage to physical environment – contained and remedial in short term
5. Insignificant	First Aid injury. No medical treatment	<$1m	< 1 day production	Low level compliance issue	Local complaints / no real impact on Community	Negligible environmental harm. Can be immediately cleaned up.

Likelihood Description

Likelihood	(2) Description	(1) Frequency
A Certain	The event is expected to occur in most circumstances	Multiple / 12 months
B Likely	The event will probably occur in most circumstances	Once 1-5 years
C Possible	The event may occur at some time	Once 5 – 10 years
D Unlikely	The event has not occurred in our company, but has occurred within the industry as a whole on a number of occasions	Once 10 - 50 years
E Rare	Event has not been known to occur in our organisation, but has been known to occur infrequently within the industry and is only likely to occur in exceptional circumstances.	Once / > 50 years

Consequence	Likelihood				
	A Certain	B Likely	C Possible	D Unlikely	E Rare
	"Common" Once or greater per annum	"Has Happened but infrequently" Could happen in 1-5 years	"Could Happen once between 5 – 10 years"	"Not Likely – but has happened in industry" May occur within 10—50 years	"May occur once > 50 years"
1	C1	C2	C4	C6	H11
2	C3	C5	C7	H12	M16
3	H8	H9	H13	M17	M20
4	H10	M14	M18	L21	L23
5	M15	M19	L22	L24	L25

Risk Tolerability Levels

Risk Rating	Risk Category		Tolerance	Generic Management Actions
1 to 7	C	Critical	Intolerable	Immediate intervention required from senior management to eliminate or reduce this risk
9 to 13	H	High	ALARA	Imperative to eliminate or reduce risk to a lower level by the introduction of control measures. Management planning required
14 to 20	M	Medium	ALARA	Corrective action required, management attention needed to eliminate or reduce risk
21 to 25	L	Low	Tolerable	Monitor and manage by corrective action where practicable,

REHABILITATION MANAGEMENT PLAN

Pursuant to condition G12 of permit
Environmental Authority EPML00732813

May 2017

Prepared by La Tierra Pty Limited for Ensham Resources

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ACRONYMS AND DEFINITIONS

ACARP	Australian Coal Association Research Program
CMLR	Centre for Mined Land Rehabilitation, Sustainable Minerals Institute, The University of Queensland
Completion criteria	These are the standards that are to be met by successful rehabilitation. They will generally be in the form of numerical values that can be verified by measurement of the indicators selected for the rehabilitation objectives.
Domain	Land management units for rehabilitation planning and execution
EA	Environmental Authority EPML00732813
EHP	Queensland Department of Environment and Heritage Protection
EMS	Environmental Management System
EP Act	Environmental Protection Act 1994
ESD	Ecologically sustainable development
FA	Financial assurance
Goals	Policy objectives for rehabilitation set by Government: • Safe • Stable • Non-polluting, and • Agreed land use
Indicator	Something that can be measured and audited according to an established protocol and used to evaluate changes in a system
ML	Mining lease
NRM	Queensland Department of Natural Resources and Mines
Plan	How we will do it
PoO	Plan of Operations
Reference site	A locality undisturbed by mining with similar land and soil attributes, vegetation characteristics and land use, which provides 'target conditions' for assessment of rehabilitation
Residual risk	As defined in schedule 4 of the EP Act, includes the risk that: • Rehabilitation will fail and need repair, replacement or maintenance; • Rehabilitation will need ongoing maintenance; or Potential environmental harm needs monitoring or management
RI	Recordable injury
RMP	Rehabilitation Management Plan (this document)
SHMS	Safety and Health Management System
Stakeholder	A person or organisation that is potentially affected by a decision, such as a resident, land owner, community group, government agency, company, traditional owner, or environmental group.
Strategy	What we will do

1 INTRODUCTION

This Rehabilitation Management Plan (RMP) describes rehabilitation at Ensham coal mine, located 40 kilometres (km) northeast of Emerald in central Queensland. Ensham is an open-cut and underground mining complex, producing high energy, low ash thermal coals from the Permian age Rangal Coal Measures. It operates on an aggregation of seven mining leases and in accordance with Environmental Authority (EA) EPML00732813 conditions.

Ensham Resources Pty Limited manages the mine on behalf of joint venture partners and Environmental Authority holders Bligh Coal Limited and Idemitsu Australia Resources Pty Limited (jointly 85%) and Natural Resources Investment (Australia) Pty Limited (15%). La Tierra Pty Limited, as independent consultants and an appropriately qualified person[1], has prepared this report for and on behalf of Ensham Resources.

1.1 Plan purpose

The purpose of this RMP is to describe rehabilitation at Ensham mine in accordance with requirements of condition G11 of the EA.

1.1.1 Plan structure

The RMP is structured as follows.

Section 1	Introductory context and purpose
Section 2	Strategy for progressive rehabilitation including schedule of works to end of mine life
Section 3	Material characteristics and management
Section 4	Landform design objectives
Section 5	Soil resource management
Section 6	Rehabilitation methods
Section 7	Native vegetation corridors
Section 8	Description of reference sites
Section 9	Objectives, indicators and completion criteria for each domain, including post-mining land use/s
Section 10	Continuous improvement
Section 11	Triple bottom line assessment – people, planet & profit
Section 12	Full references for all citations within the text of the RMP
Appendix A	Limitation subclass threshold limits for Land Suitability Assessment of rehabilitation for sustainable cattle grazing in central Queensland
Appendix B	Ensham risk matrix tool

[1] "Appropriately qualified person" has the same meaning as in EHP Guideline EM1122, version 2, dated 2014.

1.1.2 Complying with EA requirements

The RMP addresses each requirement of EA condition G11 (Table 1-1).

Table 1-1 Addressing EA requirements

Relevant criteria		Where addressed
a)	A map existing of areas of rehabilitation including classification of stage (i.e. time since establishment) and quality	Section 2, Figure 2-3
b)	A strategy for progressive rehabilitation, including a progressive rehabilitation schedule	Section 2, Table 2-1
c)	Details of the design objectives for rehabilitation of each domain to achieve rehabilitation success criteria and the identified post mining land uses	Section 4, Section 9, Table 9-1
d)	Specify the spoil characteristics, soil analysis and soil separation for use on rehabilitation	Section 3, Section 5
e)	Specify the topsoil requirements for the site and how topsoil will be managed for use in rehabilitation	Section 5
f)	Details of any topsoil deficit and how any deficit will be managed for successful rehabilitation	Section 5
g)	Details of rehabilitation methods to be applied to areas	Section 6, Table 6-1
h)	Details of landform design including end of mine design	Section 4
i)	Details of how landform design will be consistent with surrounding topography	Section 4.5
j)	Identification of planned native vegetation rehabilitation areas and corridors	Section 7
k)	Identification of at least a minimum of three (3) reference sites for use in rehabilitation monitoring	Section 8
l)	Description of rehabilitation indicators and how these will be monitored	Section 9 Section 10, Table 10-1
m)	Description of management actions to address unsuccessful rehabilitation or redesign	Section 10
n)	Description of end of mine landform design planning and post mining land uses across the mine	Section 4, Section 9
o)	Include a triple bottom line assessment (or a comparative alternative assessment method) of the proposed final landform design criteria and alternatives	Section 11

2 STRATEGY FOR PROGRESSIVE REHABILITATION

Following is the overarching strategy for progressive rehabilitation at Ensham. The areas and timing of works nominated herein are indicative only and may vary due to operational and other requirements. Specific areas for rehabilitation will continue to be nominated in successive Plans of Operations.

2.1 Rehabilitation to date and life-of-mine forecast

To end-2016, Ensham had disturbed 4,591 hectares (ha) of land and rehabilitated 1,170 ha or 25% of this area (Figure 2-1, 2-2 and 2-3). By the time coal production ceases in 2029, a total disturbance footprint of 4,743 ha is forecast. Rehabilitation earthworks are scheduled for completion by 2031.

