



SECTION 7

Rehabilitation and Mine Closure

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7 REHABILITATION AND MINE CLOSURE

This section provides a description of the proposed rehabilitation strategy for the Project, including decommissioning and rehabilitation of the:

- Dendrobium Pit Top;
- Cordeaux Pit Top;
- Kemira Valley Coal Loading Facility¹;
- Project ventilation shaft sites;
- Dendrobium/Cordeaux powerlines and Kemira Valley Rail Line infrastructure;
- Dendrobium CPP;
- West Cliff Stage 3 Coal Wash Emplacement; and
- Project underground mining areas, including the remediation of subsidence impacts on natural surface features.

South32's company-wide closure standard requires all South32-controlled operations to maintain closure plans, which address closure criteria and land use (South32, 2017c). This includes requirements for the rehabilitation of disturbed areas, decommissioning of infrastructure, remediation of contaminated sites, treatment and disposal of wastes, land use options, and post-closure monitoring and management. Consideration is also given to economic transitions at mine closure and supporting sustainable communities.

7.1 REHABILITATION AT THE APPROVED OPERATIONS

The existing *Illawarra Coal Mining Operations Plan - Dendrobium Mine and Cordeaux Colliery* (Dendrobium MOP) (South32, 2015a) describes the approved Dendrobium Mine and Cordeaux Colliery activities, as well as progress towards rehabilitation outcomes required under mining lease conditions and other statutory approvals, including Development Consent DA 60-03-2001 (as modified).

The approved West Cliff Coal Wash Emplacement activities and current rehabilitation status of completed sections of the emplacement is described in the *West Cliff Coal Wash Emplacement Area Management Plan* (Illawarra Coal, 2017) and the *Bulli Seam Operations Mining Operations Plan 1 October 2012 to 20 September 2019* (Bulli Seam Operations MOP) (Illawarra Coal, 2012).

A summary of rehabilitation activities undertaken at the Dendrobium Mine and the Cordeaux Colliery, and relevant rehabilitation monitoring results, are documented in a combined Annual Review. The rehabilitation activities undertaken at the West Cliff Coal Wash Emplacement and relevant rehabilitation monitoring results are documented in the Bulli Seam Operations Annual Reviews.

A summary of the current objectives for rehabilitation, and rehabilitation progress to date for the Dendrobium Mine, the Cordeaux Colliery and the West Cliff Coal Wash Emplacement is provided below.

7.1.1 Rehabilitation Objectives

Where relevant, existing rehabilitation objectives would be augmented or built upon for the Project (Section 7.2).

The existing overall rehabilitation objectives for the Dendrobium Mine, the Cordeaux Colliery and the West Cliff Coal Wash Emplacement are that the final rehabilitated landform must be:

- safe;
- stable;
- non-polluting; and
- consistent with key stakeholder expectations (where practical) and surrounding lands.

For all sites other than the Kemira Valley Rail Line and Dendrobium CPP, additional rehabilitation objectives are that:

- ecosystem function should be restored with the establishment of local native plant species; and
- the ecosystem must be self-sustaining.

¹ The Kemira Valley Coal Loading Facility domain includes the O'Briens Drift Base. The O'Briens Drift Base has been decommissioned and is no longer in use.

Specific rehabilitation objectives for the Kemira Valley Rail Line are that access, landscaping and land surfaces (i.e. safety, geotechnical stability and drainage) should be suitable for future rural/residential development.

7.1.2 Dendrobium Mine

To date, 8.5 ha of land associated with the Dendrobium Tunnel has been revegetated at the Dendrobium Mine.

The O'Briens Drift Base, a component of the Kemira Valley Coal Loading Facility, has been decommissioned and is no longer in use. O'Briens Drift Base infrastructure that remains at the Kemira Valley Coal Loading Facility includes a series of old conveyor structures.

No further rehabilitation of land disturbed by surface activities is planned until mine closure activities commence.

The Dendrobium Mine has approved SMPs for each of the active and completed underground mining areas (Areas 1, 2, 3A and 3B), which describe the ongoing program of subsidence monitoring and management at the Dendrobium Mine (Section 2.2.6).

Subsidence parameters measured during extraction and at completion of longwalls to date are generally similar to, or less than, predictions documented within relevant SMPs. Impacts to natural features during monitoring of completed longwalls have been within the performance measures for the Dendrobium Mine.

A specific remediation program was requested by the Secretary of the DPE for impacts to Wongawilli Creek tributary WC21 as a result of extraction of Longwalls 9 and 10. The *WC21 Rehabilitation Plan* (South32, 2015b) was submitted in March 2016 and includes surface flow monitoring and grouting at various impacted pools and rockbars along the tributary. Minor remediation works are also implemented on access tracks as a result of subsidence-induced by mining at the Dendrobium Mine.

The DPE approved the Longwall 16 SMP in May 2018. Schedule 3 Condition 10 of the SMP requires South32 to undertake remediation programs for WC21 and Donalds Castle Creek. The DPE requested South32 prepare a remediation program for Donalds Castle Creek and this was submitted in September 2017.

7.1.3 Cordeaux Colliery

The Cordeaux Colliery has been in care and maintenance since 2001. Since this time, some of the surface facilities associated with the Cordeaux Colliery (Figure 2-10) have been decommissioned and progressively rehabilitated. Table 7-1 summarises the rehabilitation status of the sites at the Cordeaux Colliery.

The Cordeaux Pit Top was used for personnel and materials access and coal clearance for the Cordeaux Colliery prior to the Colliery being placed on care and maintenance.

**Table 7-1
Rehabilitation Status of the Cordeaux Colliery**

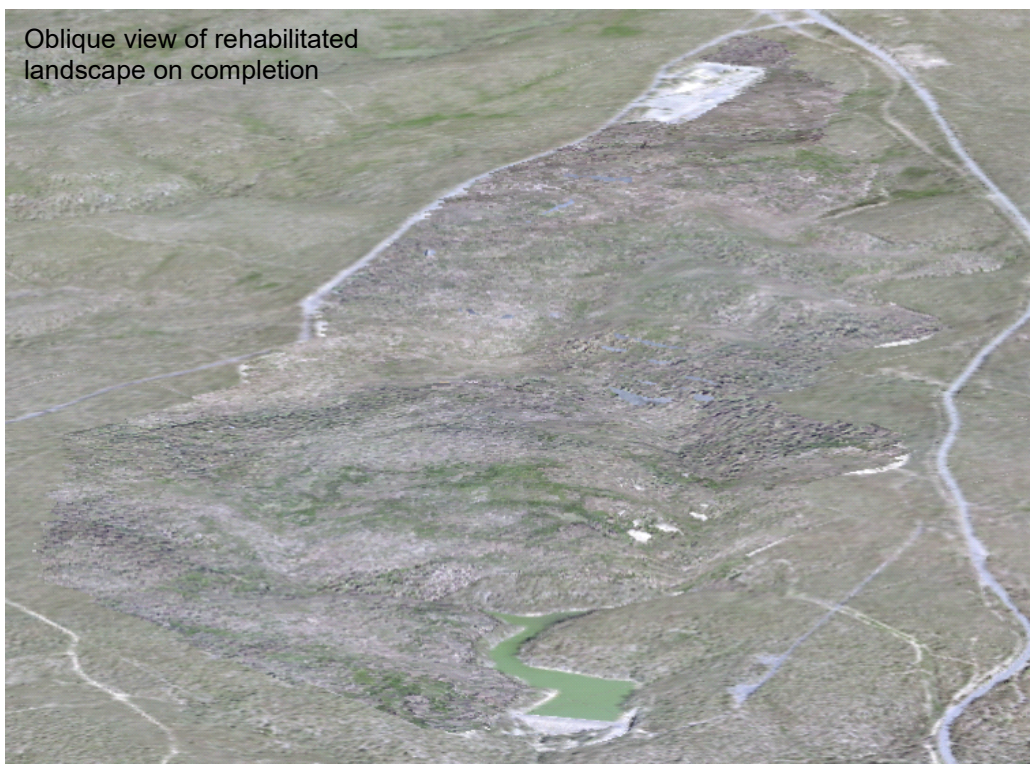
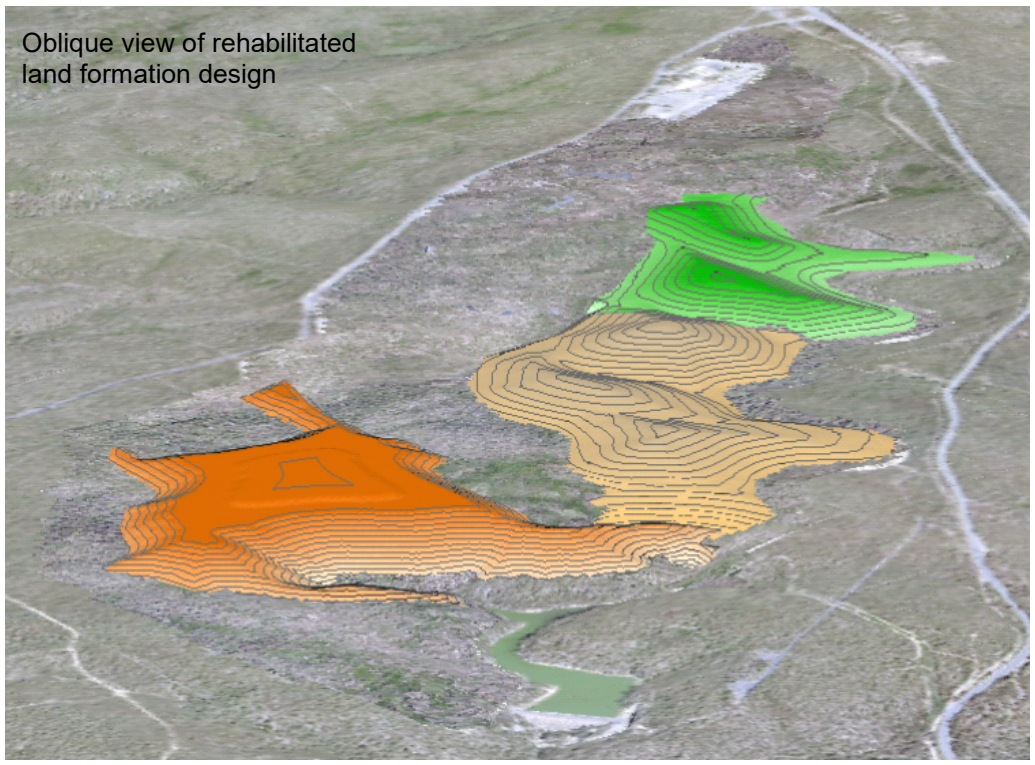
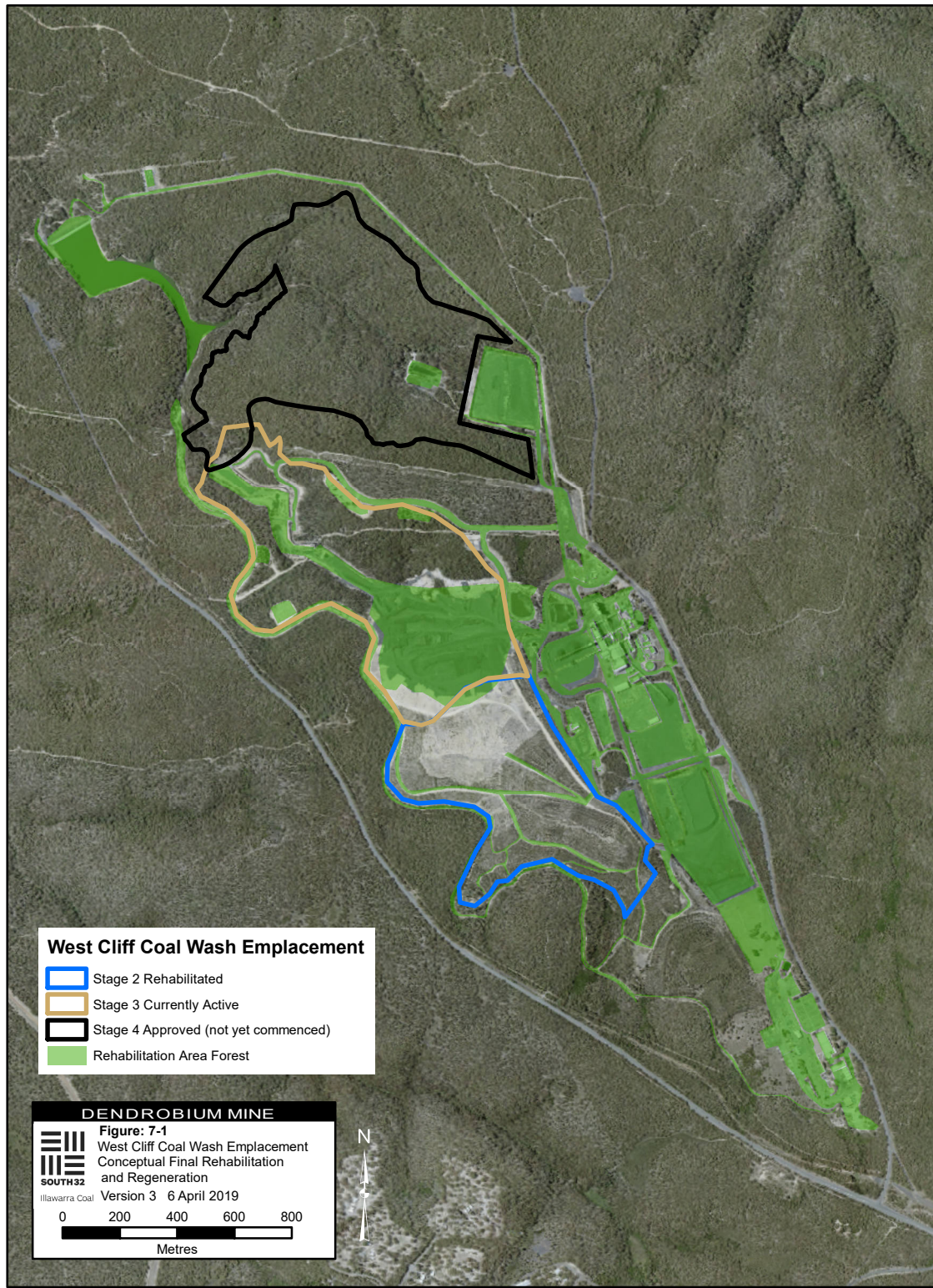
Site	Status
Cordeaux Pit Top	Care and maintenance
Corrimal No 3 Shaft	Care and maintenance
Corrimal No 3 Shaft Coal Bins	Care and maintenance
Corrimal No 2 Shaft	Sealed and rehabilitated
Cataract Weir Pump Facility	Decommissioned and rehabilitated
Cordeaux Re-injection Borehole Field	Decommissioned and rehabilitated
Wilton Spray Irrigation Area	Decommissioned, rehabilitated and sold

The Project would involve use of the Cordeaux Pit Top for mining support activities and mine access. Decommissioning and rehabilitation of the Cordeaux Pit Top at the end of the Project life has been included in the rehabilitation planning for the Project.

The remaining sites at the Cordeaux Colliery would continue to be rehabilitated and monitored in accordance with the approved Dendrobium MOP (South32, 2015a) (or the latest approved version).

7.1.4 West Cliff Coal Wash Emplacement

A portion of the coal wash produced at the Dendrobium CPP as part of the Project would be transported by road to the West Cliff Coal Wash Emplacement. The West Cliff Coal Wash Emplacement consists of four stages that are progressively developed down the valley within the contained Brennans Creek Dam catchment (Figure 7-1).



Stage 1 and Stage 2 of the Coal Wash Emplacement were completed in 2001 and 2010, respectively, and are currently undergoing rehabilitation. Rehabilitation of the West Cliff Stage 4 Coal Wash Emplacement would continue to be conducted in accordance with Project Approval 08_0150 for the Bulli Seam Operations (Figure 7-1).

Plate 7-1 shows the West Cliff Stage 1 Coal Wash Emplacement approximately 14 years after completion of landform shaping and revegetation. Plate 7-2 shows the West Cliff Stage 2 Coal Wash Emplacement approximately five years after completion of landform shaping, with a dense cover of shrubs and high native species diversity.

The rehabilitation methodology undertaken for the West Cliff Stage 2 Coal Wash Emplacement is outlined in the *West Cliff Coal Wash Emplacement Area Management Plan*. Monitoring of rehabilitation performance of the West Cliff Stage 2 Coal Wash Emplacement against set performance indicators has demonstrated (Illawarra Coal, 2017):

- Between 50 and 70 individual flora species in monitoring transects, significantly higher than benchmark levels recorded for local vegetation types in the surrounding area.
- Good general vegetation cover including difficult to grow species (such as heaths, sedges, rushes, *Persoonia* spp.).
- Two threatened plant species in the rehabilitation area (*Pultenaea aristata* and *Persoonia hirsuta*).
- Evidence that species have seeded multiple times and young germinates are present, indicating the emplacement will be self-sustaining over time (seed fall provides further resilience in the inadvertent event of a bushfire).

The success of the rehabilitation at the West Cliff Stage 2 Coal Wash Emplacement supports the continued use of the current methodology and rehabilitation practices at the West Cliff Stage 3 Coal Wash Emplacement (Sections 7.2 and 7.3).

7.2 REHABILITATION OF THE PROJECT

Rehabilitation planning for the Project was informed by existing mine closure and rehabilitation objectives and current rehabilitation practices implemented for the Dendrobium Mine and the Cordeaux Colliery. Mine closure and rehabilitation objectives have also been established for underground mining areas and new surface facilities that would be developed for the Project.

The following documents were considered during the review and development of the mine closure and rehabilitation objectives:

- *Leading Practice Sustainable Development Program for the Mining Industry – Mine Rehabilitation* (Commonwealth Department of Industry, Innovation and Science [DIIS], 2016a);
- *Leading Practice Sustainable Development Program for the Mining Industry – Mine Closure* (DIIS, 2016b);
- *Strategic Framework for Mine Closure* (Australian and New Zealand Minerals and Energy Council and Minerals Council of Australia, 2000); and
- *ESG3: Mining Operations Plan (MOP) Guidelines, September 2013* (DRE, 2013) (MOP Guidelines).

In addition, the Mining Development Rehabilitation Standard SEARs recommended by the DRE (now DRG) have been considered during rehabilitation planning for the Project.

7.2.1 General Rehabilitation and Mine Closure Criteria

In the long-term, all sites would be rehabilitated to a safe, stable and sustainable landform of a similar character to surrounding areas.

The general rehabilitation and mine closure goals for the Project would be to:

- comply with relevant or applicable legislative requirements;
- protect public and employee health, safety and welfare;
- limit or mitigate adverse environmental effects;
- protect Indigenous values; and
- achieve sustainable land use as agreed with the applicable government regulator, and engagement with local communities.

The objectives of mine subsidence remediation specific to rehabilitation would be to:

- avoid or minimise impacts to significant environmental values;
- implement TARPs to identify, assess and respond to impacts;



Plate 7-1 – West Cliff Stage 1 Coal Wash Emplacement Area – 14 Years After Completion
Source: Illawarra Coal (2015b).



Plate 7-2 – West Cliff Stage 2 Coal Wash Emplacement Area – Five Years After Completion
Source: Illawarra Coal (2015b).

- carry out mitigation and remediation works in a manner that is reasonable and feasible, to minimise impacts on the environmental values of the area;
- achieve the defined performance measures; and
- monitor and report on the effectiveness of the mitigation and remediation works.

Further investigations would be conducted closer to the end of the Project life to further inform mine closure planning and may include, but not be limited to:

- geotechnical investigations;
- hazardous materials investigations;
- non-Aboriginal heritage studies;
- water flow and quality assessments;
- risk assessments;
- the preparation of detailed rehabilitation plans; and
- the preparation of detailed engineering design drawings.

Mined lands would be considered suitable for relinquishment when the nominated standards and/or completion criteria have been met, or if the relevant Minister(s) otherwise accept(s) the rehabilitation status. Anticipated mine lease relinquishment criteria are outlined in Section 7.8.

Stakeholder consultation is recognised as an important component of the mine closure process. A stakeholder consultation strategy specific to closure would be developed and implemented at an appropriate time prior to Project closure, and would include consideration of the potential adverse socio-economic effects due to a reduction in employment (Sections 6.19 and 6.20).

7.2.2 Post-mining Land Use and Conceptual Final Landform

Post-mining Land Use

South32 has assessed potential post-mining land uses (e.g. nature conservation, agriculture), taking into account relevant strategic land use objectives for the area in the vicinity of the Project. The potential benefits of the post-mining land use to the environment, future landholders and the community have also been considered.

The proposed life of the Project is to 31 December 2048. This extended timeframe limits the certainty with which the post-mining land use can be defined, as mine and stakeholder requirements may be subject to change over this period.

A number of post-mining land uses have been considered for the Project and may be appropriate if agreed with the final landholder and relevant stakeholders. The final land uses considered for various components of the Project include:

- Native vegetation/conservation.
- Light/heavy industrial land uses (Dendrobium CPP).
- Special-purpose historical tourism (Pit Tops and Kemira Valley Coal Loading Facility and O'Briens Drift Base).
- Continuation of use of the Kemira Valley Rail Line for materials handling/transportation.
- Rail terminus/line for tourist activity (Kemira Valley Coal Loading Facility and Rail Line).
- Residential development opportunities in land surrounding the Dendrobium Pit Top.
- Pastoral land.
- Wildlife/green corridor (Kemira Valley Rail Line).

For the purposes of rehabilitation and mine closure planning for the Project, a post-mining land use of native vegetation has been selected for the majority of domains. Native vegetation represents the highest standard of rehabilitation likely to be required for all relevant sites.

An interim post-mining land use of light industrial has been selected for the Dendrobium CPP, although a post-mining land use of heavy industrial may also be adopted in consultation with relevant stakeholders. The Dendrobium CPP is located within the Port Kembla Steelworks precinct. The Port Kembla Steelworks precinct is owned and operated by a separate legal entity (BlueScope Steel), which has responsibility for the closure of the Dendrobium CPP. South32 pays a fee for the use of the facility, and the funds for closing the site are set aside from these fees.

Further discussion on alternative post-mining land uses is provided in Section 9.2.2.

Conceptual Final Landforms

The final landform in surface development areas has been designed to be generally consistent with the topography of the surrounding landscape and appropriate for the post-mining land use.

The land disturbed by surface activities associated with the Project would be re-profiled, as per the approved final landform design. The final landform design aims to reduce the slope lengths by constructing contour banks and armouring channels to prevent erosion (Section 7.3.9). Depending on the agreed final land use, surface drainage would be reinstated as closely as possible to pre-mining conditions.

Figure 7-1 illustrates the approved conceptual rehabilitated final landform of the West Cliff Stage 3 Coal Wash Emplacement.