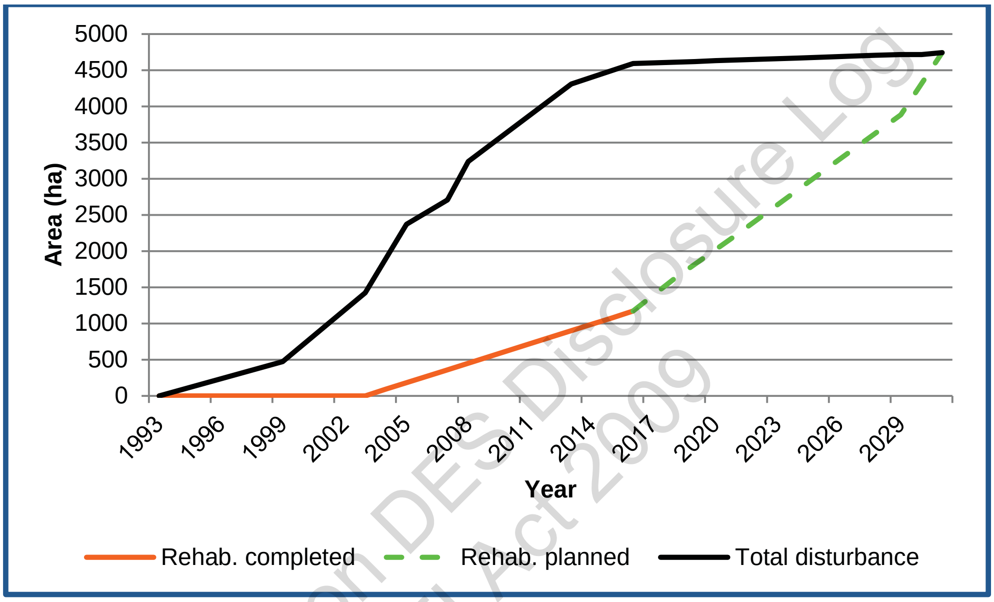

Figure 2-1 Life-of-mine disturbance and rehabilitation

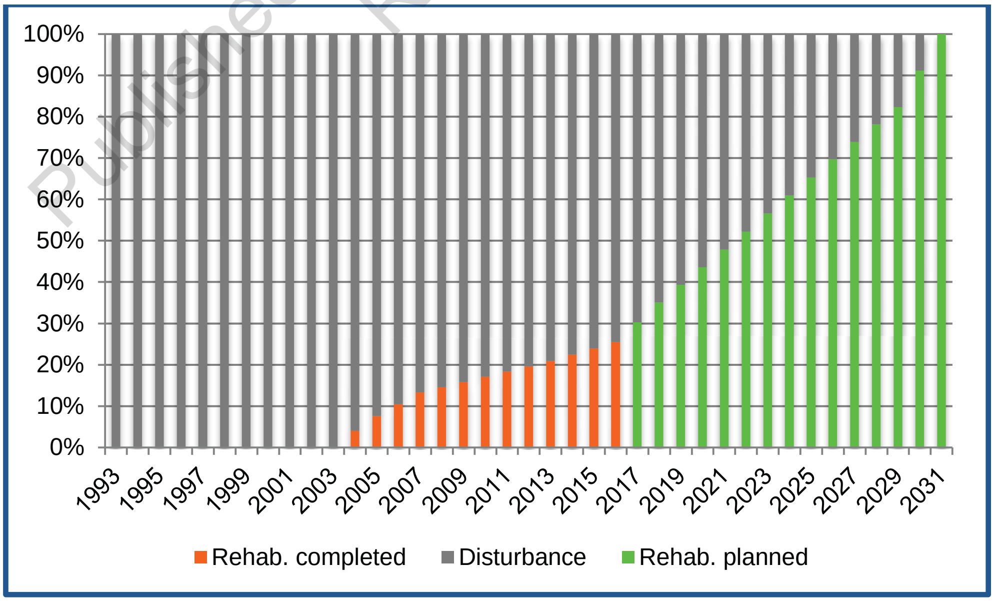

Figure 2-2 Rehabilitation as a percentage of disturbance over life-of-mine

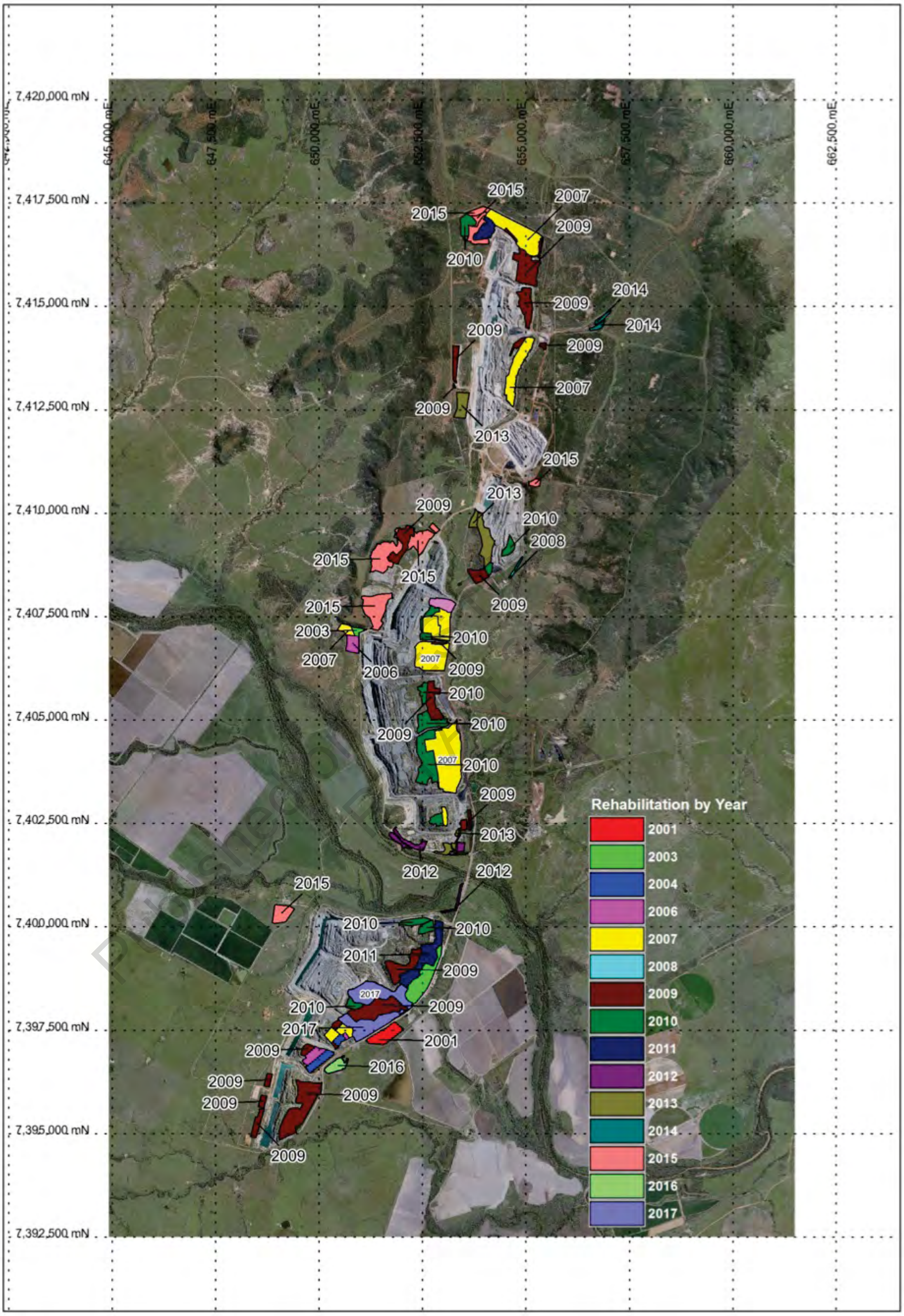

Figure 2-3 Chronology of rehabilitation completed to date

Completion of all rehabilitation requirements has been forecast based on the following constraints:

- Complete as much rehabilitation as is possible before coal production ceases and spread this more or less evenly across the 13-year period from 2017 to 2029;
- There is 861 ha associated with the safe and efficient operation of the open-cut and underground and this area is not available for rehabilitation until after production ceases in 2029; and,
- Finish rehabilitation as soon as practicable after production ceases and within two years.

This rehabilitation forecast highlights several important matters for Ensham:

- Little permanent rehabilitation was completed in the first 10 years of operation.
  Permanent rehabilitation commenced in 2004.
- The gap between disturbance and rehabilitation has widened, year-on-year from 1993 to 2016.
  This has deferred rehabilitation on-ground and costs.
- In the next 5 years from 2017 to 2021, the plan is to complete 1,050 ha of rehabilitation.
  This is almost as much rehabilitation as has been completed in the preceding 24 years (1,170 ha).
- The rehabilitation rate required from 2017 to 2029 is about 210 ha/y (mean).
- In the final two years of the rehabilitation program, i.e. 2030-31, the required rehabilitation rate is 431 ha/y.

2.2 Strategy

Rehabilitation works have been scheduled to end of mine life at strategic time intervals (Table 2-1). Based on constraints listed (see previous section) all disturbance, current and forecast, has been allocated a time period for rehabilitation (Figure 2-4).

Table 2-1 Indicative rehabilitation schedule to end of mine life

Interval (years)	Year	Period	Note	Area (ha)
Historic	End-2016	1993-2016	Period to date	1,170
2	End-2018	2017-2018	Rolling period for detailed planning	447
5	End-2021	2019-2021	Rolling period for conceptual planning	603
10	End-2026	2022-2026	Rolling period for conceptual planning	1,046
13	End-2029	2027-2029	Fixed period, end of planned production	616
15	End-2031	2030-2031	Fixed period, all rehabilitation completed	861
			TOTAL	**4,743**

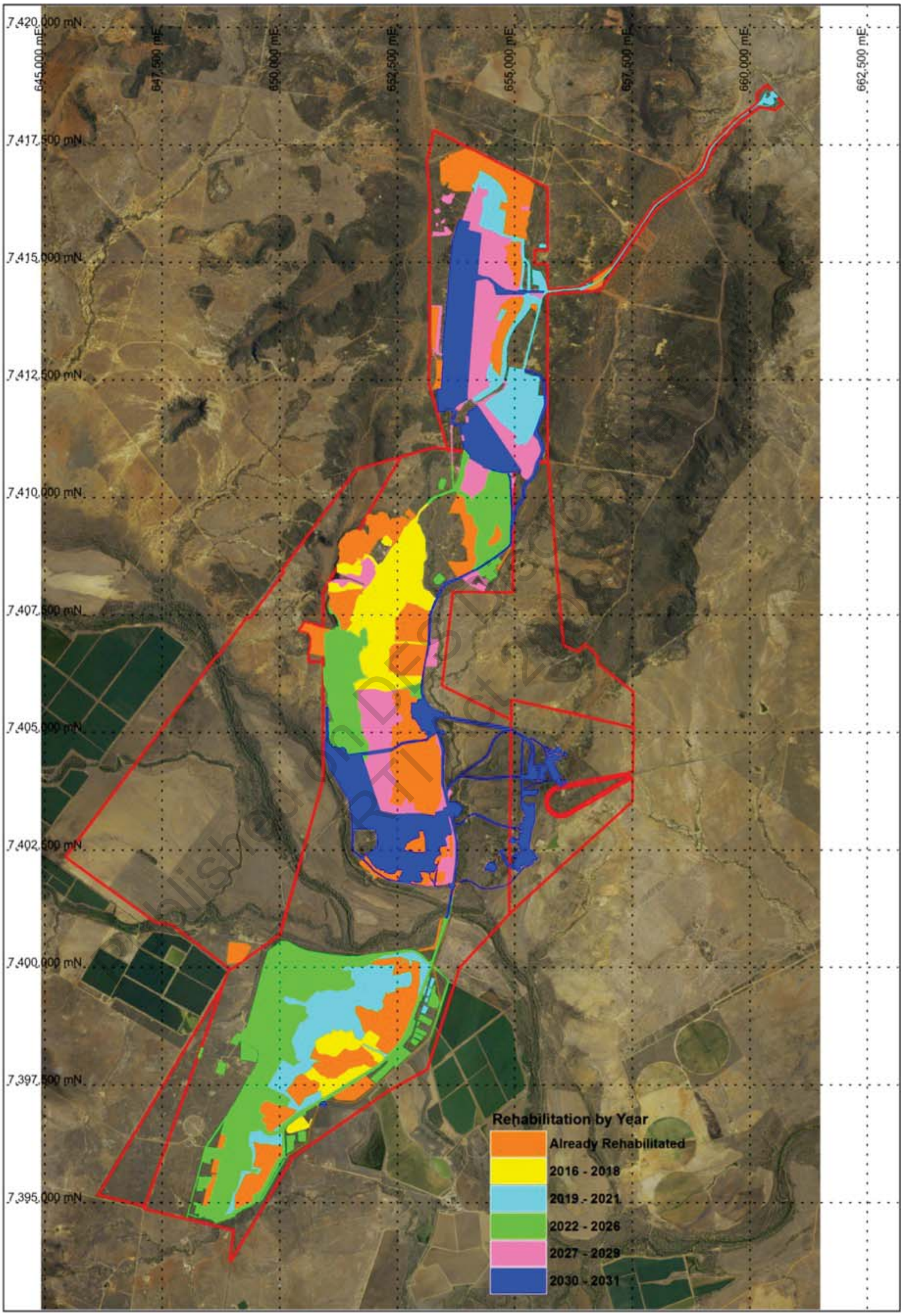

Figure 2-4 Indicative forecast progressive rehabilitation to end of mine life

3 MATERIAL CHARACTERISTICS

To determine appropriate landform design parameters for rehabilitation, it is crucial to understand material characteristics. Several reports have described materials at Ensham to varying extents, e.g. Loch (2015), URS (2005), URS (2015) and CMLR (2005), and each contain some useful information. Reports demonstrate that spoils and soils are typically sodic and saline, and non-acid forming.

3.1 Overburden types and distribution

CMLR (2005) provides a simple and practical classification of overburdens based on geology and measured physical and chemical parameters. Four distinct spoils were identified, described and mapped throughout the mine (Table 3-1).

Table 3-1 Spoil types and their distribution (adapted from CMLR, 2005)

<table>
<tr><th rowspan="2">Era</th><th rowspan="2">Period</th><th rowspan="2">Group</th><th rowspan="2">Description</th><th colspan="7">Ensham pit</th></tr>
<tr><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th><th>F</th><th>Y</th></tr>
<tr><td rowspan="3">Cainozoic</td><td>Quaternary</td><td>n/a</td><td>Alluvial sands, silt gravel</td><td colspan="3">Q</td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Tertiary</td><td rowspan="2">n/a</td><td rowspan="2">Sandstone, siltstone, claystone</td><td></td><td colspan="2">T2</td><td></td><td></td><td colspan="2">T2</td></tr>
<tr><td colspan="7">T1</td></tr>
<tr><td rowspan="2">Palaeozoic</td><td rowspan="2">Upper Permian</td><td rowspan="2">Blackwater</td><td rowspan="2">Rangal coal measures</td><td colspan="7">P</td></tr>
<tr><td colspan="7">COAL</td></tr>
</table>

A description of each overburden type follows.

3.1.1 Quaternary (Q) overburden

Pale brown to yellow alluvial sands and gravels (Figure 3-1). Low clay content means material has little water or nutrient holding capacity. Non-saline but sodic with low surface cohesion, this overburden is highly dispersive and prone to excessive erosive when exposed to rainfall.

Figure 3-1 Quaternary overburden in B Pit is screened for gravel and sand for use around site (left) and erosion of in situ Quaternary overburden on B Pit endwall (right)

3.1.2 Tertiary (T2) overburden

This overburden is Tertiary age material that appears above T1 overburden in B, C, F and Y pits. It is distinguishable from T1 by its darker colour but is otherwise physically and chemically similar.

3.1.3 Tertiary (T1) overburden

Overlying the Permian overburden, this material is derived from Tertiary age alluvium or colluvium (Figure 3-2). It is consistently saline to extremely saline, with chloride levels toxic to plants at Y Pit, and consistently sodic to extremely sodic. This material is extremely dispersive.

Figure 3-2 Tertiary overburden overlying Permian overburden in Y Pit (left) and F Pit (right)

3.1.4 Permian (P) overburden

Easily distinguished by its bluish grey colour, consisting on rapidly weathering mudstones and siltstones, with orange/yellow resistant sandstone fragments (Figure 3-3). Derived from Permian sedimentary rocks of the Blackwater Group, it is generally non-saline to saline and sodic.

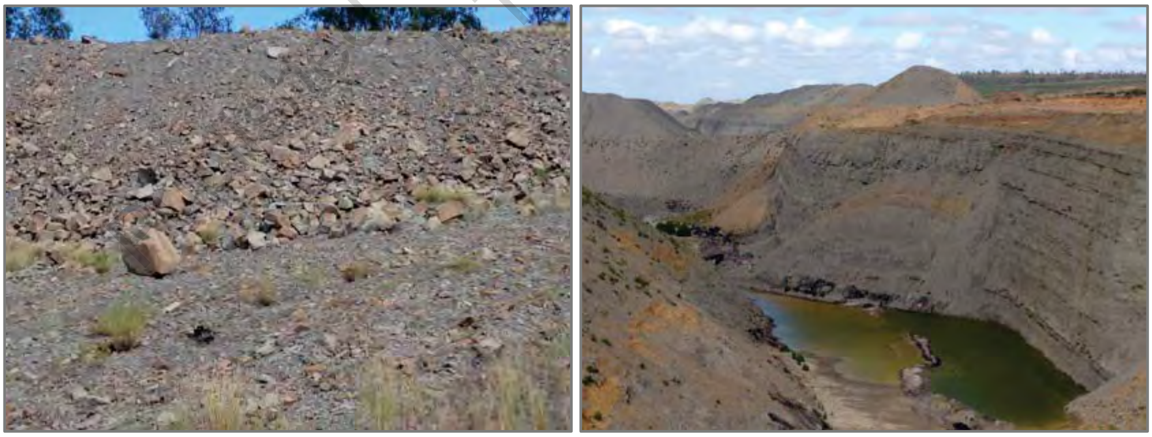

Figure 3-3 Permian overburden in D Pit emplacement (left) and E Pit highwall (right)

3.2 Soil types and distribution

A range of soil types is present at Ensham and these have previously been grouped into six major types (Hansen 2006):

- *Soil Group (1) – Shallow Rocky Soils* (Rudosols) that occur on low rocky hills and steep escarpment slopes and eroded plateau remnants. These soils are shallow (<0.5m), exhibit very little profile development and contain gravel and rock cobbles from various geological formations.