The West Cliff Stage 3 Coal Wash Emplacement final landform has been designed to:

- mimic micro-topographic features;
- reach a maximum height of approximately 353 m AHD;
- have batter slopes constructed at a maximum grade of 1(Vertical):3(Horizontal); and
- limit erosion and sediment runoff using concave slope profiles and slope angles seen in natural landforms.

The finished surface profile of the emplacement would be in accordance with design contours, as defined in the approved *West Cliff Coal Wash Emplacement Area Management Plan* (Illawarra Coal, 2017).

Figure 7-2 provides cross-sections of the approved conceptual final landform of the West Cliff Stage 3 Coal Wash Emplacement. The cross-section indicates that the final landform for the emplacement is compatible with natural topographic variation in the area.

7.2.3 Rehabilitation Domains and Conceptual Objectives

Conceptual rehabilitation domains for the Project have been categorised based on the primary and secondary domains defined by the MOP Guidelines (DRE, 2013) (Figures 7-3 to 7-6) (Table 7-2).

These conceptual rehabilitation domains have been further summarised into the following broad scale domains:

- Pit tops and ROM coal handling facilities – Dendrobium Pit Top, Cordeaux Pit Top and Kemira Valley Coal Loading Facility and O'Briens Drift Base (Domains 1, 2 and 5).
- Ventilation shaft sites – including Dendrobium Ventilation Shaft Site Nos 1, 2 and 3, 5A, 5B, 6A and 6B (Domains 3, 7 and 11).
- Powerlines and rail line – Dendrobium/Cordeaux powerlines and Kemira Valley Rail Line (Domains 8 and 9).
- Underground Mining Area (Domain 10).
- West Cliff Stage 3 Coal Wash Emplacement (Domain 12).
- Dendrobium CPP (Domain 13).

Conceptual mine closure and rehabilitation objectives were determined for the broad-scale domains based on the following rehabilitation phases, as defined by the MOP Guidelines (DRE, 2013):

- Decommissioning;
- Landform Establishment;
- Growth Medium Development;
- Ecosystem Establishment; and
- Ecosystem Development.

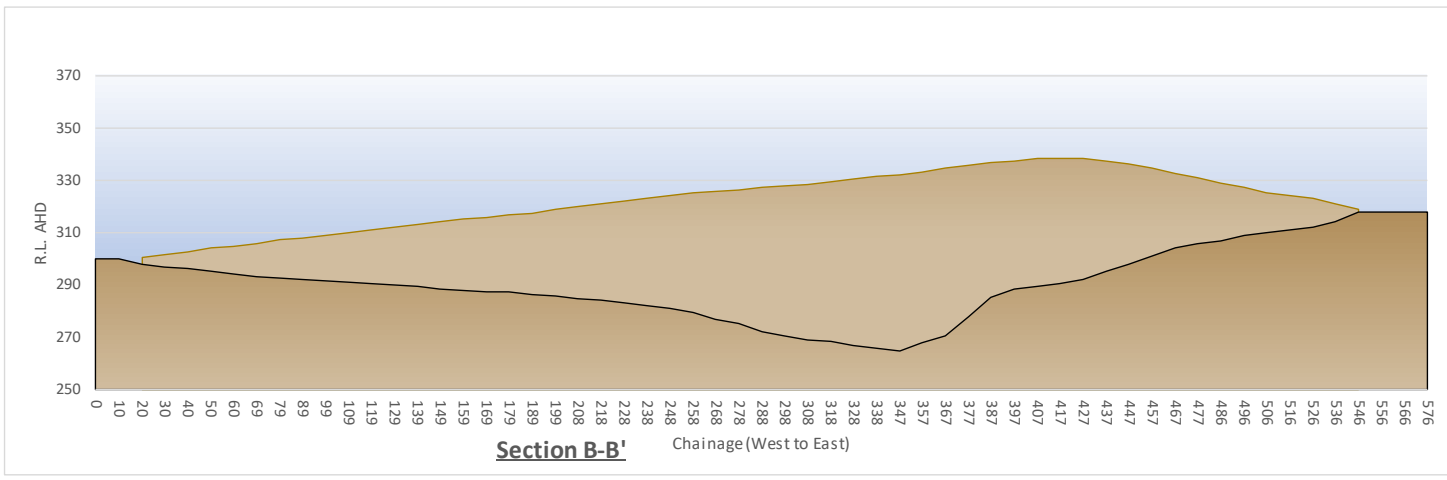
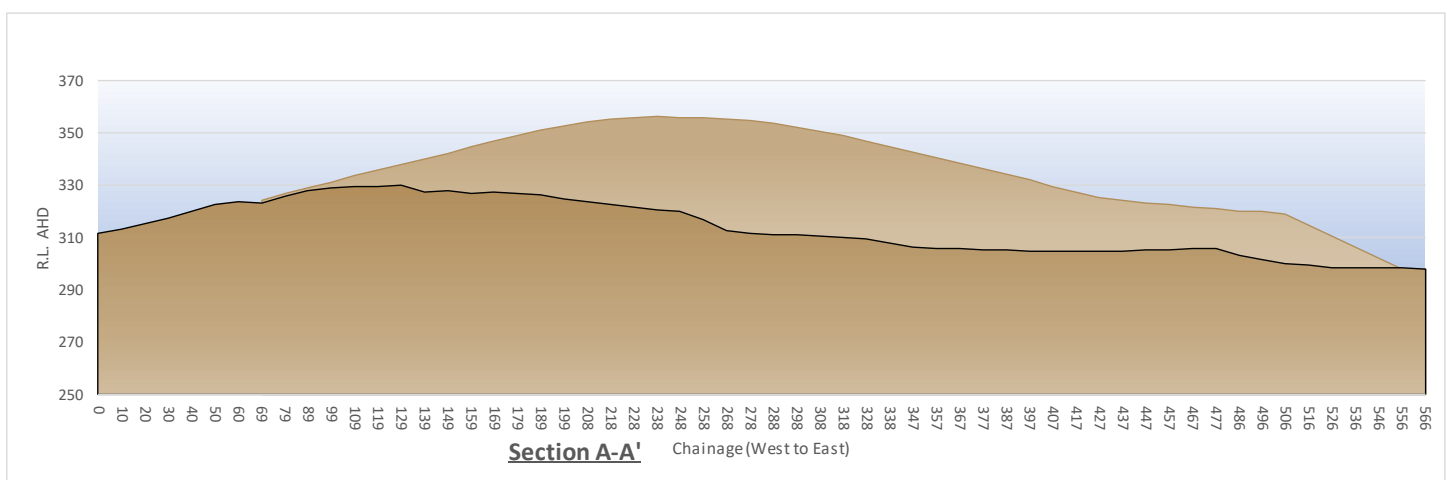
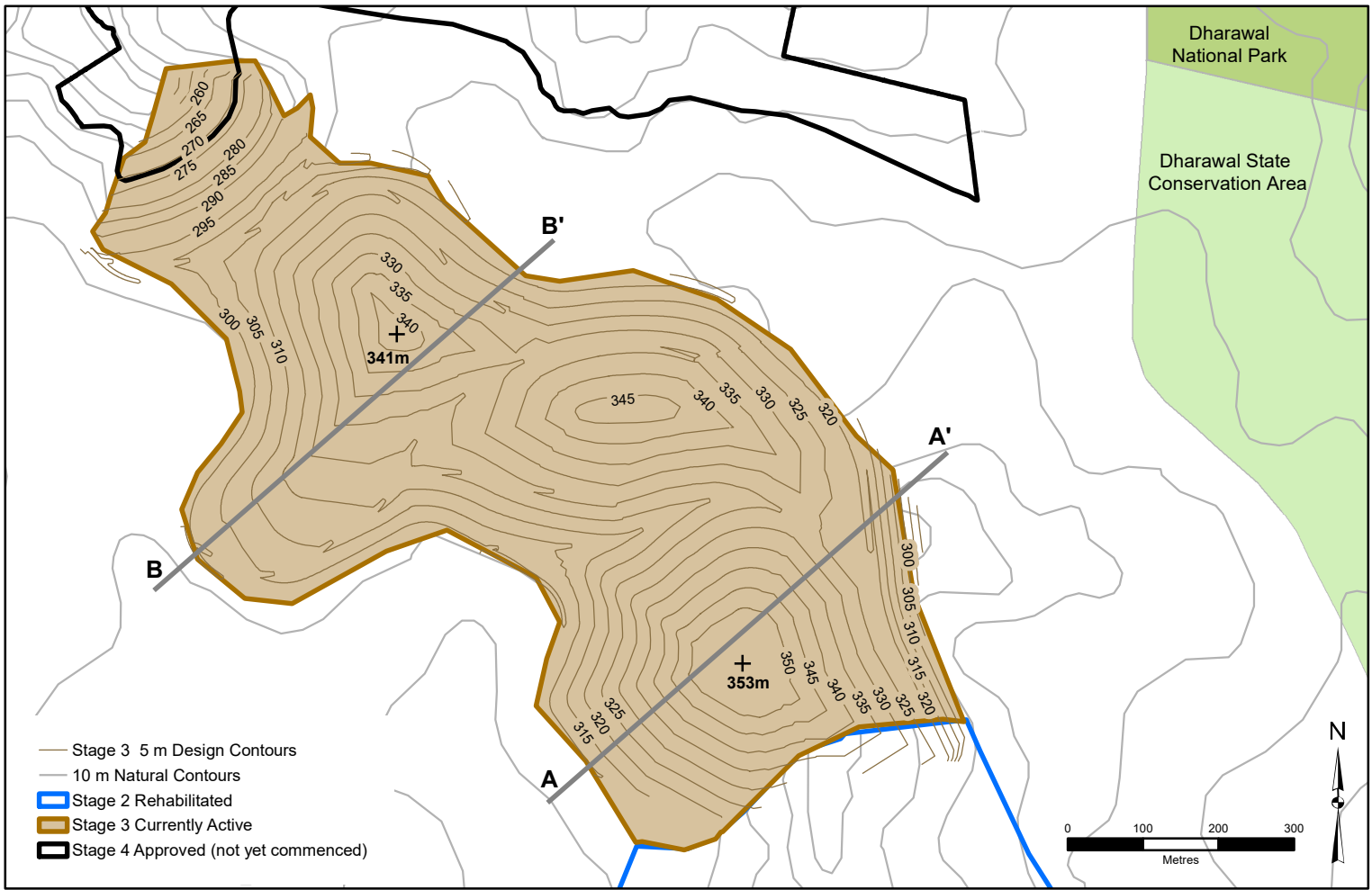
The mine closure and rehabilitation objectives for the broad scale rehabilitation domains are summarised in Table 7-3.

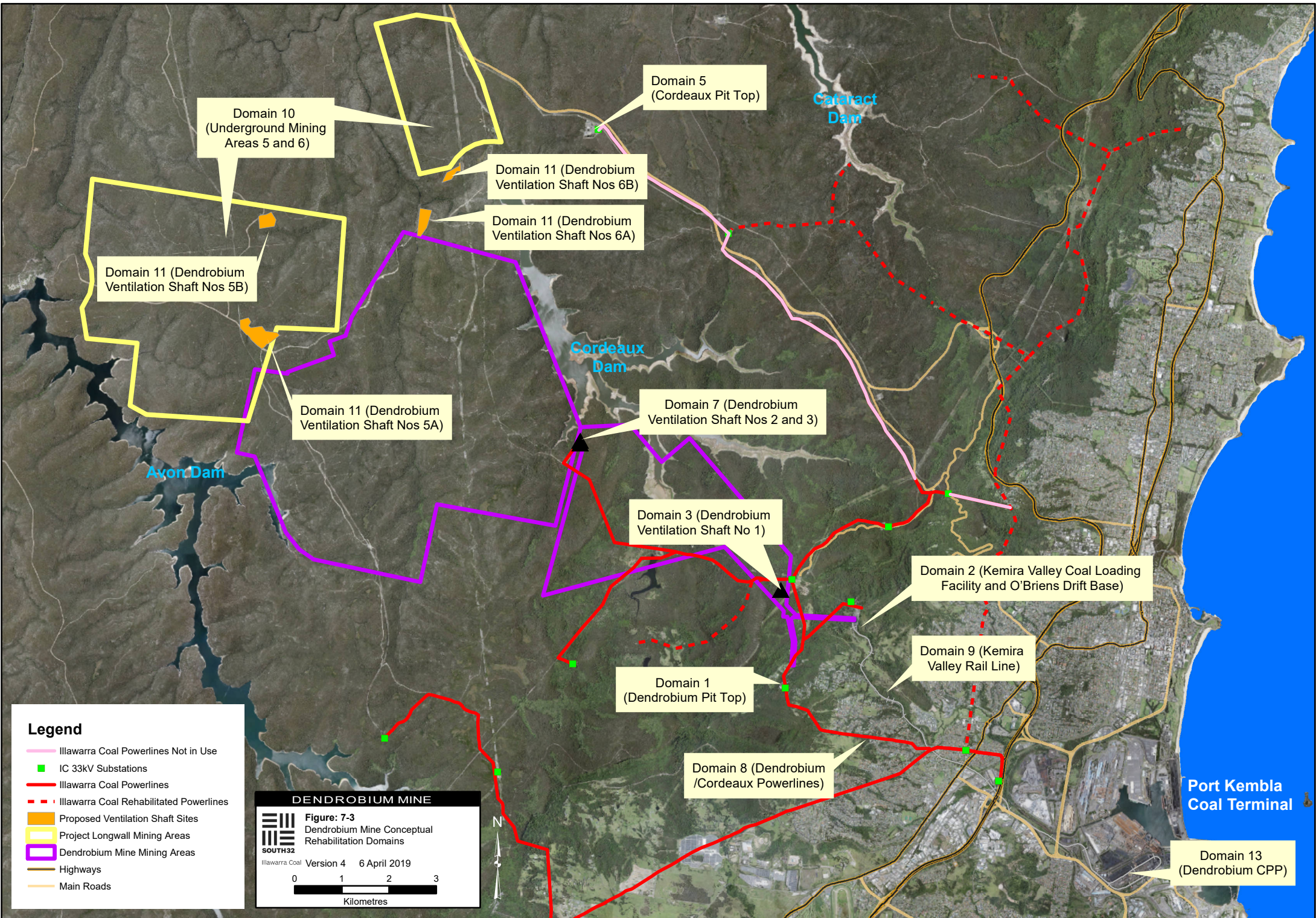
7.2.4 Biodiversity Offset Strategy

The existing Biodiversity Offset (Maddens Plains) for the Dendrobium Mine would be augmented with additional biodiversity offsets for the Project. Details of the proposed Biodiversity Offset Strategy for the Project are provided in Section 6.9.

7.2.5 Key Rehabilitation Performance Measures and Completion Criteria

Key rehabilitation performance measures and completion criteria have been developed for the Project with regard to the *Leading Practice Sustainable Development Program for the Mining Industry – Mine Closure* (DIIS, 2016b).





Legend

- Illawarra Coal Powerlines Not in Use
- IC 33kV Substations
- Illawarra Coal Powerlines
- - - Illawarra Coal Rehabilitated Powerlines
- Proposed Ventilation Shaft Sites
- Project Longwall Mining Areas
- Dendrobium Mine Mining Areas
- Highways
- Main Roads

DENDROBIUM MINE

Figure: 7-3
Dendrobium Mine Conceptual Rehabilitation Domains

SOUTH32
Illawarra Coal

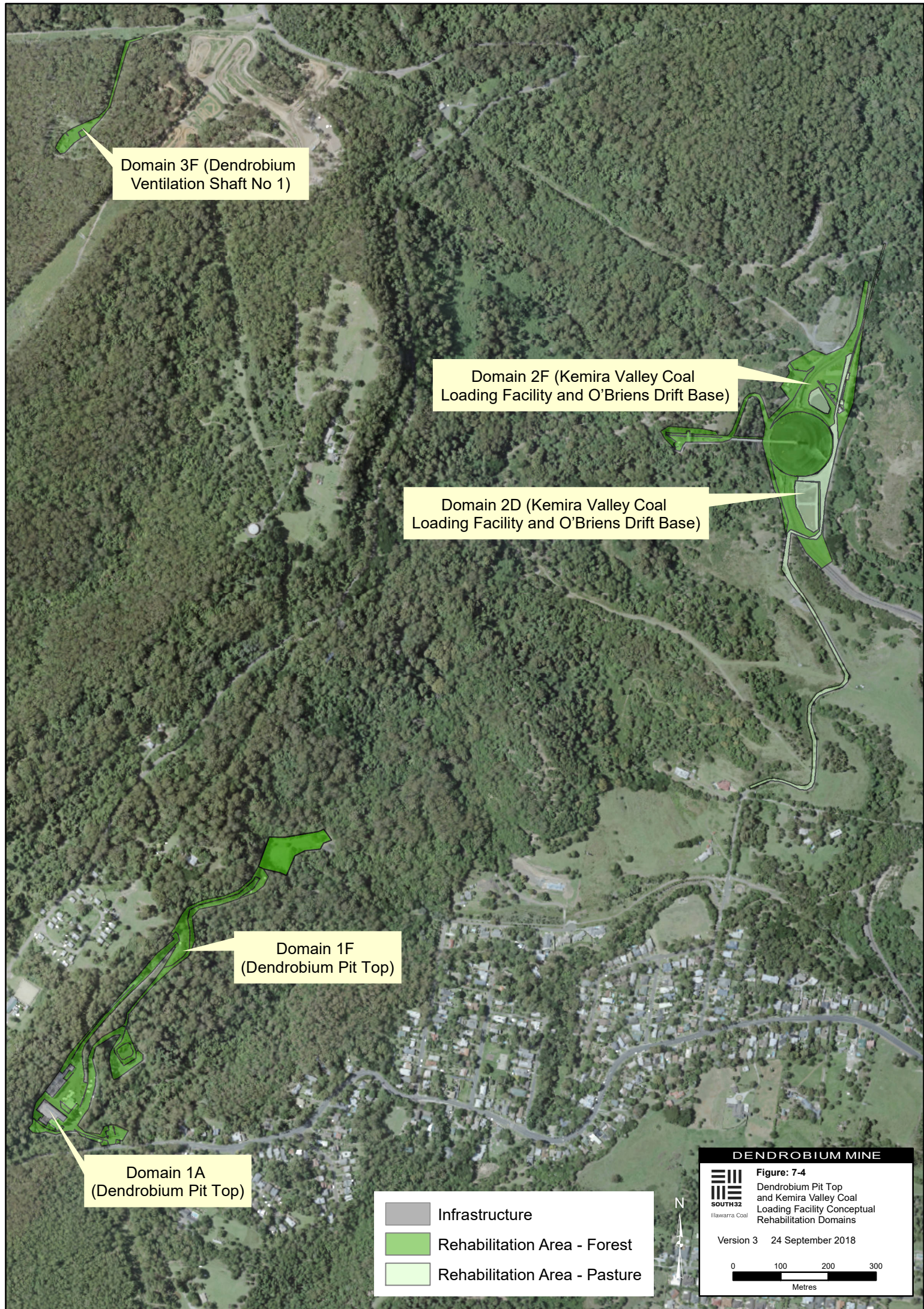
Version 4 6 April 2019

0 1 2 3
Kilometres

N

Port Kembla Coal Terminal

Domain 13 (Dendrobium CPP)



Domain 3F (Dendrobium Ventilation Shaft No 1)

Domain 2F (Kemira Valley Coal Loading Facility and O'Briens Drift Base)

Domain 2D (Kemira Valley Coal Loading Facility and O'Briens Drift Base)

Domain 1F (Dendrobium Pit Top)

Domain 1A (Dendrobium Pit Top)

- Infrastructure
- Rehabilitation Area - Forest
- Rehabilitation Area - Pasture

DENDROBIUM MINE

Figure: 7-4
 Dendrobium Pit Top and Kemira Valley Coal Loading Facility Conceptual Rehabilitation Domains

Version 3 24 September 2018

0 100 200 300
 Metres



Domain 5F
(Cordeaux Pit Top)

Rehabilitation Area - Forest


DENDROBIUM MINE

Figure: 7-5
Cordeaux Pit Top Conceptual
Rehabilitation Domains

SOUTH32
Illawarra Coal

Version 2 17 August 2018

0 50 100 150
Metres



Domain 12F
(West Cliff Stage 3
Coal Wash Emplacement)

Rehabilitation Area - Forest

Appin - Bulli Rd


DENDROBIUM MINE

Figure: 7-6
West Cliff Stage 3 Coal Wash
Emplacement Conceptual
Rehabilitation Domains

SOUTH32
Illawarra Coal

Version 1 26 July 2018

0 100 200 300
Metres



**Table 7-2
Primary and Secondary Domains**

Rehabilitation Domain ¹	Primary Domain for the Project (Operational)	Secondary Domain for the Project (Post-closure Land Use)
Domain 1: Dendrobium Pit Top	1. Infrastructure Area 3. Water Management Area	A. Infrastructure F. Rehabilitation Area – Forest
Domain 2: Kemira Valley Coal Loading Facility and O'Briens Drift Base ²	1. Infrastructure Area 3. Water Management Area 5. Stockpiled Material	D. Rehabilitation Area – Pasture F. Rehabilitation Area – Forest
Domain 3: Dendrobium Ventilation Shaft No 1	1. Infrastructure Area	F. Rehabilitation Area – Forest
Domain 5: Cordeaux Pit Top	1. Infrastructure Area 3. Water Management Area	F. Rehabilitation Area – Forest
Domain 7: Dendrobium Ventilation Shaft Nos 2 and 3	1. Infrastructure Area 3. Water Management Area	E. Rehabilitation Area – Woodland
Domain 8: Dendrobium/Cordeaux Powerlines	1. Infrastructure Area	F. Rehabilitation Area – Forest
Domain 9: Kemira Valley Rail Line	1. Infrastructure Area	A. Infrastructure
Domain 10: Underground Mining Areas	8. Underground Mining Area	A. Infrastructure F. Rehabilitation Area – Forest
Domain 11: Dendrobium Ventilation Shaft Nos 5A, 5B, 6A and 6B	1. Infrastructure Area	F. Rehabilitation Area – Forest
Domain 12: West Cliff Stage 3 Coal Wash Emplacement	2. Tailings and Rejects	F. Rehabilitation Area – Forest
Domain 13: Dendrobium CPP	1. Infrastructure Area	A. Infrastructure

¹ Domain numbers have been adopted for consistency with the existing Dendrobium MOP (South32, 2015a). Domain 4 (O'Briens Drift Top) and Domain 6 (Corrimal No 3 Shaft and Coal Bins) would not form part of the Project. Domains 4 and 6 would continue to be managed and rehabilitated in accordance with the Dendrobium MOP.

² The O'Briens Drift Base has been decommissioned and is no longer in use.