- *Soil Group (2) – Moderately Shallow Gravelly Sands, Loams and Clay Soils* (Rudosols and Tenosols) that occur on eroded middle and lower slopes and broad low gravelly rises. These soils are shallow to medium depth and comprise uniform or weakly gradational sands, loamy sands or sandy loams, loams or clayey soils with varying amounts of ferrundinous and siliceous gravel or stone. These soils exhibit low soil fertility and water storage capacity.
- *Soil Group (3) – Gradational Red and Yellow Earth Soils* (Kandosols-Tenosols, Kandosols and Ferrosols) present on the elevated dissected and eroded Tertiary plateau remnants and undulating plains associated with the Tertiary Emerald Formation. These soils include sandy, sandy loam or loamy surface soils grading to red, reddish brown or yellowish brown sandy loam to light to medium massive or structured clay subsoils often with appreciable amounts of ferruginous gravel.
- *Soil Group (4) – Texture Contrast (Duplex) Soils* (Sodosols) that have formed on Permo- Triassic sedimentary rocks, on gently inclined slopes, dissection slope interfluves, broad low rises and plains and on alluvial terraces and drainage flats. These soils are sandy, silty or loamy on the surface with a clear to abrupt change to a clayey subsoil horizon.
- *Soil Group (5) – Uniform Fine-textured (non-cracking) Clay Soils* (Dermosols) present on erosional plains, levees and high terraces along stream systems, undulating alluvial plains and associated with cracking clays of Soil Group 6. These soils exhibit uniform profiles or weakly gradational profiles where clay content may increase slightly with depth.
- *Soil Group (6) – Cracking Clay Soils (Vertosols)* that form the dominant soil type within the alluvial plains associated with the Nogoa River and its tributaries. These soils have uniform medium to high clay content, pronounced swelling and shrinkage properties and commonly feature gilgai.

Most soils are highly weathered, chemically and physically poor, and can be saline and sodic at depth.

3.3 Effect of salinity and sodicity

Salinity is the presence of soluble salts in soil solution, while sodicity is the relative percentage of Na^+ attached to clay particles, i.e. on the cation exchange surfaces. Salinity and sodicity are opposing forces in soil / overburden stability: salinity is aggregating and sodicity is dispersing. Salinity and sodicity often occur together and salt affected materials have historically been grouped as saline, non-saline and sodic, or saline and sodic, depending on the relative composition of the salts present. Using available data, Ensham overburdens and soils can be grouped into these categories (Figures 3-4 and 3-5). Here, a saturated electrical conductivity (ECe) >4 (dS/m) and an exchangeable sodium percentage (ESP) >6 are the generally

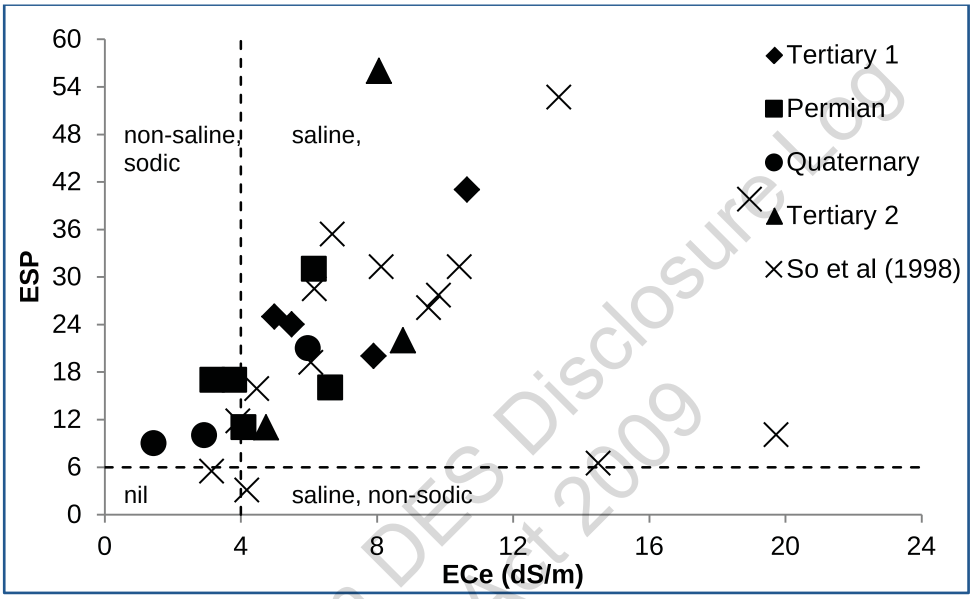

Figure 3-4 Salinity and sodicity categorisation of Ensham overburdens (after CMLR 2005) and 16 central Queensland overburdens by ACARP C4011 (So *et al* 1998)

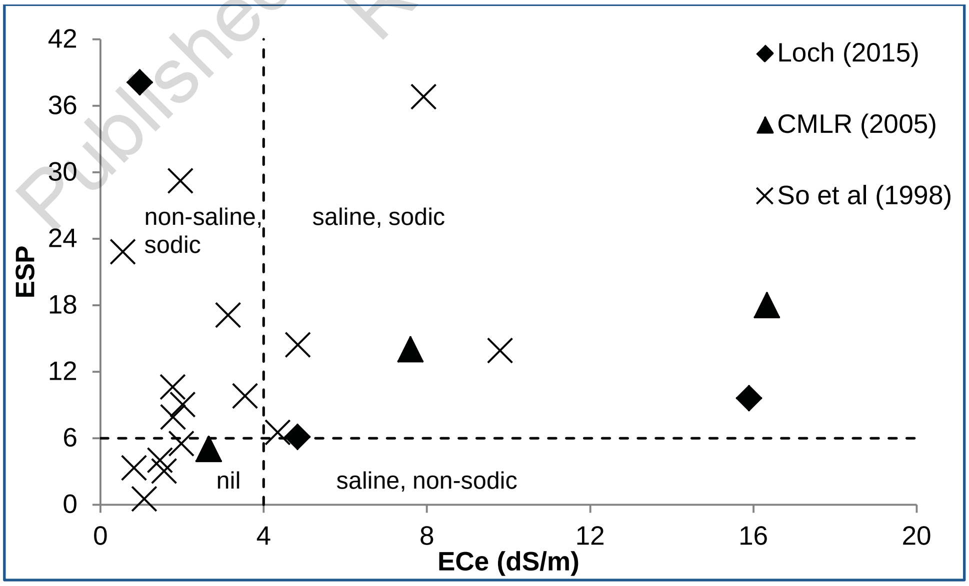

Figure 3-5 Salinity and sodicity categorisation of Ensham soils (after Loch 2015 and CMLR 2005) and 16 central Queensland soils by ACARP C4011 (So *et al* 1998)

accepted threshold limits for salinity impacts on plants and sodicity impacts on soil structure. For regional context, the 32 central Queensland soils and overburdens assessed by So *et al* (1998) in ACARP Project C4011 are included.

However, for a given sodicity value, as EC increases soil dispersion decreases. Conversely, very low EC values mean that a soil may become dispersive where the ESP is very low, e.g. ESP of 2. The relationship between salinity and sodicity is the electrochemical stability index (ESI). ESI is determined by calculating the ratio of EC to ESP, i.e. ESI = EC1:5/ESP. The adopted critical ESI value for Australian soils is 0.05 (McKenzie 1998). Materials with an ESI less than the critical value will be prone to dispersion. Most of the Ensham overburdens and soils are highly dispersive (Figures 3-6 and 3-7).

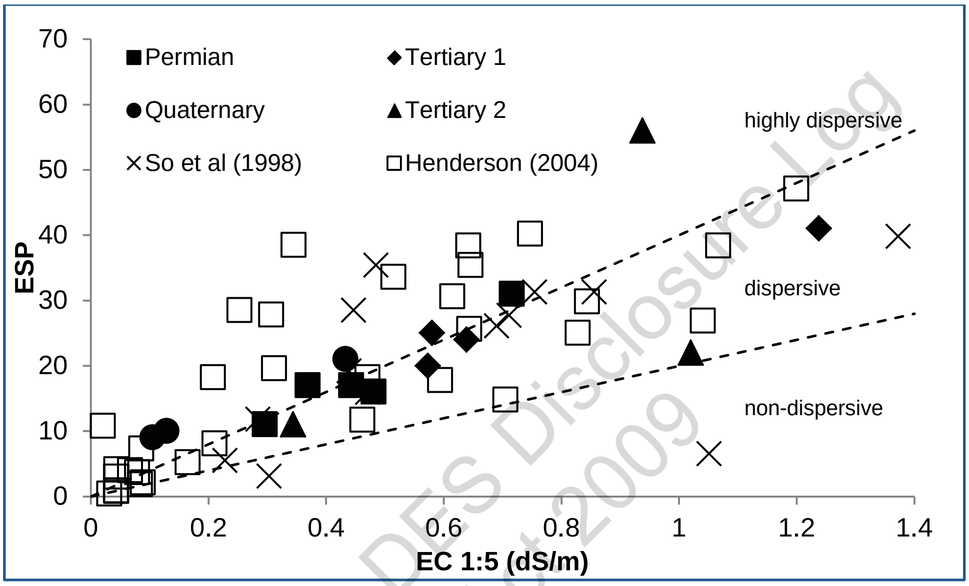

Figure 3-6 Classification of dispersive materials showing Ensham overburdens (after CMLR 2005), 16 central Queensland overburdens by ACARP C4011 (So *et al* 1998) and 40 central Queensland overburdens by ACARP C12031 (Henderson 2004)

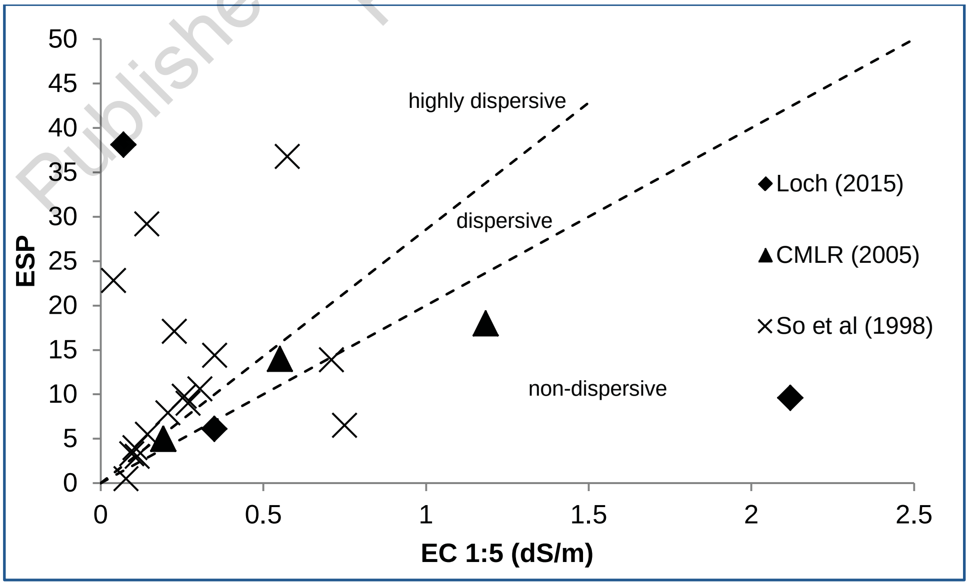

Figure 3-7 Classification of dispersive materials showing Ensham soils (after CMLR 2005 and Loch 2015) and 16 soils by ACARP C4011 (So *et al* 1998)

ESI explains the extremely dispersive nature of some overburdens, particularly Tertiary age materials. Although also highly saline, this salinity is insufficient to counter the effects of extreme sodicity, and the material disperses readily and is prone to excessive erosion.

Ensham overburdens can be ranked in terms of salinity, sodicity and dispersivity (Figure 3-8).