**Table 7-3
Rehabilitation Phases and Objectives**

Rehabilitation Domain	Rehabilitation Phase	Domain Rehabilitation Objective
Pit Tops and ROM Coal Handling Facilities	Decommissioning	<ul style="list-style-type: none"> All infrastructure removed to ensure site is safe and free of hazardous materials (subject to heritage and alternative end use considerations). Site is safe, stable and non-polluting. Portals, ventilation shafts and mine entrances are decommissioned and sealed. Any contaminated soils identified are remediated by removal, encapsulation or land-farming on-site.
	Landform Establishment	<ul style="list-style-type: none"> Final landform established is consistent with the surrounding environment or post-mining land use. Final landform is stable with minimal erosion.
	Growth Medium Development	<ul style="list-style-type: none"> Plant growth medium is established.
	Ecosystem Establishment	<ul style="list-style-type: none"> Ecosystem function is restored with local native plant species.
	Ecosystem Development	<ul style="list-style-type: none"> Ecosystem is self-sustaining.

Table 7-3 (Continued)
Rehabilitation Phases and Objectives

Rehabilitation Domain	Rehabilitation Phase	Domain Rehabilitation Objective
Ventilation Shaft Sites	Decommissioning	<ul style="list-style-type: none"> All infrastructure removed to ensure site is safe and free of hazardous materials (subject to heritage and alternative end use considerations). Site is safe, stable and non-polluting. Ventilation shafts are decommissioned and sealed. Any contaminated soils identified are remediated by removal, encapsulation or land-farming on-site.
	Landform Establishment	<ul style="list-style-type: none"> Final landform established is consistent with the surrounding environment. Landform is stable with minimal erosion.
	Growth Medium Development	<ul style="list-style-type: none"> Plant growth medium is established.
	Ecosystem Establishment	<ul style="list-style-type: none"> Ecosystem function is restored with local native plant species.
	Ecosystem Development	<ul style="list-style-type: none"> Ecosystem is self-sustaining.
Powerlines and Rail Line	Decommissioning	<ul style="list-style-type: none"> All infrastructure removed to ensure site is safe and free of hazardous materials (subject to heritage and alternative end use considerations). Site is safe, stable and non-polluting. Any contaminated soils identified are remediated by removal, encapsulation or land-farming on-site.
	Landform Establishment	<ul style="list-style-type: none"> Final landform is stable with minimal erosion.
	Growth Medium Development	<ul style="list-style-type: none"> Plant growth medium is established.
	Ecosystem Establishment	<ul style="list-style-type: none"> Disturbed sites' rehabilitation is consistent with surrounding land use.
	Ecosystem Development	<ul style="list-style-type: none"> Site is returned to agreed post-mining land use.
Underground Mining Area (other surface infrastructure)	Decommissioning	<ul style="list-style-type: none"> All infrastructure removed to ensure site is safe and free of hazardous materials (subject to heritage and alternative end use considerations). Site is safe, stable and non-polluting. Any contaminated soils identified are remediated by removal, encapsulation or land-farming on-site.
	Landform Establishment	<ul style="list-style-type: none"> Landform is stable with minimal erosion.
	Growth Medium Development	<ul style="list-style-type: none"> Plant growth medium is established.
	Ecosystem Establishment	<ul style="list-style-type: none"> Ecosystem function is restored with local native plant species.
	Ecosystem Development	<ul style="list-style-type: none"> Ecosystem is self-sustaining.
West Cliff Stage 3 Coal Wash Emplacement	Decommissioning	<ul style="list-style-type: none"> Remove all infrastructure to ensure site is safe and free of hazardous materials (subject to alternative end use considerations). Any contaminated soils identified are remediated by removal, encapsulation or land-farming on-site.
	Landform Establishment	<ul style="list-style-type: none"> Final landform established is consistent with the surrounding environment or post-mining land use. Final landform is stable with minimal erosion.
	Growth Medium Development	<ul style="list-style-type: none"> Plant growth medium is established.
	Ecosystem Establishment	<ul style="list-style-type: none"> Ecosystem function is restored with local native plant species.
	Ecosystem Development	<ul style="list-style-type: none"> Ecosystem is self-sustaining.

**Table 7-3 (Continued)
Rehabilitation Phases and Objectives**

Rehabilitation Domain	Rehabilitation Phase	Domain Rehabilitation Objective
Dendrobium CPP	Decommissioning	<ul style="list-style-type: none"> Remove all infrastructure to ensure site is safe and free of hazardous materials (subject to heritage and alternative end use considerations). Site is safe, stable and non-polluting. Any contaminated soils identified are remediated by removal, encapsulation or land-farming on-site.
	Landform Establishment	<ul style="list-style-type: none"> Final landform established is consistent with the surrounding environment or post-mining land use and facilitates drainage. Final landform is stable with minimal erosion.

¹ Subsidence remediation are described in Sections 7.3.6 to 7.3.8.

It is appropriate that the rehabilitation performance measures and completion criteria described remain at the strategic level for this EIS.

A MOP would be developed for the Project and would incorporate the proposed changes in operations at the Dendrobium Mine and the Cordeaux Colliery.

The MOP would describe the rehabilitation and performance measures and completion criteria, including more detailed and quantified criteria where applicable (based on the Development Consent conditions for the Project). The rehabilitation performance measures and completion criteria included in the MOP would be specific, measurable, realistic and time-bound.

Rehabilitation of the West Cliff Stage 3 Coal Wash Emplacement would continue to be conducted in accordance with the *West Cliff Coal Wash Area Emplacement Management Plan* (Illawarra Coal, 2017) (or the latest approved version) and the Bulli Seam Operations MOP.

Over the life of the Project, rehabilitation performance measures and completion criteria would, periodically, be updated and refined in consultation with relevant regulatory authorities and stakeholders to reflect evolving mine site rehabilitation practices and standards.

The key rehabilitation performance measures and strategic completion criteria for the Project are described below.

Decommissioning

- All non-heritage listed buildings and infrastructure decommissioned and removed (including offices, workshops, fuel tanks, ventilation shaft infrastructure [i.e. fan housing and winders], transformers, electrical services [i.e. powerlines and posts], rail infrastructure [i.e. rails and sleepers], roads and other buildings).
- Portals, ventilation shafts and mine entrances decommissioned and sealed in accordance with the Mine Closure Plan and DRG requirements.
- Water and soil contaminants are within applicable National Water Quality Management Strategy, ANZECC and EPL guidelines.

Landform Establishment

- Each domain re-profiled to the final landform design in accordance with the Mine Closure Plan.
- Surface water management infrastructure designed and implemented in line with the approved Water Management Plan.

Growth Medium Development

- Bare or stripped areas that are to be returned to vegetation would be topsoiled in accordance with the Landscape Management Plan. Topsoil depth would be determined by the desired vegetation, quantity and quality of the surface and subsoil available, and the nature of the underlying material.

Ecosystem Establishment

1. Each domain rehabilitated as per the approved revegetation and/or landscape management plan, utilising local and native species. Generally, the area would be ripped and seeded using the appropriate method.

Ecosystem Development

1. Adequate species diversity, succession and habitat development that meets applicable benchmark levels, as confirmed by survey (e.g. using BioMetric attributes).
2. Satisfies the post-mining land use objective, as agreed with relevant regulatory authorities and stakeholders. Followed by lease relinquishment where applicable.

7.3 GENERAL REHABILITATION PRACTICES AND MEASURES

Rehabilitation progress of the Project and rehabilitation techniques and materials would be regularly evaluated. The results would inform future rehabilitation initiatives and refinement/amendment of the practices and measures described below through adaptive management.

7.3.1 Vegetation Clearing Measures

The clearance of vegetation would be undertaken progressively, with the area of vegetation cleared at any particular time generally being no greater than that required to accommodate projected development activities for the next 12 months.

Vegetation clearance protocols would be documented in the MOP and the Landscape Management Plan. Key components of the vegetation clearance protocols would include aspects such as the delineation of vegetation areas to be cleared, clearing inspections and re-use of cleared vegetation debris in revegetation.

Vegetation clearance at the West Cliff Stage 3 Coal Wash Emplacement would continue to be undertaken in accordance with the *West Cliff Coal Wash Emplacement Area Management Plan* (Illawarra Coal, 2017) (or the latest approved version). Where possible, clearing of hollow-bearing trees would be performed in a two-stage process. This involves the clearance of surrounding vegetation separately, before the removal of habitat trees, to allow fauna the opportunity to move.

Further detail on management of potential impacts on flora and fauna during clearing is provided in Section 6.9.2.

7.3.2 Soil Stripping and Handling Measures

The soils within the Project surface disturbance areas are characterised in Section 6.4.1.

West Cliff Stage 3 Coal Wash Emplacement

Following vegetation clearance, soil would be stripped from the West Cliff Stage 3 Coal Wash Emplacement area surface in layers.

The top 50 mm of soil contains the majority of soil stored seed and propagules, plant nutrients and beneficial soil microbes. This layer would be stripped and mixed with cleared vegetation (where suitable) and stockpiled adjacent to or on the selected and pre-prepared recipient site for spreading.

Stripping and stockpiling of subsoil horizons would be undertaken depending on the depth of bedrock. Where possible, the depth of subsoil removal would be greater than 500 mm.

Soil stripped from the West Cliff Stage 3 Coal Wash Emplacement area would be utilised as soon as possible for rehabilitation activities associated with completed emplacement sections.

Soil horizons would not be removed during, or immediately following, rain in order to minimise damage to soil structure during temporary stockpiling.

Other Project Surface Disturbance

Soil stripping would occur by layer to allow for appropriate management of topsoil and subsoil resources independently.

Recovered topsoil and subsoil would be stockpiled for later use in rehabilitation, where relevant. Any long-term soil stockpiles would be managed to maintain long-term soil viability through the implementation of the following management practices:

- soil stockpiles would be located outside of active operational areas;
- stockpiles would be constructed with a 'rough' surface condition to reduce erosion hazard, improve drainage and promote revegetation;

- stockpiles that are inactive for extended periods would be fertilised and seeded, to maintain soil structure, organic matter and microbial activity (subject to any conservation requirements);
- silt fences would be installed around soil stockpiles to control potential loss of soil where necessary; and
- long-term soil stockpiles would be deep-ripped to establish aerobic conditions, prior to soil use in rehabilitation.

A Landscape Management Plan would provide specific details on the soil resource management measures that would be implemented for each Project surface disturbance area.

7.3.3 Geotechnical Stability

Existing geotechnical stability management and monitoring measures conducted at the Dendrobium Mine would continue to be applied for the Project (e.g. for the construction and monitoring/management of surface water storages).

The Project would not result in any material additional geotechnical issues with the continued implementation of the management and monitoring measures.

Approval was obtained for the West Cliff Stage 3 Coal Wash Emplacement under section 100 of the *Coal Mine Health and Safety Act, 2002*. The application for approval was supported by a risk assessment and geotechnical stability study. South32 would continue to implement sound engineering principles and undertake appropriate civil and geotechnical supervision of the emplacement construction in accordance with the approval.

Geotechnical supervision would include:

- management of coal wash emplacement;
- monitoring of available emplacement areas, volumes and material types; and
- analysis of compaction testing results.

Compaction and geotechnical stability of the coal wash emplacement is dependent on the coal wash type (i.e. from processing of the Bulli Seam or Wongawilli Seam), volume delivered, moisture content, fine clay content and sizing.

Compaction testing of the West Cliff Stage 3 Coal Wash Emplacement would be carried out approximately 10 times per year, with each testing campaign consisting of a minimum of five representative samples. The tests would be conducted by a suitably qualified geotechnical consultant at locations selected by the geotechnical supervisor.

Developing emplacement benches would be graded backwards into the valley to prevent surface water flow over the front batter of the bench.

7.3.4 Decommissioning of Surface Infrastructure

Subject to the agreed final land use, decommissioning of surface infrastructure would include, but not be limited to, the following actions:

- de-energising equipment (e.g. removing connections to power, water, gas, compressed air and sewerage) and isolation of power to the site (if appropriate);
- removal of underground infrastructure (where practical), such as mining equipment and service infrastructure;
- sale or scrapping of underground equipment or transfer to other South32 sites;
- demolition and removal of major building infrastructure (pending non-Aboriginal heritage assessment outcomes);
- demolition and removal of major infrastructure from ventilation shaft sites;
- removal of roadway, concrete footings, drainage structures, hardstand and foundations up to 1.5 m below ground level, if not required for the post-mining land use;
- removal of acid dosing plant (Kemira Valley Rail Line) and retired underground equipment, discarded conveyor belts, pipes, hoses, cables, etc. from laydown areas;
- removal and disposal of any hazardous materials such as fuel, lubricants, chemicals or other substances of concern;
- removal of infrastructure at water release points and investigation to confirm discharge points and drainage lines are stabilised appropriately to prevent erosion;
- filling and/or sealing portals, ventilation shafts and underground roadways in accordance with the Mine Closure Plan and DRG requirements;

- demolition and removal of concrete slabs, bitumen surfaces, redundant pipelines and services and redundant powerlines;
- removal of rail line and sleepers;
- excavation and removal of rail ballast (this may be used as shaft backfill or other construction material);
- demolition and removal of all rail bridges and concrete foundations associated with the Kemira Valley Rail Line unless required for agreed final land use; and
- blocking of the Kemira Valley Rail Line tunnel at both ends in accordance with the requirements of MDG 6001 (DRE, 2012).

7.3.5 Selection of Native Plant Species for Revegetation

Disturbed areas to be revegetated with native vegetation would initially be prepared by ripping and applying a non-persistent cover crop where appropriate. Suitable native tubestock and/or seeds would then be planted/sown.

Flora species endemic to the local area would be preferentially used for rehabilitation, except where seed or tubestock supply may be a limiting factor. In this case, other appropriate native species which have performed well in the region would also be considered.

Native plant species to be planted in revegetation areas would be selected on a site-by-site basis, depending on nearby remnant vegetation associations, soil types, aspect and site conditions.

The species selected would aim to establish vegetation that reflects the composition and structure of vegetation communities present in the area. A provisional list of vegetation communities that would be considered as target rehabilitation communities is provided in Table 7-4.

It is anticipated that this list of provisional Plant Community Types (PCTs) and species would be reviewed and refined prior to final decommissioning and rehabilitation, based on experience at other South32 operations and in consultation with key stakeholders. The specific areas that would be targeted for each PCT and the area to be targeted in rehabilitation works would be defined in the MOP.

7.3.6 Remediation of Subsidence Impacts on Streams

The Project may result in the following subsidence impacts on streams and associated environmental consequences:

- fracturing of rockbars and dilation and cracking of bedrock along streams, resulting in a reduction in pool levels and/or reduction in visible surface water flow;
- alteration of surface drainage patterns, resulting in localised erosion or scour or changes in soil moisture; and
- localised changes in water quality as a result of freshly exposed fractures in sandstone rocks.

These subsidence impacts and environmental consequences are described further in Section 6.

Current mitigation and remediation methods for subsidence impacts on streams at the Dendrobium Mine are described within the WIMMCP (South32, 2017a).

It is proposed that similar remediation methods would be implemented for the Project as required, incorporating any learnings and experience from existing operations using an adaptive management approach.

Performance measures for subsidence impacts on streams would be derived from the Project Development Consent. An Extraction Plan would be developed, specific to Project activities, to demonstrate that performance measures can be met through avoidance, minimisation of impact, management and/or remediation.

In the event that performance measures are exceeded, South32 would implement actions to mitigate and remediate subsidence impacts and associated environmental consequences.

Avoidance and Minimisation

The Project longwall layout has been designed to minimise the potential for impacts on surface features (including key stream features) due to subsidence. The longwall design considered potential environmental impacts in conjunction with mine planning, scheduling and economic viability (Sections 6.3.4 and 9.2.1).

**Table 7-4
Provisional Target Revegetation Communities**

Vegetation Community	PCT Code	Formation	Class	Potential Key Canopy Species	Potential Key Shrub Species
Exposed Sandstone Scribbly Gum Woodland	1083	Dry Sclerophyll Forests (Shrubby Sub-formation)	Sydney Coastal Dry Sclerophyll Forests	<i>Corymbia gummifera</i>	<i>Acacia suaveolens</i>
				<i>Eucalyptus haemastoma</i>	<i>Acacia ulicifolia</i>
				<i>Eucalyptus oblonga</i>	<i>Banksia ericifolia</i>
				<i>Angophora costata</i>	<i>Banksia serrata</i>
				<i>Eucalyptus sieberi</i>	<i>Banksia spinulosa</i>
				<i>Eucalyptus piperita</i>	<i>Leptospermum trinervium</i>
Sandstone Gully Peppermint Forest	1250			<i>Banksia serrata</i>	<i>Leptospermum polygalifolium</i>
				<i>Eucalyptus piperita</i>	<i>Banksia ericifolia</i>
				<i>Angophora costata</i>	<i>Acacia terminalis</i>
				<i>Corymbia gummifera</i>	<i>Leptospermum trinervium</i>
					<i>Banksia spinulosa</i>
					<i>Acacia suaveolens</i>
Escarpment Moist Blue Gum Forest	1245	Wet Sclerophyll Forests (Shrubby Sub-formation)	North Coast Wet Sclerophyll Forests	<i>Acmena smithii</i>	<i>Notelaea venosa</i>
					<i>Livistona australis</i>
				<i>Synoum glandulosum</i>	<i>Eupomatia laurina</i>
				<i>Pittosporum undulatum</i>	
				<i>Cryptocarya glaucescens</i>	
				<i>Eucalyptus saligna</i>	
				<i>Eucalyptus quadrangulate</i>	
				<i>Eucalyptus pilularis</i>	
				<i>Syncarpia glomulifera</i>	
Moist Gully Gum Forest	878		Southern Escarpment Wet Sclerophyll Forests	<i>Eucalyptus smithii</i>	<i>Elaeocarpus reticulatus</i>
				<i>Eucalyptus piperita</i>	<i>Notelaea venosa</i>
				<i>Eucalyptus muelleriana</i>	<i>Synoum glandulosum</i>
Coastal Warm Temperate Rainforest	905	Rainforests	Northern Warm Temperate Rainforests	<i>Acmena smithii</i>	<i>Tasmania insipida</i>
				<i>Livistona australis</i>	<i>Cyathea australis</i>
				<i>Ceratopetalum apetalum</i>	<i>Eupomatia laurina</i>
				<i>Cryptocarya glaucescens</i>	<i>Ficus coronate</i>
				<i>Synoum glandulosum</i>	<i>Psychotria loniceroides</i>

Source: Illawarra Coal (2017); OEH (2017).

Mitigation and Remediation Methods

The following subsections outline the available methods to mitigate and/or remediate the subsidence impacts and environmental consequences outlined above.

These methods would be revised to incorporate results of rehabilitation trials, which will allow for continued improvements in rehabilitation and remediation practice (Section 7.5.2).

Remediation of Surface and Bedrock Fracturing

Surface and bedrock fracture remediation methods would depend on the type and extent of fracturing. Fracturing is able to be remediated via surface sealing and injection grouting of either high or low viscosity materials (selected based on the formation of the fracture network).

Where the surface or bedrock base of a significant permanent pool or controlling rockbar is impacted as a result of mine subsidence, and there is limited ability for the fractures to close naturally, the fractures would be sealed with grout. Grouting would be focused on fractures that result in the diversion of flow.

Grouting Materials

Grouting materials available include cementitious grout and Polyurethane Resin (PUR).

Cementitious grout can contain various additives and can be used with or without fillers (such as clean sand) (Commonwealth of Australia, 2014). Cementitious grout has previously been successfully implemented by South32 during remediation works in the Georges River. The remediation techniques used by South32 in areas of the Georges River focused on grouting of mining-induced fractures and strata dilation to reinstate the structural integrity and water-holding capacity of the bedrock of the Georges River.

The Metropolitan Colliery is currently rehabilitating areas of the Waratah Rivulet impacted by subsidence using PUR and other alternative grouting materials. South32 is consulting with the Metropolitan Colliery in relation to these technologies.

Should remediation of fractures of pools or controlling rockbars be necessary for the Project, the best grout material option at the time of the rehabilitation work would be identified and implemented with appropriate approvals. Grouts would be mixed on-site and placed by hand or injected into a fracture network (described further below). Both methods of placement have been successfully implemented in the Georges River.

Grouting has the potential to result in additional environmental impacts and, therefore, would be carefully planned and executed to minimise the risk of contamination. The selection of grouting materials would be:

- determined in consultation with WaterNSW and other stakeholders;
- based on demonstrated effectiveness; and
- designed to avoid significant impacts to water quality or ecology.

Methods for Surface Sealing

Surface fractures can be sealed by application of grout by hand, using cement-based grout. Generally surface grouting would require only small amounts of grout material, which can be mixed and placed on-site. The Marhnyes Hole rockbar on the Georges River demonstrates that hand grouting of large surface cracks is a successful remediation technique (Commonwealth of Australia, 2014).

Injection Grouting

Injection grouting involves the delivery of grout through holes drilled into bedrock to target remediation of fractures. The purpose of injection grouting is to achieve a low permeability layer below any affected pool, as well as the full depth of any significant rockbar.

Current practice indicates that grouting holes should be drilled in a pattern with grid spacing of 1 m x 1 m to 2 m x 2 m, using handheld drills powered by compressed air (Plate 7-3). Grout is then delivered via mechanical packers (Plate 7-4). The grout would be mixed and pumped according to a predetermined grout design (Commonwealth of Australia, 2014).

Grout with a high viscosity (shorter setting time) may be used if vertical fracturing is believed to be present. A low viscosity grout is ideal for use when cross-linking between fractures is noted.



Plate 7-3 - Drilling into Bedrock to Form Grouting Holes

Source: Good *et al.* (2010).



Plate 7-4 - Example of Rockbar Grouting Injection Undertaken in the Georges River

Source: Good *et al.* (2010).

After the grout material sets, areas may be in-filled with additional grout to target areas where substantial amounts of grout were used in the previous grouting pass (indicating more fracturing). Once grout take has significantly reduced and the material has set, the pool would be tested to determine the rate at which water drains, compared to pre-grouting results. In the Georges River, the majority of pools were sealed within two to three grout passes.

Where flow diversion is observed through a large rockbar, it may be more appropriate to implement alternative grouting techniques, such as a deeper grout curtain delivered via traditional or directional drilling. Where alluvials overlie sandstone, grouts may be injected through grout rods to seal voids in or under the soil or peat material (Commonwealth of Australia, 2014).

Grouting would be undertaken after subsidence movements in the area have ceased, to reduce the risk of the area being re-impacted. This may necessitate delay to remediation works until subsequent longwalls have been completed.

Remediation of Areas of Altered Surface Drainage

The existing surface drainage of streams may be altered as a result of subsidence-induced tilting. Subsidence-induced tilting can concentrate runoff and lead to scour and erosion. In other areas, subsidence-induced tilting can reduce water and soil moisture.