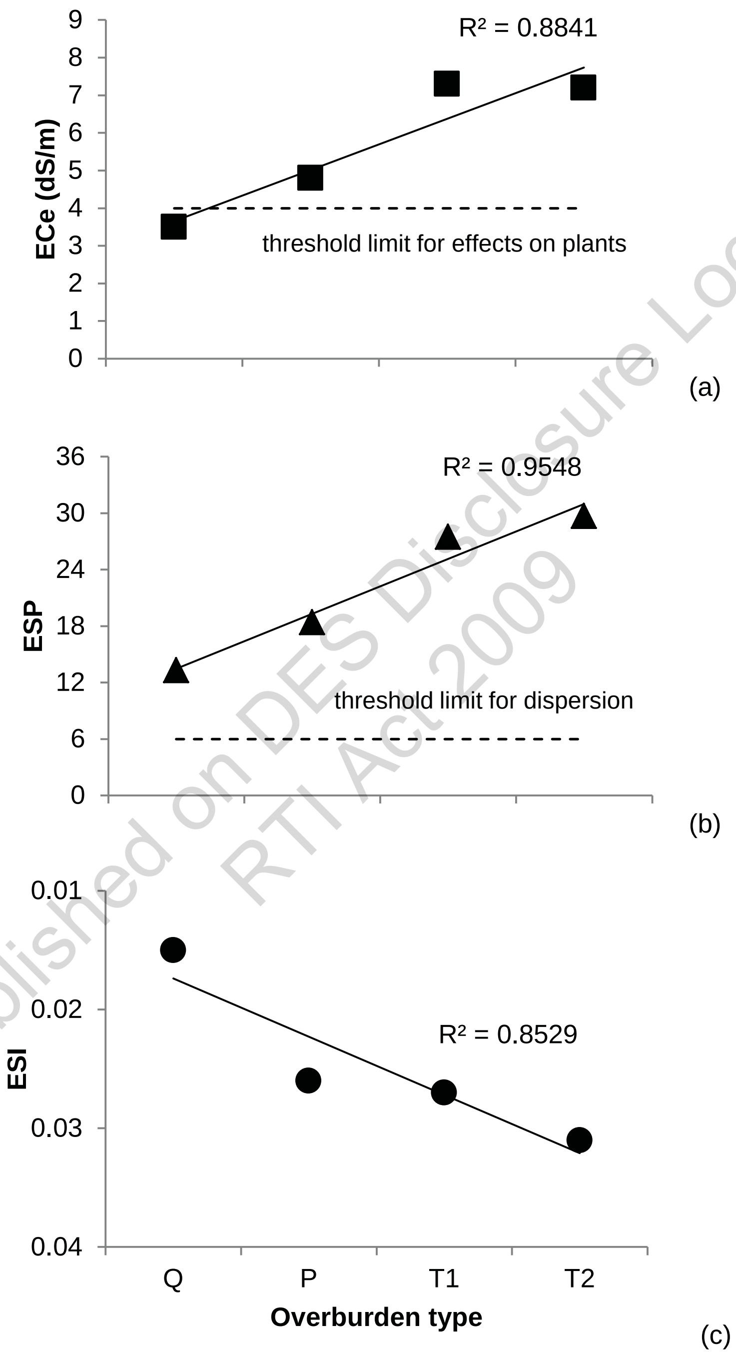

Figure 3-8 Relative salinity (a), sodicity (b) and dispersivity (c) of Ensham overburdens (after CMLR 2005)

This analysis shows that:

- Quaternary overburden is the most dispersive, but Tertiary overburdens are the most saline and most sodic;
- Tertiary overburdens are about twice as saline as Permian overburdens; and,

- All overburdens are highly dispersive.

3.4 Management of overburdens in rehabilitation landscapes

3.4.1 Quaternary (Q) overburden

Quaternary overburden is the most dispersive and least cohesive overburden at Ensham, making it prone to excessive tunnel and gully erosion. This material will be selectively placed and buried beneath other material to ensure it does not present at or near the surface of final landforms. It is not suitable for topsoil application and rehabilitation.

3.4.2 Tertiary (T1 and T2) overburden

Tertiary overburdens are the most saline and sodic, are prone to excessive dispersion and erosion, and occur in every pit at Ensham. Common throughout central Queensland mines, Tertiary overburdens have been extensively studied by ACARP and other industry-led research.

For example, ACARP C12031 *Rehabilitation of Dispersive Tertiary Spoil in the Bowen Basin* by Henderson (2004) made the following recommendations in ascending order of risk of poor outcome, i.e. decreasing hazard control effectiveness.

- Bury under another spoil type.
- Cover with at least a metre of rocky spoil to create a '<u>store and release</u>' cover system.
- Topsoil and grass cover at slope angles that avoid sliding failure along the soil/spoil interface when wet. Provide measures to assist erosion control until grass is established.

Practice at Ensham and other mines in central Queensland shows that conservative slope gradients are required to control erosion of Tertiary overburden. The common approach is to limit slope gradients to not more than 10%. Ensham can demonstrate appropriate hazard control effectiveness with respect to dispersion and erosion risks when:

- Slope gradients of Tertiary overburden do not exceed 10% maximum gradient;
- Slope lengths do not exceed 200m;
- Contour banks and rock-lined waterways are not used; and,
- Hay mulch is applied at the time of sowing.

3.4.3 Permian (P) overburden

Permian overburden is about 50% less saline and 50% less sodic than Tertiary overburdens. Though similarly dispersive, the material is favoured for rehabilitation because it is:

- Less hostile to the establishment and growth of plants; and,
- More erosion resistant, due in part to its variable content of course sandstone fragments.

Practice at Ensham and other mines in central Queensland shows that this material can be effectively rehabilitated with slope gradients of up to 15%. If steeper than this, than Permian overburdens should be clad with at least 1m of durable rock to prevent erosion.

4 LANDFORM DESIGN OBJECTIVES

Ensham has developed an innovative rehabilitation domain model and determined rehabilitation objectives for each area. The overarching objectives for rehabilitation are:

1. Conduct safe operations;
2. Meet regulatory requirements;
3. Minimise social and environmental risk; and,
4. Control costs.

Specific objectives for each rehabilitation domain are detailed as follows.

4.1 Rehabilitation domains

Ensham has developed an enhanced domain model in which there are two types of domains to consider for rehabilitation, i.e. primary and secondary domains (Table 4-1). All areas to be rehabilitated have been assigned primary and secondary domains that describe the type of mining disturbance and a target post-mining land use.

Primary domains are areas of mining disturbance with unique operational purpose or function and therefore similar geophysical characteristics and rehabilitation treatment requirements. Secondary domains are areas in the post-mining landscape with the same sustainable land use objective, e.g. sustainable cattle grazing. It is possible that a primary domain could have more than one secondary domain, e.g. 3A (sustainable cattle grazing on mine infrastructure areas) and 3E (landholder retained infrastructure on mine infrastructure areas), in different areas at Ensham. Whilst secondary domains may exist adjacent to each other, they are mutually exclusive on-ground and not overlapping. This allows clear and unambiguous indicators and criteria to be nominated for each combination of primary and secondary domains.

Table 4-1 Ensham rehabilitation domain model

Code	Primary domains	Code	Secondary domains
1	Overburden emplacement	**A**	Sustainable cattle grazing
2	Mining pit	**B**	Water storage
3	Mining infrastructure	**C**	Remnant mining voids
4	Boggy creek diversion	**D**	Watercourse bed, banks and riparian vegetation
		E	Landholder retained infrastructure

The location and extent of each rehabilitation domain in the post-mining landscape has been determined (Figure 4-1).

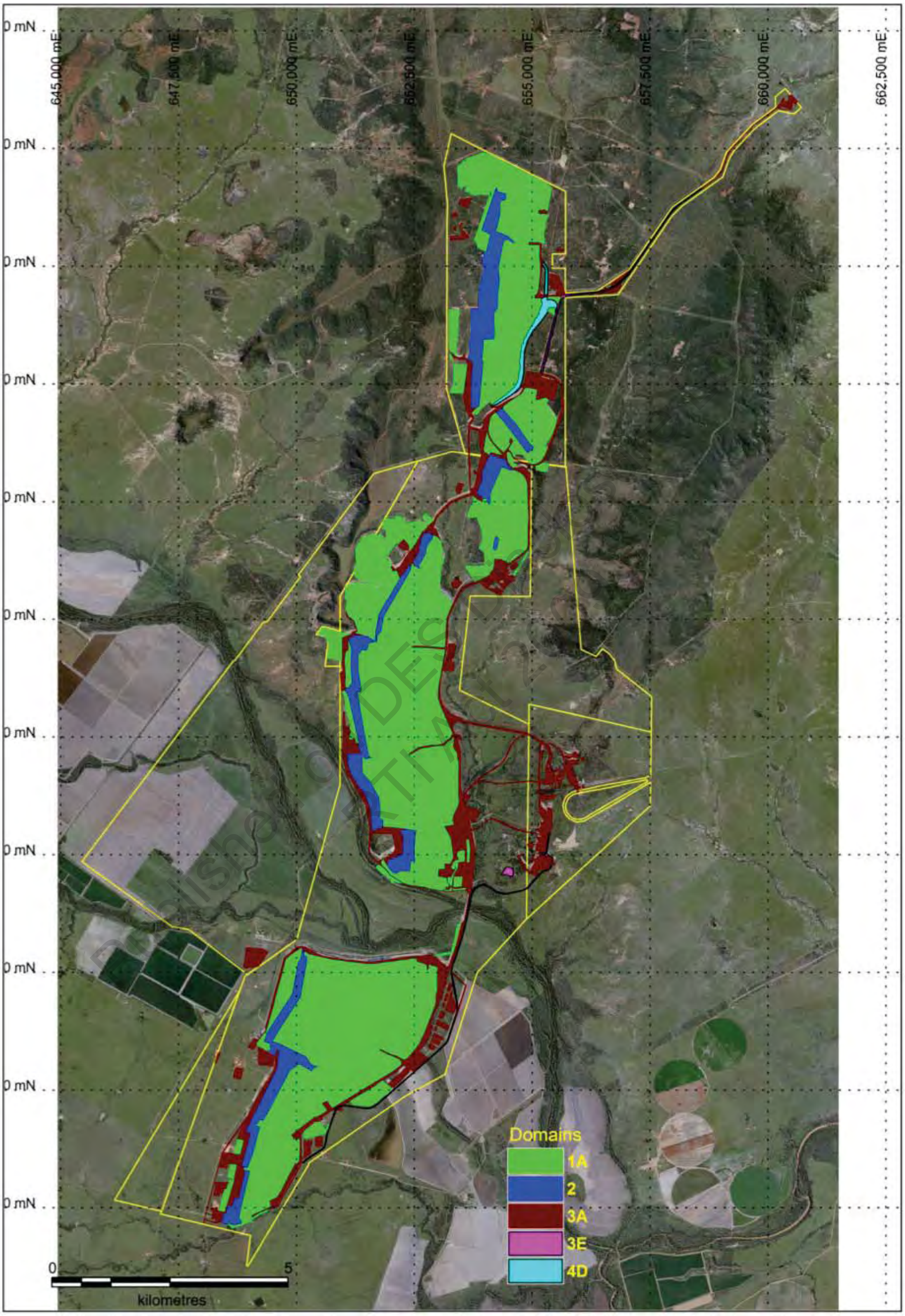

Figure 4-1 Location and extent of rehabilitation domains in the post-mining landscape

4.2 Rehabilitation goals

In accordance with EHP *Guideline - Rehabilitation requirements for mining projects* (EM1122)[2], Ensham has adopted the Government's policy objectives for rehabilitation and called these 'rehabilitation goals'. These goals are:

1. Safe to humans and wildlife
2. Non-polluting;
3. Stable; and
4. Able to sustain an agreed post-mining land use.

Ensham has determined that there are no additional goals that are relevant to the site.

4.3 Objectives

Ensham has developed objectives that clearly describe desired rehabilitation outcomes within each domain on the mine site (Table 4-2). Objectives recognise the general rehabilitation goals and ESD principles set by government. The overarching objectives for rehabilitation at Ensham are to ensure safety hazards are not greater than those that exist in the surrounding landscape, and to establish a structurally stable, non-polluting landscape that maximises potential for a sustainable grazing land use. Reinstating the previous land use of grazing is fourth on the rehabilitation hierarchy, and this is the highest practicable level for rehabilitation at Ensham.

Table 4-2 Rehabilitation objectives for each domain

Domain	Description	Objectives based on goals			
		Safe to humans and wildlife	*Non-polluting*	*Stable*	*Able to sustain an agreed post-mining land use*
1A	Sustainable cattle grazing on overburden emplacement areas	Safety hazards in rehabilitation are similar to surrounding unmined landscapes[3].	Surface runoff leaving domain is non-polluting to receiving waters (Nogoa River).	Landforms are both geo-technically and erosionally stable.	Rehabilitation is suitable for sustainable cattle grazing.
3A	Sustainable cattle grazing on mining infrastructure areas				
3E	Landholder retained infrastructure on mining infrastructure areas	Safety hazards accepted by landholder.		Landholder accepts the condition of infrastructure, including its structural integrity.	Landholder formally accepts infrastructure for his/her ongoing beneficial use.

[2] Guideline, Resource Activities, Rehabilitation requirements for mining resource activities, EM1122 Version 2, Department of Environment and Heritage Protection, 2014.
[3] The surrounding landscape, particularly landform, has been comprehensively described in EIS, EMOS and EMP documentation.

Domain	Description	Objectives based on goals			
		Safe to humans and wildlife	*Non-polluting*	*Stable*	*Able to sustain an agreed post-mining land use*
4D	Watercourse bed, banks and riparian vegetation of the Boggy creek diversion	Safety hazards in rehabilitation are similar to surrounding unmined landscapes.		Landforms are both geo-technically and erosionally stable.	Riparian vegetation is suitable for conservation of rehabilitated creek diversion areas.
2(x[4])	Per condition G6, this information is to be provided by 31 March 2019.				

4.4 Design objectives for slope gradients and lengths

With respect to slope gradient and length, the basic design objective for all rehabilitation is to control erosion risk. So *et al* (1998) measured the rate of erosion-derived sediment delivery from 32 bare soils and overburdens in central Queensland at slope gradients from 5 to 30%. Unremarkably, sediment delivery rates increased linearly with slope (Figure 4-2) and also with slope length. The effect of increasing slope gradient from 5% to 30% was a 12-fold and 4-fold increase in sediment delivery rates for soils and spoils, respectively. Soils and spoils with 20-30% silt tended to form strong raindrop impact seals (hard surface crusts) under rainfall and consequently had very low erodibilities.