To mitigate scour and erosion impacts, coir log dams can be installed at knickpoints², such as those shown in Plate 7-5. The coir log dam slows the water flow in the eroding drainage line to encourage silt build-up.



Plate 7-5 - Square Coir Logs for Knickpoint Control

Source: Good *et al.* (2010).

A trench is cut into the soil so that either the first layer of the coir log dam sits on the underlying substrate or the top layer sits at ground level. Coir log dams would be held in place by wooden stakes and bound together with wire. Small coir log dams would then be constructed at intervals down the eroding drainage line. Where increased sediment filtering of stream flow is required, the coir logs are wrapped in fibre matting (Plate 7-6) (Commonwealth of Australia, 2014).

² A knickpoint is a location on a river/channel where a sharp change in channel bed elevation occurs.



Plate 7-6 - Coir Log Dams Constructed at Intervals with Wrapping of Fibre Matting
Source: Good et al. (2010).

Maintenance of moisture in rehabilitation areas can be accomplished via water-spreading techniques. These techniques include implementing long lengths of coir logs and hessian 'sausages', linked together in such a way that water flow builds up behind them and slowly seeps through the water spreaders (Plate 7-7).



Plate 7-7 - Round Coir Logs Installed to Spread Water
Source: Good et al. (2010).

Erosion control and water spreading involves soft-engineering materials that are biodegradable and would eventually become integrated into the soil profile.

Remediation of Environmental Consequences Associated with Gas Releases

Gas release at the surface above an underground mine is driven by pressure changes and dilation and/or fracturing of the rock mass. In the Southern Coalfield, gas releases have all been documented to reduce over time, typically over a period of months to years.

Grouting and surface treatments discussed above can limit gas flow.

Areas of vegetation impacted by gas release would be revegetated (through seeding/planting) after cessation of gas release or if gas release reduces to a minimal level.

Remediation Options for Changes in Water Quality

There is potential for water quality impacts to occur in streams as a result of subsidence-induced fracturing of bedrock and/or rockbars. These impacts may include changes to pH and mobilisation of suspended metals (e.g. iron and manganese).

If agreed with WaterNSW, water treatment techniques such as liming streams and rivers could be used for remediation of water quality or aquatic ecosystem impacts.

There is potential for atmospheric oxygen to react with ferruginous springs, resulting in excessive precipitation of metals and further generation of local acidity. To remediate this, the point of maximum oxygenation could be moved closer to the ferruginous spring via the deposition of rocks and boulders within affected streams. This would increase the turbulence and hence rates of oxygenation, precipitation of hydrous oxides and acid generation, allowing natural effects downstream to ameliorate the effects of the spring.

Other Potential Remediation Methods

Where natural infilling is not occurring for soil cracking, minor surface treatment works (i.e. manual infilling and compacting) to prevent erosion would be implemented. Larger cracks may require more work to repair them (e.g. mulch protection layer or grout application [see above]). Surface treatments would remain in place until revegetation covers the disturbed area. Wider cracks may require gravel or sand infilling and revegetation using brush matting.

Surface treatment of cracking can also be undertaken with placement of a geofabric material that minimises water flow entering the cracks. Geofabric remediation techniques are not ideal for stream remediation for the Project, as the implementation of these methods generally requires significant additional surface disturbance associated with site preparation and/or installation.

7.3.7 Remediation of Subsidence Impacts on Upland Swamps

The Project may result in the following subsidence impacts on upland swamps and associated environmental consequences:

- a reduction or loss of water in the swamp sediments as a result of:
 - fracturing of downstream rockbars;
 - fracture networks forming in the bedrock below the swamp; and/or
 - upsidence and dilation of bedrock below the swamp; and
- alteration of surface drainage patterns due to subsidence-induced tilting, resulting in localised erosion or scour or alteration of water distribution.

These subsidence impacts and environmental consequences are described further in Section 6.

Current mitigation and remediation measures for subsidence impacts on upland swamps at the Dendrobium Mine are described within the SIMMCP (South32, 2017b).

In accordance with the conditions of the Area 3B SMP Approval, South32 is also conducting research into methods for swamp rehabilitation as described in the *Dendrobium Area 3B Swamp Rehabilitation Research Program* (South32, 2016).

Subject to confirmation from key stakeholders that swamps undermined in Area 3 have been successfully remediated and is practicable, swamp remediation measures could be implemented for the Project.

Avoidance and Minimisation

Consideration of avoidance and minimisation of impacts on upland swamps is described in Sections 6.8 and 9.2.1.

Mitigation and Remediation Methods

The following subsections outline the available methods to mitigate and/or remediate the subsidence impacts and environmental consequences outlined above.

These methods would be revised to incorporate results of rehabilitation and remediation trials, which would allow for continued improvements in rehabilitation and remediation practice (Section 7.5.2).

Remediation of Surface and Bedrock Fracturing and Dilation

The DoEE has released a report that evaluates mitigation and remediation techniques for Temperate Highland Peat Swamps on Sandstone (Commonwealth of Australia, 2014). The subsidence mitigation and remediation methods for swamps outlined by the DoEE are summarised in Table 7-5.

Remediation of Areas of Altered Surface Drainage

The types of erosion that could manifest in swamp areas are sheet, rill, gully, tunnel and stream channel erosion. Sheet and rill erosion processes in upland swamps can reduce vegetation on the surface and/or be a precursor to the formation of gully and stream channel erosion.

Erosion would be monitored in upland swamps in the Project area in addition to reference monitoring of upland swamps outside of the Project area. Erosion has the potential to create preferred flow paths, which could ultimately act to dewater the swamp sediments.

Erosion control techniques may include the installation of coir log dams at knickpoints to slow water flow, and wrapping coir log dams in fibre matting to encourage silting (Commonwealth of Australia, 2014). These methods would be implemented consistent with the description outlined in Section 7.3.6.

Treatment to prevent the formation of channels and maintain swamp moisture involves water-spreading techniques such as the implementation of long lengths of coir logs and hessian 'sausages'. Water spreading is detailed in Section 7.3.6.

**Table 7-5
Mitigation and Remediation Strategies for Subsidence Impacts on Swamps Associated with Surface and Bedrock Fracturing and Dilation**

Component of Swamp	Potential Mitigation and Remediation Strategies
Downstream rockbar	<ul style="list-style-type: none"> • Avoid or minimise impacts based on mine planning. • Fill fractures with grout, sand or other materials (Section 7.3.6). • Construct slots to decrease fracturing. • Construct artificial barrier to replace the rockbar.
Near-surface fracture zone within bedrock below the swamp	<ul style="list-style-type: none"> • Fill near-surface fractures with grout or other materials to maintain a surface flow path (Section 7.3.6). • Drill boreholes into the fracture zone and inject grout (Section 7.3.6). Fill materials need to be cohesive or cemented. • Fill fractures along the length of the channel or line the channel (Section 7.3.6).
Main upsidence zone	<ul style="list-style-type: none"> • Fill fracture network at key locations (Section 7.3.6). • Drill longer boreholes or trench for access to fractures. • Use high-volume injection of material into large fractures (Section 7.3.6). This approach lends itself to the use of natural materials, such as sand, gravel and clay to fill the fractures.

Source: After Commonwealth of Australia (2014).

7.3.8 Remediation of Subsidence Impacts on Other Natural Features

In addition to the stream and upland swamp remediation measures outlined in Sections 7.3.6 and 7.3.7 above, rehabilitation may be undertaken to remediate mine subsidence impacts (e.g. surface cracking or erosion) on other natural surface features.

The requirement and methodology for any subsidence remediation techniques would be determined in consideration of:

- Potential consequences of the unmitigated impact, including potential risks to public safety and the potential for self-healing or long-term degradation.
- Potential impacts of the remediation technique, including potential environmental impacts associated with site accessibility.

Regular visual monitoring above longwall panels would be conducted to identify any areas subject to excessive erosion and sedimentation as a result of Project subsidence effects. Specific mitigation measures that may be employed include:

- filling of cracks and minor erosion, where practicable;
- installation of sediment fences downslope of subsidence-induced erosion areas;
- stabilisation of erosion areas using rock or other appropriate material;

- stabilisation of slopes and banks subject to soil slumping; and
- revegetation using brush matting, seeding or tubestock.

7.3.9 Erosion and Sediment Control Measures

An Erosion and Sediment Control Plan has been developed and approved as part of the Water Management Plan for the Dendrobium Mine. Similar measures would be adopted for the Project.

As described in Section 6.3.3, mine subsidence has the potential to cause surface cracking, including surface tension cracking near the top of slopes. If tension cracks are left untreated, there is potential for soil erosion to increase. Where significant cracks are detected and the potential for soil erosion (or other environmental consequences) is considered to be material, they would be repaired/filled as soon as practicable (Section 7.3.8).

The active emplacement area of the West Cliff Stage 3 Coal Wash Emplacement would be kept to a practicable minimum to reduce erosion potential.

Operational sediment and erosion control works would be maintained during decommissioning and revegetation. Post-closure erosion and sediment control measures would include reducing the slope lengths of final landforms by constructing contour banks and armouring channels to minimise erosion.

Once stable final landforms have been achieved within an area, key elements of the operational sediment control structures would either be left as passive water control storages or would be removed and the area would become free-draining. Depending on the agreed final land use, surface drainage would be reinstated as closely as possible to pre-mining conditions.

7.3.10 Land Contamination Measures

Dependent on the final post-mining land use, investigations would be undertaken at mine closure to identify and remediate any contaminated soil that may exist (e.g. in infrastructure areas), in accordance with the requirements of the *Contaminated Land Management Act, 1997*. Contaminated land would be remediated by removal and disposal at an appropriately licensed facility, encapsulation, or appropriate remediation treatment on-site.

7.3.11 Weeds and Pest Control

Project weed and pest control measures are described in Section 6.9.4.

7.3.12 Bushfire Management

Bushfire management measures for the Project are described in Section 6.22.3.

7.3.13 Post-closure Maintenance

The management and maintenance of rehabilitation areas post-closure would be determined in consultation with relevant government authorities and stakeholders, and would be outlined in the MOP and Mine Closure Plan (Sections 7.4 and 7.7).

7.4 MINING OPERATIONS PLAN

A MOP would be developed to address Project operations at the Dendrobium Mine and the Cordeaux Colliery. Preparation of this MOP would occur in consultation with the relevant government agencies, and in accordance with the rehabilitation and closure standards outlined in the MOP Guidelines (DRE, 2013) (or the latest version). The MOP would describe how rehabilitation is undertaken, provide rehabilitation performance and completion criteria, and address all aspects of rehabilitation including mine closure, final landforms and final land use.

7.5 MONITORING AND TRIALS

A summary of rehabilitation activities and performance to date is provided in Annual Reviews and the current Dendrobium MOP (South32, 2015a) and Bulli Seam Operations MOP (Illawarra Coal, 2012). Rehabilitation monitoring and trials would be conducted throughout the life of the Project, as described below.

7.5.1 Rehabilitation Monitoring

Post-closure monitoring of rehabilitation areas at the Project would be conducted to assess the:

- progress of rehabilitation areas; and
- the effectiveness of the rehabilitation techniques being used to determine the need for any maintenance and/or contingency measures.

Post-closure monitoring would focus on achieving the stated outcomes in terms of:

- contamination remediation;
- gas emissions from former underground mining areas;
- water management;
- land stability (geotechnical);
- revegetation; and
- site safety and security.