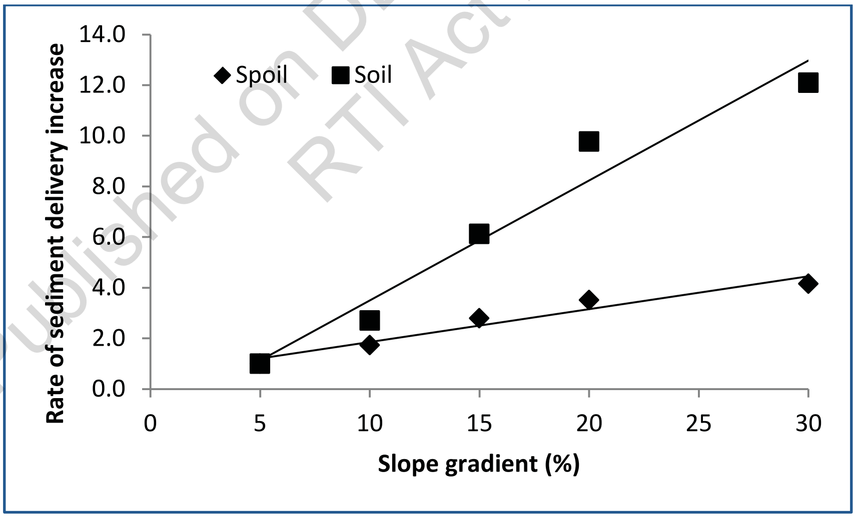

Figure 4-2 Effect of slope gradient on the rate of sediment delivery for central Queensland soils and overburdens (after So *et al* 1998)

There is no guideline that provides the optimal slope gradient and length combination for rehabilitation. Erosion is a function of not only slope gradient and length, but also of material properties, surface condition and groundcover, and rainfall. For example, the impact of vegetation on erosion from rehabilitated soils in central Queensland has been described as “enormous” (So *et al* 1998) and the single most important control on erosion (Grigg *et al* 2001).

[4] To be determined and provided in accordance with EA condition G6 by 31 March 2019.

With consideration to material characteristics (see section 3) and more than 40 years of industry-led research and practice, Ensham has determined the following design objective for slopes.

1. Tertiary overburden slopes, regardless of soil type, will have:
   - Gradients ≤10%, and
   - Lengths ≤200m, variable depending on the size of the contributing upper catchment.
2. Permian overburden slops, regardless of soil type, will have:
   - Gradients ≤15%, and
   - Lengths ≤100m, variable depending on the size of the contributing upper catchment.

4.5 Design objectives for aesthetics and sympathy to the surrounding landscape

The visual appeal and/or natural appearance of rehabilitation are not rehabilitation goals. The notion that form and function are closely linked and hence mining landscapes should be fashioned to look natural, as though they are the product of natural geomorphic processes, can not displace operational safety, cost and stability considerations in rehabilitation.

Mining is transformative in the landscape, and in central Queensland unconsolidated overburden emplacements are inherently more erodible than natural landforms. However, form (landscape attributes) and function (flow of energy, material and species) must be matched in rehabilitation too. This will likely be a fundamental characteristic of successful post-mining landscapes.

Ensham accepts that a 'natural appearance' may be important to some stakeholders and will endeavour to design landforms within the natural range of geometries of regional landforms. Natural landforms in the vicinity of Ensham are described as follows (Ensham Resources, 1996):

- Terrain in the northern half of the mine comprises mainly mildly dissected gently to moderately sloping and undulating lands, which form slopes and outwash plains flanking Boggy Creek. Erosion has occurred below the elevated plateau remnants that occur in the north.
  Plateau remnants feature steep escarpments, with sloes in the order of 33% to 66% gradient or more, with local relief up to 50 m between plateau crests and adjacent escarpment foot slopes.
- In the southern half, terrain is essentially gently sloping. This encompasses the extensive floodplain area of the Nogoa River.

Key post-mining landform design parameters for rehabilitation are within the natural range of geometries of local landforms, e.g. slope gradients and lengths.

5 TOPSOIL MANAGEMENT

Topsoil is salvaged in advance of mining disturbance and preserved for use in rehabilitation.

5.1 Topsoil quantity

Ensham currently holds about 3.5 million cubic metres (Mm^3) of topsoil in stockpiles, preserved for use in future rehabilitation (Table 5-1).

Table 5-1 Location and volume of preserved topsoil

Location (pits)	Volume (m^3)
A and B	2,491,370
C, D and E	362,038
F	342,271
Y	474,635
TOTAL	3,670,332

If respread to create a 200mm soil layer for rehabilitation this quantity is sufficient to cover approximately 1,800ha. This highlights a topsoil deficit of around 3,000 ha. Ensham will manage this deficit by:

- Strategically using topsoil to promote rapid groundcover establishment and stabilisation of outer slopes that drain to the broader environment.
- Ameliorating Permian overburden to create a plant growth media or 'topsoil substitute', e.g. by additions of organic matter, gypsum and/or fertiliser.

6 REHABILITATION METHODS

Following is a summary of on-ground rehabilitation methods used at Ensham (Table 6-1).

Table 6-1 Rehabilitation methods for each domain

Domain		Rehabilitation methods
1A	Sustainable cattle grazing on overburden emplacement areas	1. Reshape to achieve post-mining landform design parameters using draglines, dozers or truck/shovel equipment; 2. Apply ameliorants such as gypsum, if needed; 3. Respread topsoil to 200mm depth (average); 4. Deep rip to 600mm on 2m centres using the 'Ensham ripper'; 5. Sow seed and spread fertiliser; 6. Spread hay mulch for immediate groundcover; 7. Monitor and maintain rehabilitation domains; 8. Erect fencing and supply stockwater then establish post-mining grazing land use.
3A	Sustainable cattle grazing on mining infrastructure areas	1. Remove infrastructure; 2. Complete contaminated land assessment and management; 3. Reshape to achieve post-mining landform design

Domain		Rehabilitation methods
		parameters, if required; 4. Apply ameliorants such as gypsum, if needed; 5. Respread topsoil to 200mm depth (average); 6. Deep rip to 600mm on 2m centres using the ‘Ensham ripper’; 7. Sow seed and spread fertiliser; 8. Spread hay mulch for immediate groundcover; 9. Monitor and maintain rehabilitation domains; 10. Erect fencing and supply stockwater then establish post-mining grazing land use.
3E	Landholder retained infrastructure on mining infrastructure areas	1. Remove unwanted infrastructure; 2. Complete contaminated land assessment and management; 3. Monitor and maintain rehabilitation domains.
4D	Watercourse bed, banks and riparian vegetation of the Boggy Creek diversion	1. Reshape to achieve post-mining landform design parameters based on ACARP research; 2. Apply ameliorants such as gypsum, if needed; 3. Strategically respread topsoil to 200mm depth (average); 4. Where vegetation is to be established, i.e. banks, then a. Deep rip to 600mm on 2m centres using the ‘Ensham ripper’; b. Sow seed and spread fertiliser; c. Spread hay mulch for immediate groundcover; 5. Monitor and maintain rehabilitation domains; 6. Erect fencing to exclude domestic stock for the protection of riparian vegetation.

7 NATIVE VEGETATION CORRIDORS

Much of the native vegetation surrounding Ensham has been extensively cleared for agricultural land development. Existing vegetation corridors mainly associated with the Nogoa River and its tributaries will remain in the post-mining landscape (Figure 7-1). As the most appropriate post-mining land use for Ensham is sustainable cattle grazing, no additional native vegetation corridors will be constructed in rehabilitation.

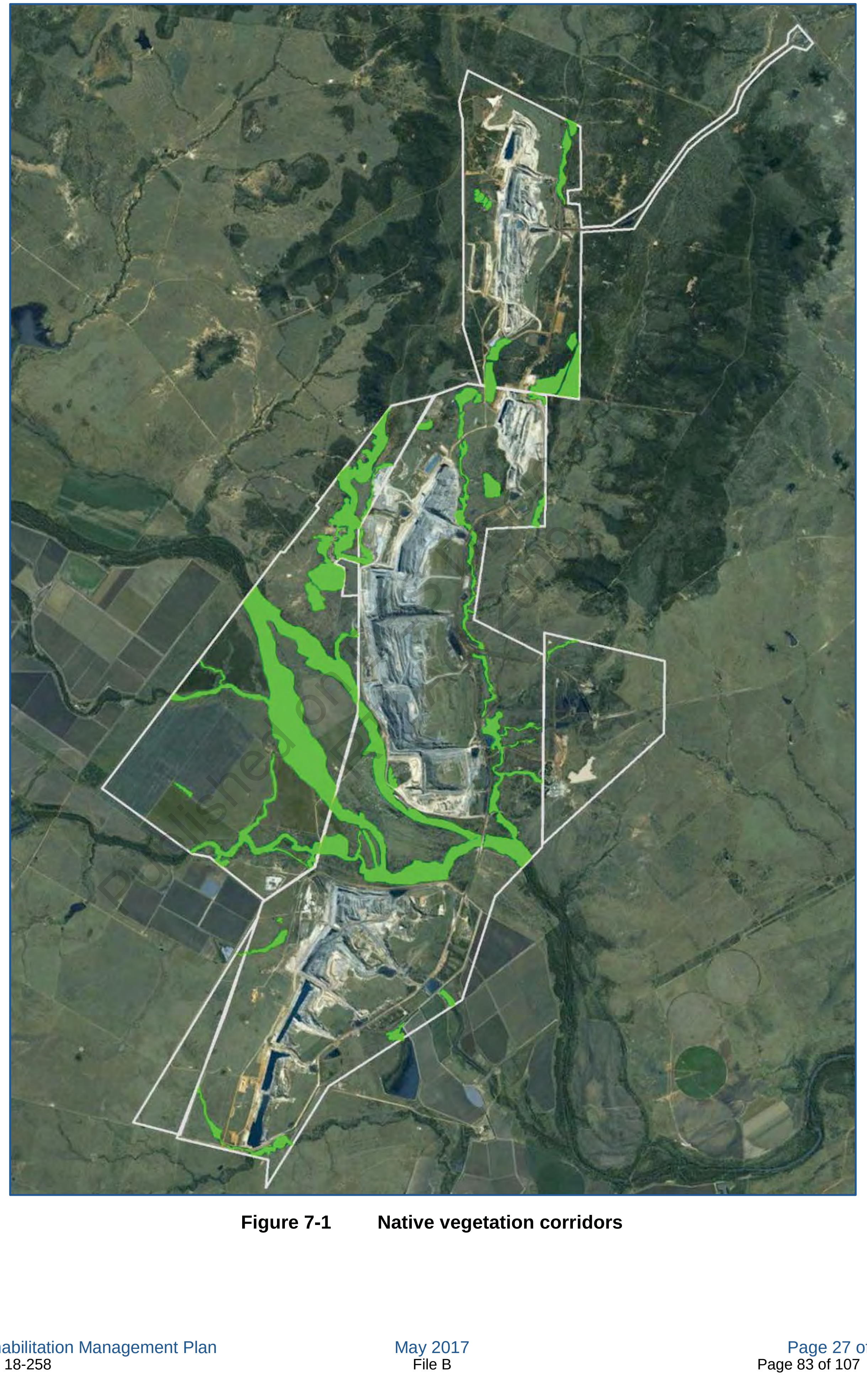

Figure 7-1 Native vegetation corridors

8 REFERENCE SITES

Since 2005, rehabilitation monitoring has included assessment and comparison of rehabilitation outcomes to reference sites. Reference sites are selected to provide 'target conditions' for rehabilitation and therefore, have should comparative:

- Soil, landform and land suitability;
- Vegetation form;
- Species assemblages;
- Land use.

However, it is difficult to select reference sites to compare rehabilitation due to the transformative impacts of mining on hydrology, topography and geology of the land. This may ultimately limit the usefulness of reference sites in benchmarking rehabilitation outcomes. For example, it is reasonably foreseeable that some rehabilitation may achieve the rehabilitation goals of safe, stable, non-polluting and sustainable land use, but remain *'different'* in form and function to unmined reference sites.

Despite recognised difficulties with this approach, a number of reference sites have been established and monitored at Ensham (Table 8-1). As an objective for most rehabilitation is sustainable cattle grazing land use, selection of reference sites has been skewed towards unmined areas used for pasture and/or grazing.

Table 8-1 Details of reference sites for rehabilitation monitoring (GDA 94, Zone 55)

Site ID	Description	Easting	Northing
DPREF1	Alluvial plain, ungrazed	650976	7402880
DPREF2	Alluvial plain, grazed	649302	7403072
ENREF1	Ungrazed grassland	654151	7408247
ENREF2	Grazed grassland	654063	7408087
Ironbark REF5	Open woodland	655590	7411002
Yapunyah REF6	Open woodland	650168	7406780

9 VALUES, INDICATORS AND COMPLETION CRITERIA

Rehabilitation goals and objectives (refer to section 4) and indicators and completion criteria are interdependent with environmental values. The following describes environmental values, identifies indicators and completion criteria, and outlines linkages between environmental values and rehabilitation indicators and completion criteria.

9.1 Environmental values

Ensham has previously identified environmental values (EVs) for air, groundwater, surface water, noise, ground vibration and air-blast overpressure, waste, land, community, nature conservation and cultural heritage (Hanson Bailey 2009). Some of these are not relevant to the post-mining landscape, e.g. noise, ground vibration and air-blast overpressure, and cultural heritage.

EVs relevant to rehabilitation are:

Air - In accordance with the *Environmental Protection (Air) Policy 2008 (EPP Air)*, the environmental values of the air environment to be enhanced or protected are the qualities of the air environment that are conducive to suitability for the life, health and wellbeing of humans.

Groundwater - The environmental values associated with groundwater resources that may potentially be affected by Ensham include the water level and water quality of the Nogoa River alluvial aquifer and the coal seam aquifer.

Surface water -The surface water environmental values which may potentially be affected by Ensham Mine include the following:

- Surface water quality, including the Nogoa River and tributary streams;
- The Nogoa Mackenzie Water Supply Scheme, which includes conveyance of allocated water supply flows via the reach of the Nogoa River traversing the mine site; and

Land - The environmental values to be protected or enhanced are the:

- The suitability of the project site for agricultural activities; and
- The aesthetic qualities of the landscape.

Community - The environmental values to be enhanced or protected are those that relate to the existing lifestyle of the surrounding community, including the general wealth, health, safety and wellbeing of the community.

The potential impacts of rehabilitation indictors and completion criteria on relevant EVs, the risks of those impacts and mitigation measures have been identified (Table 9-1). As indicators and criteria set the standards that rehabilitation must achieve, and these standards must ensure protection of the environment, these also constitute mitigation measures for EV risk management. The robust scientific bases of criteria are found in references provided as footnotes where each criterion appears for the first time in table text. Risk evaluation was performed in accordance with the Ensham Risk Matrix Tool (Appendix B).

Ensham RESOURCES

Table 9-1 Environmental value linkages to rehabilitation indicators and completion criteria

EV	Potential impacts[5]	Rehabilitation objective	Mitigation measures		Final risk[6]
			Indicators	Completion criteria	
Air	Dust Odour	Landforms are both geotechnically and erosionally stable	Dust - Groundcover percentage Odour – none proposed	≥50%	L24 (low)
Groundwater	Deep drainage (seepage) of contaminants	Deep drainage (seepage) from domain is non-polluting to recognised groundwater resources	Contaminated land assessment	Zero contaminated sites	L25 (low)
			Per condition G6 of the EA		
Surface water	Runoff containing contaminants	Surface runoff leaving domain is non-polluting to receiving surface waters (Nogoa River)	pH	7.5 – 8.3[7]	L21 (low)
			EC (salinity)	125 - 1250 µS/cm[8]	L21 (low)
			TSS (sed. loss)	85 mg/L (max)[9]	L21 (low)
			Sulphate	2.2-22.0 mg/L[10]	L25 (low)

[5] As relevant to each domain, refer to Table 9-2
[6] Risk assessed in accord with Ensham risk matrix (Appendix B)
[7] 10th and 90th Percentiles of pH from Government water sampling for Nogoa River upstream at Duckponds (141 samples, 1993-2015 period), see *"Water sample analysis summary report"*, available at https://water-monitoring.information.qld.gov.au. Values derived in accordance with Section 4.3 of Queensland Water Quality Guidelines 2009, DEHP, State of Queensland, 2013
[8] 10th and 90th Percentiles of EC for the Nogoa Basin north of Emerald, highly disturbed system (regulated river), from Queensland Water Quality Guidelines 2009, DEHP, State of Queensland, 2013
[9] Total suspended solids (TSS) post-construction phase, from Queensland Water Quality Guidelines 2009, DEHP, State of Queensland, 2013
[10] 10th and 90th Percentiles of sulphate from Government water sampling for Nogoa River upstream at Duckponds (70 samples, 1993-2016 period), see *"Water sample analysis summary report"*, available at https://water-monitoring.information.qld.gov.au. Values derived in accordance with Section 4.3 of Queensland Water Quality Guidelines 2009, DEHP, State of Queensland, 2013

EV	Potential impacts[5]	Rehabilitation objective	Mitigation measures		Final risk[6]
			Indicators	Completion criteria	
		Riparian vegetation is suitable for conservation of rehabilitated creek diversion areas.	Index of diversion condition (IDC)	>10[11]	L23 (low)
Land	Changes to land suitability Changes to land use	Rehabilitation is suitable for sustainable cattle grazing	Land suitability assessment	Land suitability classes 2-4[12]	L23 (low)
	Land contamination		Contaminated land assessment	Zero contaminated sites[13]	L25 (low)
	Loss of aesthetic qualities	Landforms are erosionally stable	Groundcover	50%[14]	L23 (low)
			Slope gradient	15% (max) [15]	L25 (low)
Community	Additional safety hazards in the post-mining landscape.	Safety hazards in rehabilitation are similar to surrounding unmined landscapes.	Hazard assessment	No difference pre- and post-mining[16]	L25 (low)
	Land instability	Landforms are geotechnically	Factor of safety	≥1.5[17]	L23 (low)

[11] White K, Moar D, Hardie R, Blackham D and Lucas R 2014, 'Criteria for functioning river landscape units in mining and post-mining landscapes', final report of ACARP Project number C20017, Australian Coal Research Limited, Brisbane.
[12] Guidelines for Agricultural Land Evaluation in Queensland, second edition, DNRM and DSITIA, State of Queensland 2013 (about 15 land and soil attributes are assessed to determine land suitability class)
[13] In accordance with statutory requirements for the identification and management of contaminated land in Queensland
[14] Many studies have demonstrated that with groundcover >50% erosional soil loss from rehabilitation is negligible, e.g. see Carroll, C and Tucker, A 2000, 'Effects of pasture cover on soil erosion and water quality on central Queensland coal mine rehabilitation', Tropical Grasslands, vol. 34, pp 254-262; Carroll C, Tucker A, Merton P, Burger P and Pink L 2001, 'Sustainability indicators for coal mine rehabilitation, ACARP Project Number C7006, Australian Coal Research Limited, Brisbane; Loch, R 2000, 'Effects of vegetation cover on runoff and erosion under simulated rain and overland flow on a rehabilitated site on the Meandu Mine, Tarong, Queensland'. *Australian Journal of Soil Research*, vol. 38, pp 299-312; So H, Sheridan G, Loch R, Carroll C, Willgoose G, Short M and Grabski A 1998, 'Post-mining landscape parameters for erosion and water quality control', final report of ACARP Project Numbers C1629 and C4011, Australian Coal Research Limited, Brisbane.
[15] In accordance with the Ensham Rehabilitation Management Plan
[16] Methodology in accordance with AS/NZS ISO 13000:2009 Risk Management (this standard is currently applied in risk management at Ensham)

EV	Potential impacts[5]	Rehabilitation objective	Mitigation measures		Final risk[6]
			Indicators	Completion criteria	
		stable			
	Landholders may benefit from retaining some mining infrastructure.	Landholder formally accepts rehabilitation for his/her ongoing beneficial use.	Legally binding agreement	Executed by each party	L25 (low)

9.2 Rehabilitation indicators and completion criteria

Ensham has identified meaningful indictors to provide robust and defensible measurements of progress towards rehabilitation objectives and protection of environmental values. Every domain has been assigned indicators (Table 9-2). Each indicator has a valid scientific basis and a practical and reliable method of measurement, and also reveals something important about the rehabilitation domain.

Criteria are the threshold limits or benchmarks against which indicators will be assessed to determine if rehabilitation objectives have been met. Every indicator has been allocated a relevant criterion or set of criteria. Importantly, criteria are numeric and will be measured to form a set of statistical metrics for on-going analysis during the period of rehabilitation monitoring and evaluation.

Table 1-2 Indicators and completion criteria

Mine domain	Rehabilitation feature name	Goals	Objective	Indicators	Completion criteria
1A	Sustainable cattle grazing on overburden emplacement areas	Safe	Safety hazards in rehabilitation are similar to surrounding unmined landscapes.	Hazard assessment	0 (zero) significant difference
		Non-polluting	Surface runoff leaving domain is non-polluting to receiving surface waters (Nogoa River).	pH	7.5 – 8.3
				EC (salinity)	125 - 1250 µS/cm
				TSS (sed. loss)	85 mg/L (max)
				Sulphate	2.2-22.0 mg/L

[17] Geotechnical slope stability, DME, State of Queensland 1995; Geotechnical considerations in open pit mines, guideline, version 1, DME, State of Western Australia 1999

Mine domain	Rehabilitation feature name	Goals	Objective	Indicators	Completion criteria
			Deep drainage (seepage) from domain is non-polluting to recognised groundwater resources	Per condition G6, this table is to be updated by 31 March 2019 to include indicators and criteria for any potential groundwater impacts, as this may be influenced by residual mining voids.	
		Stable	Landforms are both geo-technically and erosionally stable.	Factor of safety	≥1.5
				Slope gradient	15% (max)
				Groundcover	≥50%
		Land use	Rehabilitation is suitable for sustainable cattle grazing.	Land suitability assessment	Classes 2 to 4
2x	Remnant mining voids on mining pit areas	Per condition G6, this table is to be updated by 31 March 2019 to include indicators and criteria for residual mining voids.			
3A	Sustainable cattle grazing on mining infrastructure areas	Safe	Safety hazards in rehabilitation are similar to surrounding unmined landscapes.	Hazard assessment	0 (zero) significant difference
		Non-polluting	Surface runoff leaving domain is non-polluting to receiving surface waters (Nogoa River).	pH	7.5 – 8.3
				EC (salinity)	125 - 1250 µS/cm
				TSS (sed. loss)	85 mg/L (max)
				Sulphate	2.2-22.0 mg/L
				Contaminated land assessment	0 (zero) contaminated sites
		Stable	Landforms are both geo-technically and erosionally stable.	Factor of safety	≥1.5
				Slope gradient	15% (max)
				Groundcover	≥50%
		Land use	Rehabilitation is suitable for sustainable cattle grazing.	Land suitability assessment	Classes 2 to 4

Mine domain	Rehabilitation feature name	Goals	Objective	Indicators	Completion criteria
3E	Landholder retained infrastructure on mining infrastructure areas	Safe	Safety hazards accepted by landholder.	Legally binding agreement	Executed by each party
		Non-polluting	Surface runoff leaving domain is non-polluting to receiving surface waters (Nogoa River).	pH	7.5 – 8.3
				EC (salinity)	125 - 1250 µS/cm
				TSS (sed. loss)	85 mg/L (max)
				Sulphate	2.2-22.0 mg/L
				Contaminated land assessment	0 (zero) contaminated sites
		Stable	Landholder accepts the condition of infrastructure, including its structural integrity.	Legally binding agreement	Executed by each party
		Land use	Landholder formally accepts infrastructure for his/her ongoing beneficial use.	Legally binding agreement	Executed by each party
4D	Watercourse bed, banks and riparian vegetation of the Boggy creek diversion	Safe	Safety hazards in rehabilitation are similar to surrounding unmined landscapes.	Hazard assessment	0 (zero) significant difference
		Non-polluting	Surface runoff leaving domain is non-polluting to receiving surface waters (Nogoa River).	pH	7.5 – 8.3
				EC (salinity)	125 - 1250 µS/cm
				TSS (sed. loss)	85 mg/L (max)
				Sulphate	2.2-22.0 mg/L
		Stable	Landforms are both geo-technically and erosionally stable.	Factor of safety	≥1.5
				Index of diversion condition	>10
		Land use	Riparian vegetation is suitable for conservation of rehabilitated creek diversion areas.	Index of diversion condition	>10

9.3 Land suitability class as an indicator for sustainable cattle grazing as a post-mining land use

The vast majority of rehabilitation at Ensham is focussed to establishing sustainable cattle grazing as a post-mining land use. Land Suitability Assessment has been identified as the best indicator to determine progress towards this rehabilitation objective. This will be of primary interest to stakeholders and is therefore, worthy of further explanation.

In Queensland, five land suitability classes are defined (DNRM/DSITIA 2013a), with land suitability decreasing progressively from Class 1 to Class 5. These classes are used to describe an area of land in terms of suitability for a particular land use which allows optimum, sustainable production with current technology, while minimising degradation to the land resource in the short, medium or long-term. Land is considered less suitable as the severity of limitations affecting a particular land use increases, reflecting either:

- Reduced potential for production; and/or,
- Increased inputs required to achieve an acceptable level of production; and/or,
- Increased inputs required to prepare the land for successful production; and/or,
- Increased inputs required to prevent land degradation.

The five land suitability classes defined for Queensland are as follows.

Class 1 - Suitable land with negligible limitations – land that is well suited to a proposed use;

Class 2 - Suitable land with minor limitations – land that is suited to a proposed use but which may require minor changes in management to sustain the use;

Class 3 - Suitable land with moderate limitations – land that is moderately suited to a proposed use but which requires significant inputs to ensure sustainable use;

Class 4 - Marginally suitable land with severe limitations – land which is marginally suited for a proposed use and would require major inputs to ensure sustainability; often the inputs required may not be justified in terms of the benefits to be gained from using the land for a proposed use and the land is considered presently unsuitable for that use; and

Class 5 - Unsuitable land with extreme limitations – land that is unsuited and cannot be sustainably used for a proposed use.

Classes 1 to 3 are considered suitable for a specified land use because the benefits from using the land (for that particular use) outweigh the inputs required to initiate and maintain production.

Typically, the benefits from using Class 4 land are similar in magnitude to the level of inputs required to achieve production and its long-term suitability for the specified land use is doubtful. Class 4 is also used in situations where reducing the effect of a particular limitation may indicate production is possible, but additional studies are needed to determine the feasibility of such actions, e.g. fertilisation.

In contrast, there is no doubt regarding the long-term suitability of Class 1–3 lands or the unsuitability of Class 5 land. Class 5 land has limitations that in aggregate are so severe that the benefits do not justify the inputs required to initiate and maintain production. It would require a major change in economics, technology or management expertise before the land could be considered suitable for the land use being considered. Many Class 5 lands have physical characteristics that totally preclude any form of development, e.g. very steep slops, and will always remain unsuitable for agriculture.