A rehabilitation monitoring program would be developed for the Project that, along with the application of adaptive management, would allow the desired outcomes to be achieved. It is expected that the rehabilitation monitoring would include (subject to final land use agreement):

- Baseline monitoring to determine conditions pre-mining and during mining.
- Documentation of all rehabilitation activities undertaken.
- Initial monitoring for a period of 1 to 2 years post-closure and comparison with control sites.
- Ongoing monitoring (less frequently) from two years post-mining until lease relinquishment.
- Post-lease relinquishment monitoring (to be negotiated with future landholders).
- Use of adaptive management techniques and facilitation of research trials where appropriate.

Subsidence monitoring would be conducted two to five years post-mining, although it is expected that monitoring of upland swamps for subsidence impacts would continue for a minimum of 10 years following completion within a domain. Timeframes for subsidence monitoring would be detailed within the Extraction Plans specific to the Project.

Monitoring measures specific to individual domains would be outlined within the Landscape Management Plan. These monitoring measures would be implemented for the Project rehabilitation where suitable.

Rehabilitation Monitoring of the West Cliff Stage 3 Coal Wash Emplacement

Rehabilitation monitoring specific to the West Cliff Stage 3 Coal Wash Emplacement Area would be undertaken in accordance with the program outlined in the *West Cliff Coal Wash Emplacement Area Management Plan* (Illawarra Coal, 2017) (or latest approved version). These rehabilitation monitoring methods would be applied to other Project rehabilitation areas where appropriate.

The rehabilitation monitoring program is designed to monitor success against the following criteria:

- Adequate regeneration of vegetation communities.
- BioMetric attributes relative to local benchmarks.
- Weed cover of less than 20%.
- Use of the rehabilitated area by native fauna.

The monitoring program would include the following assessment methods:

- BioMetric vegetation assessment (including fixed photo points);
- threatened plant random meanders; and
- fauna camera traps.

BioMetric Vegetation Assessment

BioMetric vegetation assessment uses the BioBanking Assessment Methodology outlined in the *BioBanking Assessment Methodology and Credit Calculator Operational Manual* (OEH, 2014c). This methodology assesses vegetation condition based on a comparison of site attributes against benchmarks for those attributes within relevant vegetation types. Local benchmark data can be collected to reflect local conditions.

BioMetric vegetation plots of 50 m x 20 m would be established within each vegetation monitoring zone. The BioMetric vegetation plots would be stratified across the emplacement area in accordance with existing monitoring sites, with consideration of:

- past vegetation treatment methods;
- established vegetation age; and
- respective occupied area of the vegetation treatment type.

Six control sites are monitored to provide long-term data for comparison. Local benchmark data is collected at these control sites according to the BioBanking Assessment Methodology. The selected control sites are stratified evenly between the locally dominant vegetation types.

BioMetric vegetation assessment, including photographic point monitoring, would continue to be undertaken annually.

Threatened Plant Random Meanders

Random meander monitoring surveys are undertaken by two people, 10 m apart, and target local species such as:

- *Acacia bynoeana*;
- *Epacris purpurascens* var. *purpurascens*;
- *Grevillea parviflora* subsp. *parviflora*;
- *Melaleuca deanei*;
- *Persoonia hirsuta*;
- *Persoonia nutans*; and
- *Pultenaea aristata*.

Random meanders for threatened plants would continue to be undertaken every three years.

Fauna Camera Traps

Infra-red camera traps would continue to be deployed within rehabilitation areas targeting specific habitat features (e.g. logs, hollows, rock crevasses/overhangs) using a passive survey approach (i.e. non-baited). Fauna monitoring using camera traps would be undertaken annually, starting five years after soil translocation. Generally, a minimum of one camera trap would be deployed within each area of rehabilitation with a similar vegetation age, for a minimum of 12 nights.

7.5.2 Rehabilitation Trials

South32 would continue to undertake rehabilitation and subsidence remediation trials and investigations over the life of the Project to allow for continued improvements in rehabilitation and remediation practice.

It is anticipated that these trials and investigations by South32 would continue to focus on:

- rehabilitation practices implemented at the West Cliff Coal Wash Emplacement and at decommissioned surface facility sites; and
- techniques and processes for remediation of subsidence impacts (particularly remediation of impacts on streams and upland swamps).

Rehabilitation trials to date at the West Cliff Coal Wash Emplacement have identified the following best practice methods (South32, 2015a):

- Specific surface reshaping to limit the loss of sediment off the slope and assist with erosion control, by mimicking micro-topographic features and, where possible, using concave slope profiles and angles seen in natural landforms.
- Direct redistribution of stripped soils to a completed emplacement area, wherever possible, to maintain the inherent nutrient and seedbank value in the soil.
- Collection of local native seed that is then spread over completed emplacement areas.
- Creation of fauna habitat through transplanting of dead stags, habitat logs and woody debris, use of nest boxes and reconstruction of rock outcrops.

These measures are implemented across South32's operations and would be implemented for the Project where relevant and feasible (South32, 2015a).

The *WC21 Rehabilitation Plan* (South32, 2015b), submitted in March 2016, outlines proposed mitigation and remediation methods for identified and predicted surface impacts to pools and rockbars along the WC21 tributary of Wongawilli Creek above the Dendrobium Mine.

The *WC21 Rehabilitation Plan* was prepared based on a review of successful subsidence remediation and mitigation methods, including the measures implemented by South32 for impacts to the Georges River.

The performance of subsidence remediation at tributary WC21 would be monitored and reported. Any lessons learnt from these works would be implemented for future subsidence remediation works for the Project.

The remediation program was updated in September 2017 to include Donalds Castle Creek. In addition to trials and investigations undertaken by South32, industry developments and improvements in rehabilitation techniques and processes would be evaluated by South32 and implemented for the Project if applicable. This would include subsidence remediation techniques trialled at the Metropolitan Mine, the Wongawilli Colliery, the Russell Vale Colliery, the Springvale Colliery, the Angus Place Colliery or other relevant underground mines.

7.6 POTENTIAL BARRIERS AND LIMITATIONS TO EFFECTIVE REMEDIATION

Table 7-6 outlines potential barriers and limitations to rehabilitation success that would be monitored, and where relevant, addressed by further trials and investigations and suitable mitigation measures throughout the life of the Project.

7.7 MINE CLOSURE PLAN

A Mine Closure Plan would be developed for the Project in consultation with relevant regulatory authorities and community stakeholders. The Mine Closure Plan would be reviewed and updated over the Project life, with more detailed measures developed closer to Project completion.

The Mine Closure Plan would include consideration of amelioration of potential adverse socio-economic effects due to the reduction in employment at Project closure.

**Table 7-6
Identification of Potential Key Barriers and Limitations to Effective Rehabilitation and Management Strategies**

Key Barrier/Limitation	Potential Causes/Issues	Key Mitigation Strategies
Community objection to proposed final land use	<ul style="list-style-type: none"> • Poor community consultation. • Perceived negative environmental impacts. • Perceived loss of social conditions/amenity change. • Community expectation does not align with legal requirements. 	<ul style="list-style-type: none"> • Community consultation throughout the Project life, increasing prior to mine closure. • Ongoing consideration of future land use alternatives.
Unauthorised access to site	<ul style="list-style-type: none"> • Personal injury. • Property damage. • Environmental damage. • Litigation fines. • Reputation damage. • Heritage issues. 	<ul style="list-style-type: none"> • Installation of appropriate fencing for the stage of the Project. • Security of all buildings and structures, including patrols. • Provision of signage. • Securing portals and shafts, boreholes and goaf wells. • Emptying and securing bulk storage tanks.
Security of dangerous goods and hazardous substances (e.g. explosives)	<ul style="list-style-type: none"> • Dangerous goods/hazardous substances remain on-site after closure. • Deterioration. • Theft. • Unauthorised access. • Possible personal injury. • Property damage. • Litigation fines. • Reputation damage. 	<ul style="list-style-type: none"> • Audits of dangerous goods and hazardous substances. • Management and storage of chemicals in accordance with South32's prescribed management procedures, Australian Standards and Codes.
Unplanned delay in commencement/execution	<ul style="list-style-type: none"> • Inadequate planning process. • Delays in approvals. • Inadequate resources. • Environmental damage. • Reputation damage. • Financial loss. 	<ul style="list-style-type: none"> • MOP process and mine closure planning.
Contamination greater than expected	<ul style="list-style-type: none"> • Unidentified previous uses. • Inadequate studies. • Financial loss. • Delays. 	<ul style="list-style-type: none"> • Contaminated land assessments. • Remediation of contaminated land by removal and disposal at an appropriately licensed facility, encapsulation or land-farming on-site.
Failure to fully provide for closure costs	<ul style="list-style-type: none"> • Inadequate planning process. • Inadequate resources. • Change in scope. • Change in legislation. • Financial loss/delay. 	<ul style="list-style-type: none"> • MOP process, financial securities and mine closure planning.

Table 7-6 (Continued)
Identification of Potential Key Barriers and Limitations to Effective Rehabilitation and Management Strategies

Key Barrier/Limitation	Potential Causes/Issues	Key Mitigation Strategies
Landform instability	<ul style="list-style-type: none"> Inadequate planning process. Poor landform design. Poor emplacement technique. 	<ul style="list-style-type: none"> Experience at West Cliff Coal Wash Emplacement. Rehabilitation trials and investigations. Geotechnical supervision. Compaction testing. Geotechnical investigations and engineering design prior to decommissioning surface facilities.
Failure to establish suitable plant species/communities	<ul style="list-style-type: none"> Inadequate planning process. Poor species selection. Climatic/environmental events (e.g. drought, bushfire). Weed/pest invasion. 	<ul style="list-style-type: none"> Experience at West Cliff Coal Wash Emplacement. Rehabilitation trials and investigations. Monitoring and maintenance. Weeds and pest control.
Failure of subsidence remediation techniques	<ul style="list-style-type: none"> Inadequate planning process. Inadequate resources. Implementation of new technologies. Climatic/environmental events (e.g. drought, bushfire). 	<ul style="list-style-type: none"> Extraction Plan approval process. Subsidence impact performance measures and provisions for offsets. Rehabilitation trials and investigations. Monitoring and maintenance.
Groundwater/surface water impacts due to water accumulating in underground workings	<ul style="list-style-type: none"> Inadequate planning process. Inadequate resources. 	<ul style="list-style-type: none"> Sealing of portals, ventilation shafts and mine entrances in accordance with regulatory requirements. Placement of hydraulic seals in underground workings in accordance with the <i>Avon and Cordeaux Reservoirs DSC Notification Area Management Plan</i> (Illawarra Coal, 2015a).

Source: After South32 (2015a).

7.8 LEASE RELINQUISHMENT

Upon cessation of mining operations, it would be expected that tenure of the mining leases would be maintained by Illawarra Coal until such time as mining lease and other statutory approval relinquishment criteria were satisfied. These criteria would be formulated and prescribed in consultation with relevant authorities and stakeholders.

It is anticipated that mine lease relinquishment criteria would include, but not necessarily be limited to, the following:

- decommissioning and removal of infrastructure, where appropriate and required;
- landform stability and public safety;
- maintenance of downstream water quality;
- establishment of self-sustaining vegetation in previously cleared areas; and
- fulfilment of mining lease and other statutory approval conditions.

Lease relinquishment criteria would be detailed in the Mine Closure Plan.

The *Strategic Framework for Mine Closure* published by the Australian and New Zealand Minerals and Energy Council and Mineral Resources Council of Australia (2000) (or its contemporary version) would be used as a guide for mine closure.