9.3.1 Suitability for grazing

The suitability classification for grazing evaluates soils in terms of the potential to graze and finish cattle on improved pastures (QDME 1995, Shields and Williams 1991). Typically, grazing systems in inland Central Queensland aim to produce young, finished, grassfed, export quality cattle without inputs other than pasture development. Most production is based around improved grass-legume pastures. Improved pasture development in many areas is dominated by buffel grass, although Rhodes grass, introduced bluegrasses (Indian bluegrass, creeping bluegrass), purple pigeon grass and panic species all have a role in certain situations. Legume establishment and species vary significantly depending on soil characteristics and microclimates. Commonly used legumes include shrubby stylos species, Desmanthus species, Wynn cassia (sandy soils), butterfly pea (clay soils), siratro, medics and leucaena (cropping soils).

Class 1 and 2 land is considered suitable for grazing improved pastures and is capable of attaining maximum grazing productivity (QDME 1995, Shields and Williams 1991). In inland Central Queensland this can be defined as the production of young, finished, grassfed, export quality cattle in most seasons, and such country is termed ‘fattening country’.

Class 3 land is suitable for grazing improved pastures but is generally less productive than Classes 1 and 2 and encompasses a range in productivity. Land in this class is often termed *‘growing country’* and is defined as country on which younger cattle perform well but may be difficult to finish at a young age, depending on seasonal conditions, i.e. cattle on Class 3 land may take longer to achieve the desired weight class or finished grade than equivalent cattle on Classes 1 and 2 land.

Class 4 land is considered marginal for grazing improved pastures, but is generally considered suitable for grazing native pastures of varying quality all year round, depending on soil characteristics, (QDME 1995, Shields and Williams 1991). In inland Central Queensland such country is typically termed ‘breeding country’. It encompasses a range in productivity from the lower end of Class 3 growing country through to the poorer end of Class 4 breeding country. Shields and Williams (1991) suggest 3 possible subclasses exist within Class 4:

- Land with native pasture of low productivity, which while physically capable of being developed to improved pasture, is subject to low soil fertility and doubtful long term productivity;
- Land with high quality native pasture (typically black soil downs) on which improved pasture establishment is marginal because of unfavourable soil characteristics and limited species; and
- Land with native pasture of low productivity, which has physical limitations that preclude fully improved pasture development, but allow over-sowing of legumes such as shrubby stylo.

Class 5 land is unsuitable for any form of pasture improvement and land use is limited to extensive grazing of native pastures of low productivity. In many cases, lands are of such poor quality they are considered marginal as breeding country and may be destocked in the winter/dry season, unless grazed in conjunction with better quality country. Land in this class is mostly used as breeding country during the summer/wet season when planes of nutrition are higher.

9.3.2 Land use requirements and limitations

Following DNRM/DSITIA (2013a, 2013b), QDME (1995), and Shields and Williams (1991), a set of 15 land use requirements and associated limitations has been identified as important for sustainable grazing of land rehabilitated after mining in central Queensland (Table 9-2). Limitation subclass threshold limits have been defined (Appendix A).

Table 1-3 Land use requirements and limitations for sustainable grazing of rehabilitated land in central Queensland

Count	Land use requirement	Limitations	Code	Attributes to assess each limitation
1	Appropriate slope gradients for particular soil types	Surface soil erodibility	Ea	Slope, ESI, ESP, salinity
2		Subsoil erodibility	Eb	Slope, ESI, ESP, salinity

Count	Land use requirement	Limitations	Code	Attributes to assess each limitation
3	Adequate water supply	Soil water availability	M	PAWC, ERD, deep drainage losses, infiltration rate
4	Ease of pasture establishment	Surface condition	Ps	Soil structure, condition, texture
5	Rock free surface soils	Rockiness	R	Size and content of coarse fragments, % rock outcrop
6	Level land	Micro-relief	Tm	Size and frequency of micro-relief
7	Adequate soil aeration	Wetness	W	Soil drainage (field observation)
8	Not affected by AMD or acid sulphate soils	Acid drainage water hazard, real	Ar	Depth to buried PAF materials, water pH
9		Acid drainage water hazard, potential	Ap	Depth to buried PAF materials, water pH
10	Adequate nutrient supply	Nutrient deficiency	Nd	Levels of P (mg/kg) in surface soils (0-10cm)
11	Absence of elemental enrichment in surface soils	Element toxicity	Tx	pH (1:5 water) in surface soils (0-10cm)
12	Adequate soil depth to support vegetation	Soil depth	Sd	Measurement to rooting impediment
13	Salinity free root zone	Root zone salinity	Sa	EC, chloride level
14	Absence of undesirable vegetation	Vegetation	V	Vegetation type, regrowth potential
15	Practical land area available	Landscape complexity	Lc	Contiguous land area

10 CONTINUOUS IMPROVEMENT

Continuous improvement is an essential part of rehabilitation management at Ensham. The continuous improvement cycle has four interrelated phases, otherwise known as the Plan, Do, Check, Act cycle (Figure 10-1):

1. **PLAN –** establish the actions and resources necessary to implement the RMP.
2. **DO –** implement the RMP and allocate resources, including time.
3. **CHECK –** monitor, measure and report on rehabilitation outcomes, and compare and contrast these with ‘completion criteria’.
4. **ACT –** incorporate actions for improvement into planning and/or execution to maximise rehabilitation success.

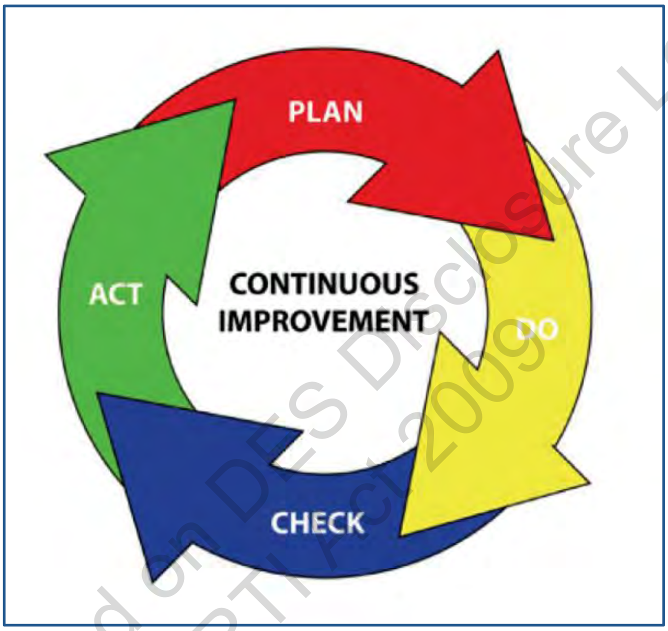

Figure 10-1 Continuous improvement cycle for rehabilitation

PLAN and DO are discussed elsewhere in this document. CHECK and ACT are detailed as follows.

10.1 Monitoring (check)

Monitoring will be required at various intervals for a range of indicators to ensure that completion criteria are met. It may take several years of monitoring to produce a statistically valid data set to do this. This relies on information being collected in a consistent manner to allow multi-year comparison of trends and assessment of outcomes against completion criteria and/or specific actions.

Monitoring methods and intervals for each indicator are provided (Table 10-1). This is considered the minimum data requirement and additional ad hoc monitoring may be performed. Some statistical analysis of monitoring data will be needed to determine if differences are significant or not. This will help to determine if management intervention is required to adjust performance trajectories. However, in most cases, data analysis will be simple and restricted to plotting of trends, calculation of averages, standard deviations and basic statistics.

Table 10-1 Monitoring methods and intervals for each indicator

Objective	Indicator	Completion criteria	Monitoring method	Monitoring frequency	By whom
Safety hazards in rehabilitation are similar to surrounding unmined landscapes.	Hazard assessment	Zero significant difference between rehabilitation and surrounding landscape	AS/NZS ISO 13000:2009 Risk Management	5 years	Appropriately qualified person[18]
Safety hazard accepted by landholder	Legally binding agreement	Executed document	Qualitative (yes/no)	Once following cessation of mining	Legal document executed by EA holder and landholder/s
Surface runoff leaving domain is non-polluting to receiving surface waters (Nogoa River).	pH	7.5 – 8.3	Water sampling of receiving waters upstream and downstream, and point of release from domains	Monthly and also at each rainfall runoff event	Sampling by technical personnel, data review and reporting by appropriately qualified person
	EC (salinity)	125 - 1250 µS/cm			
	TSS (sed. loss)	85 mg/L (max)			
	Sulphate	2.2-22.0 mg/L			
	Contaminated land assessment	Zero contaminated sites	Contaminated land assessment	Once following cessation of mining	Suitably qualified person[19]
Landforms are both geo-technically and erosionally stable.	Factor of safety	≥1.5	Engineering calculation	5 years	Registered Professional Engineer Queensland (RPEQ)[20]
	Slope gradient	15% (max)	Remote sensing, e.g. LIDAR survey, or On-ground survey	As constructed	Registered Surveyor Queensland[21]
	Groundcover	≥50%	Grass Check by NRM	2 years	Appropriately qualified person

[18] "Appropriately qualified person" has the same meaning as in EHP Guideline EM1122
[19] "Suitably qualified person" has the same meaning as in EHP Guideline ESR/2016/1938
[20] "RPEQ" by Board of Professional Engineers Queensland
[21] "Registered Surveyor" by Surveyors Board Queensland

Objective	Indicator	Completion criteria	Monitoring method	Monitoring frequency	By whom
Landholder accepts the condition of infrastructure, including its structural integrity.	Legally binding agreement	Executed document	Qualitative (yes/no)	Once following cessation of mining	Legal document executed by EA holder and landholder/s
Landholder formally accepts infrastructure for his/her ongoing beneficial use.	Legally binding agreement	Executed document	Qualitative (yes/no)	Once following cessation of mining	Legal document executed by EA holder and landholder/s
Rehabilitation is suitable for sustainable grazing by cattle	Land suitability assessment	Classes 2 - 4	Land suitability assessment by NRM	Within 2 years of construction	Appropriately qualified person
Riparian vegetation is suitable for conservation of rehabilitated creek diversion areas.	Index of Diversion Condition (IDC)	IDC score >10	ACARP C9068 and C20017	Annually	Appropriately qualified person

10.2 Corrective actions (act)

Monitoring data will be used in conjunction with completion criteria to determine when and where corrective interventions are needed. This may include:

- Re-evaluation of monitoring data;
- Additional monitoring;
- Amendments to rehabilitation planning and/or execution; and/or
- Redoing rehabilitation earthworks or parts thereof.

11 PEOPLE, PLANET AND PROFIT

Assessing different rehabilitation options as part of the triple bottom line framework means giving consideration to the people (social), environmental (planet) and economic (profit) outcomes of the different options. This means that our rehabilitation will achieve outcomes that support a strong and viable post-mining land use, do not cause environmental harm and are feasible for Ensham to deliver. This approach has been developed based on best practice approaches in the literature and is considered fit for purpose (Figure 11-1).

ACCOUNTABILITY AND TRANSPARENCY

LEGISLATIVE NEED:	PRACTICAL NEED:
Environmental Protection Act 1994	Complex evidence base, facilitating understanding amongst stakeholders

TRIPLE BOTTOM LINE ASSESSMENT FRAMEWORK

↓

Acceptable rehabilitation outcomes are based on comprehensive assessments of **economic, social** and **environmental** outcomes

Figure 11-1 The legislative and practical need for a triple bottom line framework, guided by an overarching principle of accountability and transparency

11.1 Legislative need

The object of the EP Act is to *protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends (ecologically sustainable development)* (Section 3). The act is implemented in several ways, including environmental strategies and integrating them into efficient resource management. The reasons for rehabilitation are to remedy potential impacts on environmental values and to minimise the potential for future environmental harm. Therefore, rehabilitation of land disturbed by resource activities assists to achieve the objectives of the EP Act.

11.2 Practical need

Setting rehabilitation indictors and completion criteria is a highly complex process that requires the specialised skill set of an appropriately qualified person. There are quantitative and qualitative outcomes of different options to compare across economic, social and environmental dimensions, as well as differing spatial and temporal settings. There is a large amount of information to weigh and process, and no definitive formula for the 'acceptable rehabilitation'. There are also multiple stakeholders to consider – government, community and us – with potentially conflicting views on what are acceptable outcomes.

11.3 Process steps

The steps in the triple bottom line assessment for rehabilitation at Ensham were:

1. Goals: confirm the appropriateness of rehabilitation goals.
2. Domains: decide rehabilitation domains, and their projected location and extent.
3. Objectives: set rehabilitation objectives.
4. Indicators and completion criteria: determine appropriate indicators and set threshold limits as completion criteria.
5. Alternatives: explore different combinations of completion criteria for rehabilitation.
6. Triple bottom line assessment: assess the evidence base to compare the economic, social and environmental outcomes for each alternative. Interpret information and evaluate outcomes.
7. Propose amendment: confirm rehabilitation indicators and completion criteria.

11.4 Assessment summary

Ensham is a mature mining operation and has a large and complex information base relating to rehabilitation. This information supported selection of indicators and associated completion criteria. The types of information used has been summarised (Figure 11-2).

	SUMMARY PAPERS		
	Economic	Social	Environment
Indicators	Cost to complete, land use economics	Qualitative narrative - perceptions of land use by agricultural sector, land suitability assessment	Per Table 9-1 in section 9 of this report
Detailed evidence	Rehabilitation cost modelling by Ensham, annual budgets, FA calculations	Stakeholder feedback, land suitability assessments, EIS documentation	ACARP reports, rehabilitation monitoring reports, various site specific technical studies

Figure 11-2 Summary of the detailed economic, social and environmental evidence base and overarching indicators used in the triple bottom line assessment

Process steps 1 through 4 have been defined in sections 4 and 9 of this report. A process summary table of relevant considerations for the triple bottom line assessment is provided (Table 11-1).

11.4.1 Conclusions

The triple bottom line assessment for rehabilitation followed sound principles in setting rehabilitation objectives, indicators and completion criteria. It enabled a complex evidence base to be logically and clearly understood. The development of indicators allowed for an iterative process of assessing alternatives and outcomes. Each scenario was considered against all others to ensure there was consistent deliberation. Selected indicators are meaningful and, when monitored and reported, will inform stakeholders about the rehabilitation and allow good decisions.

While the triple bottom line framework facilitated effective decision making, it did not remove the need for considered judgement in decision-making. This highlights the important and on-going role of appropriately qualified persons in the assessment, interpretation and communication of rehabilitation outcomes at Ensham and elsewhere.

Ensham Resources

Table 11-1 Qualitative process summary for rehabilitation indicators (TBL Assessment)

Objective	Indicator	Considerations		
		Economic	**Social**	**Environmental**
Safety hazards in rehabilitation are similar to surrounding unmined landscapes.	Hazard assessment	Indirect costs may apply if this delays closure.	Stakeholder expectations will be that hazards in the rehabilitation are no greater than those in the surrounding landscape. Use Australian Standard for risk management to ensure robust, valid process.	n/a
Safety hazard accepted by landholder	Legally binding agreement	Agreements for landholders to retain mining infrastructure may reduce rehabilitation costs.	Failure to reach agreement may cause reputational damage and unrest with other stakeholders.	n/a
Surface runoff leaving domain is non-polluting to receiving surface waters (Nogoa River).	pH	Water monitoring is a long-term cost associated with rehabilitation.	Stakeholder expectations will be that rehabilitation is free of contamination and not a source of environmental pollutants.	Use NRM provided upstream river water quality data and Queensland Water Quality Guidelines to determine completion criteria. Indicators should be consistent with EA conditions.
	EC (salinity)			
	TSS (sed. loss)			
	Sulphate			
	Contaminated land assessment	One off cost at end of mine life. Remediation may add significant costs if necessary.		Must comply with EP Act and requirements for contaminated land assessment and management in

Objective	Indicator	Considerations		
		Economic	Social	Environmental
				Queensland.
Landforms are both geo-technically and erosionally stable.	Factor of safety	Different FoS can require different volumes of materials to be moved and therefore, can add significantly to cost.	Stakeholder will expect rehabilitation is geotechnically stable.	Geotechnical stability is different to erosional stability, and rehabilitation must demonstrate both.
	Slope gradient	Different slope gradients require different volumes of materials to be moved and therefore, can add significantly to cost. Rehabilitation construction must be optimised to available equipment.	Slopes will need to be appropriate to proposed grazing land use, i.e. <20%.	Slope gradients (and lengths) need to recognise inherent material characteristics, e.g. propensity to dispersion and erosion.
	Groundcover	n/a	Stakeholders are aware of the role of groundcover in controlling erosion.	ACARP reports indicate minimum groundcover requirements for control of erosion.
Landholder accepts the condition of infrastructure, including its structural integrity.	Legally binding agreement	Agreements for landholders to retain mining infrastructure may reduce rehabilitation costs.	Failure to reach agreement may cause reputational damage and unrest with other stakeholders.	n/a
Landholder formally accepts infrastructure for his/her ongoing beneficial use.	Legally binding agreement	Agreements for landholders to retain mining infrastructure may reduce rehabilitation costs.	Failure to reach agreement may cause reputational damage and unrest with other stakeholders.	Must ensure this is non-polluting.
Rehabilitation is suitable for	Land suitability assessment	Rehabilitation must have an	Stakeholders are aware of	Rehabilitation will need to

Objective	Indicator	Considerations		
		Economic	Social	Environmental
sustainable grazing by cattle		appropriate land suitability class to have a post-mining land use, i.e. anthropic land use.	previous commitments to return rehabilitation to grazing land use.	meet a suite of land use limitations to achieve an appropriate land suitability class.
Riparian vegetation is suitable for conservation of rehabilitated creek diversion areas.	Index of Diversion Condition (IDC)	Rehabilitation of the Boggy Creek diversion will likely be the most costly rehabilitation on a ‘per hectare’ basis.	Stakeholders will expect the Boggy Creek diversion to function as though it were a natural watercourse.	ACARP C9068 and C20017 provide a sound technical basis for creek diversion rehabilitation, monitoring and assessment.

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APPENDIX A – LAND USE LIMITATION SUBCLASS THRESHOLD LIMITS

Limitation	Land suitability class				
	1	2	3	4	5
Surface soil erodibility, Ea	Moderately stable soils, <5% Non-cohesive soils, <5% Dispersive soils, <3% Highly erodible soils, <1%	Moderately stable soils, 5-10% Non-cohesive soils, 5-8% Dispersive soils, 3-5% Highly erodible soils, 1-3%	Moderately stable soils, 10-15% Non-cohesive soils, 8-10% Dispersive soils, 5-8% Highly erodible soils, 3-5%	Moderately stable soils,15-20% Non-cohesive soils, 10-15% Dispersive soils, 8-10% Highly erodible soils, 5-8%	Moderately stable soils, >20% Non-cohesive soils, >15% Dispersive soils, >10% Highly erodible soils, >8%
Subsoil erodibility, Eb	Non-dispersive, <5%; Non-cohesive, <1%; Dispersive, <0.5%; Extremely dispersive, n/a	Non-dispersive, 5-10%; Non-cohesive, 1-5%; Dispersive, 0.5-1%; Extremely dispersive, <0.5%	Non-dispersive, 10-15%; Non-cohesive, 5-10%; Dispersive, 1-5%; Extremely dispersive, 0.5-3%	Non-dispersive, 15-20%; Non-cohesive, 10-15%; Dispersive, 5-10%; Extremely dispersive, 3-8%	Non-dispersive, >20%; Non-cohesive, >15%; Dispersive, >10%; Extremely dispersive, >8%
Soil water availability, M	PAWC >125mm/m	PAWC 100-125mm/m	PAWC 75-100mm/m	PAWC 50-75mm/m	PAWC <50mm/m
Surface condition, Ps	Soft or loose sandy to sandy loam; or Very fine self-mulching clays (peds less than 2mm)	Soils with soft, firm or only weakly had setting, sandy to loamy surface; or Fine self-mulching clays (peds 2-5mm) or Course self-mulching clays (peds >5-10mm)	Clay soils with hard setting, firm pedal or weakly self-mulching surface; or Very coarse self-mulching clays (peds >10mm)	Loamy, fine sand, silty or clayey surface, extremely hard setting, massive or crusting	
Rockiness, R	<20% pebbles <60mm and rock outcrop	20-50% pebbles <60mm and rock outcrop	>50% pebbles <60mm; or 20-50% cobbles 60-200mm	>50% cobbles 60-200mm; or 20-50% stone >200mm	>50% stone or rock outcrop
Micro-relief, Tm	Normal linear gilgai, 0.1-0.3m), <30% surface area	Shallow melonhole gilgai, 0.3-0.6m, 30-70% surface area	Strong, deep melonhole gilgai, 0.6-1.5m, <30% surface area	Strong, deep melonhole gilgai (0.6-1.5m), 30-70% of land surface	Strong, deep melonhole gilgai (0.6-1.5m), >70% of land surface

Limitation	Land suitability class				
	1	2	3	4	5
Wetness, W	Rapid draining to moderately well drained and slowly permeable	Imperfectly drained and highly permeable	Imperfectly drained and moderately permeable	Imperfectly drained and slowly permeable	Poorly to very poorly drained
Acid drainage water hazard, actual, Ar	AASS (pH<4) not present or present at depths >2m	AASS present at depths 1-2m	AASS present at depths 0.5-1m	AASS present <0.5m	
Acid drainage water hazard, potential, Ap	PASS (%S > action threshold) not present or at depths >3m	PASS present at depths 1-2m	PASS present at depths 0.5-1m	PASS present <0.5m	
Nutrient deficiency, Nd	P >20mg/kg	P 10-20mg/kg	P 5-10mg/kg	P <5mg/kg	
Element toxicity, Tx	pH 6.6-7.3	pH 6.0-6.5	pH 5.1-5.5 or pH 7.4-8.4	pH <5 or pH>8.5	
Soil depth, Sd	>0.75m	0.5-0.75m	0.25-0.5m	<0.25m	
Salinity, Sa	ECe <2dS/m	ECe 2-4dS/m	ECe 4-8dS/m	ECe >8dS/m	
Vegetation, V	Improved pastures (grass and legumes) with Eucalypt dominated overstory on non-gilgai forming soils	Improved pastures (grass and legumes) with or without overstory species on non-gilgai forming soils	Native pastures with or without Acacia dominated overstory on non-gilgai forming soils	Native pastures with Acacia dominated overstory on gilgai forming soils	None
Landscape complexity, Lc	>10ha	5-10ha	2.5-5ha	<2.5ha	

APPENDIX B – ENSHAM RISK MATRIX TOOL

Consequence / Severity Descriptions

Rating	Consequence Note: Consequence may consist of a single event or may represent a cumulative impact over a period of 12 months					
	Personal Injury (PI)	Impact to Annual Business Plan (EBIT)	Business Interruption (BI)	Legal (L)	Reputation/ Community (R)	Environment (E)
1. **Catastrophic**	Multiple fatalities / Irreversible health impacts >50 workers	>$50m	> 2 months production	Prolonged litigation, heavy fines, potential jail term	Extended negative national media coverage. Socially irresponsible image	Serious environmental harm that is irreversible. Legal / regulatory impact.
2. **Major**	Single fatality and/or severe irreversible disability (>30%) to one or more workers	$10m - $50m	1 to 2 months production	Major breach/ major litigation	Longer term State wide and national negative media coverage > 1 week (State)	Material environmental harm –that requires extensive time & resources to remediate)
3. **Moderate**	Lost Time Injury / Illness / moderate irreversible disability (<30%) to one or more workers	$5m - $10m	1 week to 1 month production	Serious breach of regulation. prosecution/ fine	Short term State wide or extensive negative media coverage < 1 week.	Moderate (reversible) environmental effects – remedial in LOM
4. **Minor**	Medical Treatment Injury / Illness. Reversible disability / impairment	$1m - $5m	1 day to 1 week production	Non-compliance, breaches in regulation	Series of articles in local press, including radio or other media.	Minor damage to physical environment – contained and remedial in short term
5. **Insignificant**	First Aid injury. No medical treatment	<$1m	< 1 day production	Low level compliance issue	Local complaints / no real impact on Community	Negligible environmental harm. Can be immediately cleaned up.

Likelihood Description

Likelihood	(2) Description	(1) Frequency
A Certain	The event is expected to occur in most circumstances	Multiple / 12 months
B Likely	The event will probably occur in most circumstances	Once 1-5 years
C Possible	The event may occur at some time	Once 5 – 10 years
D Unlikely	The event has not occurred in our company, but has occurred within the industry as a whole on a number of occasions	Once 10 - 50 years
E Rare	Event has not been known to occur in our organisation, but has been known to occur infrequently within the industry and is only likely to occur in exceptional circumstances.	Once / > 50 years

<table>
<tr><th rowspan="3">Consequence</th><th colspan="5">Likelihood</th></tr>
<tr><th>A
Certain</th><th>B
Likely</th><th>C
Possible</th><th>D
Unlikely</th><th>E
Rare</th></tr>
<tr><th>“Common”
Once or greater per annum</th><th>“Has Happened but infrequently”
Could happen in 1-5 years</th><th>“Could Happen once between 5 – 10 years”</th><th>“Not Likely – but has happened in industry”
May occur within 10—50 years</th><th>“May occur once > 50 years”</th></tr>
<tr><td>1</td><td>C1</td><td>C2</td><td>C4</td><td>C6</td><td>H11</td></tr>
<tr><td>2</td><td>C3</td><td>C5</td><td>C7</td><td>H12</td><td>M16</td></tr>
<tr><td>3</td><td>H8</td><td>H9</td><td>H13</td><td>M17</td><td>M20</td></tr>
<tr><td>4</td><td>H10</td><td>M14</td><td>M18</td><td>L21</td><td>L23</td></tr>
<tr><td>5</td><td>M15</td><td>M19</td><td>L22</td><td>L24</td><td>L25</td></tr>
</table>

Risk Tolerability Levels

Risk Rating	Risk Category		Tolerance	Generic Management Actions
1 to 7	C	Critical	Intolerable	Immediate intervention required from senior management to eliminate or reduce this risk
9 to 13	H	High	ALARA	Imperative to eliminate or reduce risk to a lower level by the introduction of control measures. Management planning required
14 to 20	M	Medium	ALARA	Corrective action required, management attention needed to eliminate or reduce risk
21 to 25	L	Low	Tolerable	Monitor and manage by corrective action where practicable,